Analysis of barriers that affect the success of the "Zero Waste North Lombok" program

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ABSTRACT

Waste management is a cross-cutting issue closely related to various global challenges. At the local government level, waste management services are carried out to demonstrate the sustainability of a city so that local governments are responsible for finding affordable waste management solutions with the least impact on the environment. North Lombok Regency has a waste management problem that results in the realization of its handling not reaching the target. To overcome the waste management problem, the local government initiated a priority development program "Zero Waste North Lombok" which is expected to address the existing problems. In the process, the implementation of the program has not run significantly. To support the achievement of the program, a study of the barriers to zero waste was conducted using the fuzzy DEMATEL method. This method can facilitate the identification of causal relationships between criteria assessed in complex systems to provide information on various perceptions for stakeholders. The 12 barriers identified were divided into two groups: influential barriers and receptive barriers. The influential barriers consist of a lack of policies and regulations on waste, a lack of cooperation among stakeholders, uncertainty about circular economy targets and strategies, and inadequate sanctions and fines. The influential group of barriers consists of the barriers of lack of environmental awareness, inadequate recycling techniques, inadequate methods for sorting, transporting and recycling waste, lack of financial and economic assistance, lack of advertising and media coverage for waste management, lack of adequate areas for waste collection and sorting, lack of awareness about environmental protection and lack of temporary shelters. This group of influential barriers needs to be considered and addressed by the local government so that the goals of the "Zero Waste North Lombok" program can be achieved.

Keywords: waste management; zero waste; barriers; fuzzy logic; DEMATEL.

INTRODUCTION

Waste management has become a global concern in recent decades and a cross-cutting issue. Waste management is also closely related to various global challenges including health, climate change, poverty reduction, food and resource security, and sustainable production and consumption (Wilson & Velis, 2015). Proper handling of waste generation is necessary so that it does not cause significant threats to the environment and human life (Sadeghi Ahangar et al., 2021). Unfortunately, maintaining a good waste management system is still very difficult and expensive (Tirkolaee et al., 2019). In developing countries in particular, waste management conditions are often faced with problems of inadequate infrastructure, institutional administrative constraints, and financing constraints (Khan & Ali, 2022). At the local government level, waste management is one of the main public services where the efficiency of waste management services carried out shows the sustainability of a city (Phonphoton & Pharino, 2019). Local governments are responsible for finding affordable waste management solutions with the least impact on the environment (Edwards et al., 2018).

Waste management is a strategic issue in North Lombok Regency. The realization of waste handling in North Lombok Regency has not been able to exceed the set target. In 2020, the target for waste management was 70%. However, the realization was at 53.19% (Regional Medium-term

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Development Plan Document of North Lombok Regency 2021-2026). To respond to the problem of waste management, the local government of North Lombok Regency initiated the priority development program "Zero Waste North Lombok". The "Zero Waste North Lombok" program is expected to overcome the waste problem in North Lombok Regency caused by the large amount of waste both in the landfill and those that are carelessly disposed of by the community in rivers and roadsides.

The concept of zero waste is widely used to solve waste problems, which focuses on recycling products and reducing the amount of waste entering the environment (Zaman & Lehmann, 2013). Zero waste is understood as a principle that designs waste, toxins, and inefficiencies to be outside the economic system. The value of materials and products in zero waste implementation must be preserved so that they can be reused repeatedly. The zero waste approach is beneficial to municipalities in terms of reducing waste management costs and the level of waste generated. This is because the zero waste concept emphasizes stopping waste production in the first place (Khaw-ngern, 2021). The concept of zero waste is also related to the concept of circular economy. The circular economy aims to minimize waste as well as energy efficiency, environmental preservation, and economic development, which in turn can realize effective zero waste management (Nixon et al., 2017; Nizar et al., 2019).

The implementation of the "Zero Waste North Lombok" program has not been significant. Challenges and barriers that can limit the success of the program have not been identified. Studies on barriers and the influence between barriers need to be carried out to help the success of waste management activities (Zhang et al., 2019). In this study, the study of barriers and the influence between barriers in the "Zero Waste North Lombok" program was carried out using the fuzzy DEMATEL method. The fuzzy DEMATEL method was used in this study because the matrix for assessing the relationship between factors is relatively simple and easily understood by decision makers. In addition, this method can also help find relationships between factors and their influence on each factor. Furthermore, this method is able to facilitate the identification of causal relationships between criteria assessed in complex systems so as to provide information regarding diverse perceptions for stakeholders (Yadav, 2021). DEMATEL is also generally considered as one of the best techniques for identifying clusters/causal relationships between assessed criteria in system evaluation (Akyuz & Celik, 2015). This technique shows the interdependent relationship between factors and their influence values (Akyuz & Celik, 2015; Lin, 2013; Muhammad & Cavus, 2017).

RESEARCH METHODS

The data collection technique is primary data collection using observation and questionnaire methods. The barriers identified in the implementation of the zero waste concept are as follows.

Table 1. Barriers in Zero Waste Management

	Barriers	Description
B1:	Lack of financial and economic support	Waste retribution, including the ability and willingness of the community to pay, and the ability of the local government to collect the retribution, as well as referring to the community's attitude towards the value of waste.
B2:	Lack of policies and regulations on waste	Lack of regulatory pressure and unclear definitions in waste management
B3:	Lack of environmental awareness	Low sensitivity to the environment due to lack of environmental awareness
B4:	Lack of collaboration between stakeholders	Stakeholder cooperation in terms of responsibility sharing and manager support for adopting waste management is still minimal.
B5:	Lack of adequate area for waste collection and sorting	Lack of appropriate locations to dispose of waste and insufficient number of collection points
B6:	Inadequate recycling techniques	Lack of innovation in recycling and low efficiency in the recycling system
B7:	Uncertainty about circular economy targets and strategies	Poor planning for the challenges of the circular economy, as well as the absence of key strategies
B8:	Lack of temporary shelters	Insufficient number of temporary waste collection points

Barriers		Description
B9:	Inadequate methods for sorting, transporting, and recycling waste	Disorganized and inadequate waste decomposition and separation process
B10:	Inadequate sanctions and fines	Environmental regulations are weak and monetary sanctions are inadequate
B11:	Lack of awareness of environmental protection	Low environmental awareness and unsustainable cultural behavior
B12:	Lack of advertising and media coverage for waste management	A situation where information dissemination methods are not effective in reaching the public.

Source: (Ayçin & Kaya, 2021)

These barriers were observed for their suitability to the conditions in North Lombok District. Furthermore, decision makers/experts were given a questionnaire to assess the influence between these barriers. Respondents totaled 8 people and came from stakeholders/experts in the field of waste management in North Lombok Regency. The results of the questionnaire were then analyzed with the fuzzy DEMATEL method.

Fuzzy DEMATEL Mehod

The Fuzzy DEMATEL method consists of the following steps (Ayçin & Kaya, 2021; Dou et al., 2014):

1. Form a fuzzy direct relationship matrix (*D*) obtained from pairwise comparisons of experts in terms of influence and direction between barriers, where denoted as the degree to which barrier *i* influences barriers *j*, so that $D = \left[d_{ij}\right]_{nxn}$.

   Linguistic variables and fuzzy numbers are shown in table 2:

Table 2. Fuzzy DEMATEL Rating Scale

Linguistic Variables	Score	Fuzzy Equations
No influence	0	(0; 0; 0,25)
Very low inflence	1	(0; 0,25; 0,50)
Low influence	2	(0,25; 0,50; 0,75)
High influence	3	(0,50; 0,75; 1)
Very high influence	4	(0,75; 1; 1)

Source: (Ayçin & Kaya, 2021)

Fuzzy Triangular Number (TFN) is used to represent linguistic terms where each TFN has three parameters denoted as *l*, *m*, and *u* that specify the smallest possible, the most promising, and the largest possible values, respectively.

Let $A_{ij}^{k}(l_{ij}^{k}, m_{ij}^{k}, u_{ij}^{k})$ where $1 \leq k \leq K$ be the fuzzy evaluation that the Kth expert's opinion about barrier *i* has an impact on barrier *j*. The CFCS (Converting Fuzzy Data into Crisp Scores) defuzzification method or converting fuzzy data into hard values is used for the fuzzy aggregation process. The CFCS method involves a four-step algorithm as follows:

a. Normalization

$$xl_{ij}^{k} = (l_{ij}^{k} - minl_{ij}^{k})/\Delta_{min}^{max} \quad (1)$$

$$xm_{ij}^{k} = (m_{ij}^{k} - minl_{ij}^{k})/\Delta_{min}^{max} \quad (2)$$

$$xu_{ij}^{k} = (u_{ij}^{k} - minl_{ij}^{k})/\Delta_{min}^{max} \quad (3)$$

Where $\Delta_{min}^{max} = maxu_{ij}^{k} - minl_{ij}^{k}$

b. Calculating the right and left normalization values

$$xrs_{ij}^{k} = xu_{ij}^{k}/(1 + xu_{ij}^{k} - xm_{ij}^{k}) \quad (4)$$

$$xls_{ij}^{k} = xm_{ij}^{k}/(1 + xu_{ij}^{k} - xl_{ij}^{k}) \quad (5)$$

c. Calculating the total normalized value

$$x_{ij}^{k} = \left[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k} \times xrs_{ij}^{k}\right]/\left[1 - xls_{ij}^{k} + xrs_{ij}^{k}\right] \quad (6)$$

d. Determining crips values

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$$Z_{ij}^{k} = minl_{ij}^{k} + x_{ij}^{k} \times \Delta_{min}^{max} \quad (7)$$

Furthermore, the summation of the experts' assessments is carried out where *K* is the number of experts, using equation (8) as follows

$$Z_{ij} = \frac{1}{K}\left(Z_{ij}^{1} + Z_{ij}^{1} + \cdots + Z_{ij}^{k}\right) \quad (8)$$

2. Normalization of the initial direct relationship matrix (*X*)
   The initial normalized direct relationship matrix is calculated using the following equation:

$$X = s.D \quad (9)$$

$$s = min\left[\frac{1}{max_i \sum_{j=1}^{n}|d_{ij}|}, \frac{1}{max_j \sum_{i=1}^{n}|d_{ij}|}\right] \quad (10)$$

3. Determine the total relationship matrix (*T*)
   The total relationship matrix (*T*) is calculated using equation (11) where *I* is denoted as the identity matrix.

$$T = X(I - X)^{-1} \quad (11)$$

4. Calculating *D* and *R* values
   The number of rows (*D*) and number of columns (*R*) are calculated with the following equation:

$$T = \left[t_{ij}\right]_{nxn} \quad (12)$$

$$D = \left[\sum_{j=1}^{n} t_{ij}\right]_{nx1} \quad (13)$$

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{1xn} \quad (14)$$

   D values are referred to as dispatcher vectors, while *R* values are referred to as receiver vectors.
5. Determine the causal diagram
   A causal diagram is obtained by mapping the data set (*D+R, D-R*). The horizontal axis (*D+R*) is obtained by adding *D* to *R*, while the vertical axis (*D-R*) is obtained by subtracting *R* from *D*. The prominence value is the sum of the cause effect (*D*) and the effect effect (*R*). A factor with a high 'prominence' value indicates an important factor that influences other factors, but can also be influenced by other factors. A constraint belongs to the cause group if its (*D-R*) value is positive, and to the effect group if its (*D-R*) value is negative.
6. Determining threshold values and establishing network relationships.
   The threshold value is obtained from the average of the total relationship matrix values. The determination of the network relationship will be '0' if the total relationship matrix value is less than the threshold value, and will be '1' if the total relationship matrix value is more than the threshold value. The value '1' indicates the interaction of causal relationships between criteria (Abdullah et al., 2019).

RESULT AND DISCUSSION

Based on observations that have been made, all barriers to the "Zero Waste North Lombok" program are in accordance with the conditions of waste management in North Lombok Regency. Furthermore, respondents were asked to fill out a direct relationship matrix questionnaire between barriers, where if the value of *i = j*, then the value of the relationship between these barriers is 0. From the results of data processing, the total relationship matrix of the "Zero Waste North Lombok" program barriers is shown in table 3.

Table 3. Relationship Matrix of Total Barriers of the “Zero Waste North Lombok” Program

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
B1	0,4826	0,2907	0,4594	0,3554	0,3916	0,3585	0,3642	0,4158	0,3629	0,1836	0,4125	0,3704
B2	0,4587	0,4621	0,5621	0,4618	0,4252	0,3293	0,4611	0,4506	0,4195	0,3614	0,4983	0,4377
B3	0,4909	0,3969	0,6155	0,4793	0,4505	0,3713	0,4453	0,4274	0,4239	0,2958	0,4984	0,4549
B4	0,4495	0,3836	0,5272	0,4885	0,4168	0,3758	0,4586	0,4534	0,4048	0,2435	0,4620	0,4229
B5	0,3312	0,2614	0,3854	0,2962	0,3774	0,2718	0,3368	0,3427	0,3447	0,1553	0,3372	0,2621
B6	0,3584	0,2474	0,3811	0,2864	0,2915	0,3510	0,3437	0,3191	0,3461	0,1399	0,3177	0,2707
B7	0,4983	0,4020	0,5397	0,4576	0,4102	0,3911	0,4804	0,4365	0,4235	0,2149	0,4634	0,3927
B8	0,3389	0,2474	0,3765	0,2937	0,3286	0,2909	0,3168	0,3959	0,3310	0,1532	0,3304	0,2687
B9	0,3804	0,2929	0,4102	0,2971	0,3491	0,3535	0,3467	0,3351	0,3942	0,1712	0,3469	0,2943
B10	0,2562	0,2564	0,3861	0,2902	0,2291	0,2001	0,2353	0,2426	0,2190	0,2422	0,3190	0,2621
B11	0,3793	0,3225	0,4832	0,3485	0,3250	0,2796	0,3356	0,3187	0,3177	0,2145	0,4428	0,3339
B12	0,3514	0,2603	0,4361	0,3045	0,2855	0,2667	0,2486	0,2880	0,2883	0,1489	0,3754	0,3951

Source: Analysis, 2023

Furthermore, the results of the horizontal axis (*D+R*) which is the level of central role and the vertical axis (*D-R*) which is the level of relationship are shown in table 4.

Table 4. Influence Group of Barriers of the "Zero Waste North Lombok" Program

Barriers	*D*	*R*	*D+R*	*D-R*
B1	4,4476	4,7763	9,2238	-0,3287
B2	5,3459	3,8237	9,1696	1,5221
B3	5,3502	5,5627	10,9128	-0,2125
B4	5,0865	4,3592	9,4457	0,7273
B5	3,7023	4,2803	7,9827	-0,5780
B6	3,6530	3,9025	7,5555	-0,2496
B7	5,1102	4,4091	9,5192	0,7011
B8	3,6720	4,4257	8,0977	-0,7538
B9	3,9716	4,2757	8,2473	-0,3041
B10	3,1382	2,4793	5,6174	0,6589
B11	4,1019	4,8040	8,9060	-0,7021
B12	3,6848	4,1655	7,8503	-0,4808

Source: Analysis, 2023

The influence between barriers is obtained based on the threshold value. The threshold value obtained is 0,3560. Furthermore, the threshold value is juxtaposed with the total relationship matrix value of the "Zero Waste North Lombok" program barriers. The matrix value is less than the threshold value, then it is '0', meaning that there is no influence between barriers. Meanwhile, if the matrix value is more than the threshold value, it is '1', meaning that there is an influence between barriers. The matrix of influence between barriers is shown in table 5.

Table 5. Matrix of Total Influence of Barriers of "Zero Waste North Lombok" Program

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
B1	1	0	1	0	1	1	1	1	1	0	1	1
B2	1	1	1	1	1	1	1	1	1	0	1	1
B3	1	1	1	1	1	1	1	1	1	0	1	1
B4	1	1	1	1	1	1	1	1	1	0	1	1
B5	0	0	1	0	1	0	0	0	0	0	0	0
B6	1	0	1	0	0	0	0	0	0	0	0	0
B7	1	0	1	1	1	1	1	1	1	0	1	1
B8	0	0	1	0	0	0	0	1	0	0	0	0
B9	1	0	1	0	0	0	0	0	1	0	0	0
B10	0	0	1	0	0	0	0	0	0	0	0	0
B11	1	0	1	0	0	0	0	0	0	0	1	0
B12	0	0	1	0	0	0	0	0	0	0	1	1

Source: Analysis, 2023

Furthermore, the fuzzy DEMATEL causal diagram for the barriers of the "Zero Waste North Lombok" program is shown in Figure 1.

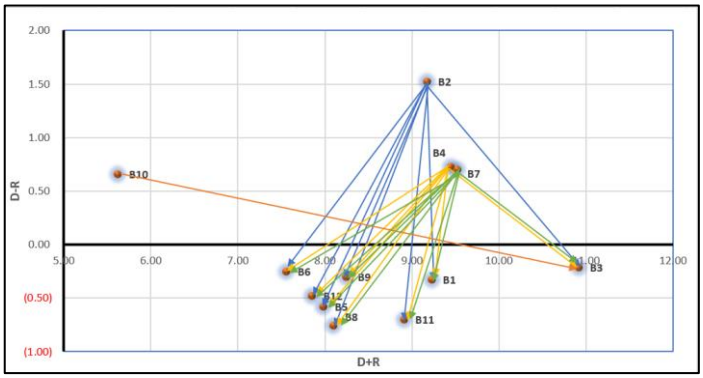

Figure 1. Fuzzy DEMATEL Causal Diagram of Barriers of the "Zero Waste North Lombok" Program in North Lombok Regency Source: Analysis, 2023

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Based on table 4, it is known that the (*D-R*) values of 'lack of policies and regulations on waste (B2)', 'lack of collaboration between stakeholders (B4)', 'uncertainty about circular economy targets and strategies (B7)', and 'inadequate sanctions and fines (B10)' have positive (+) values. Based on Figure 1, the distribution position of the four barriers is in the positive relationship quadrant (*D-R*) with the following score order B2>B4>B7>B10. All of these barriers are included in the group of barriers that are influential and play an important role in influencing the strategy of the "Waste-Free North Lombok Program".

Furthermore, the (*D-R*) scores of the barriers ‘lack of environmental awareness (B3)', 'inadequate recycling techniques (B6)', 'inadequate methods for sorting, transporting, and recycling waste (B9)', 'lack of financial and economic support (B1)', 'lack of advertising and media coverage for waste management (B12)', 'lack of adequate areas for waste collection and sorting (B5)', 'lack of awareness about environmental protection (B11)' and 'lack of temporary shelters (B8)' have negative values (-) indicating as a group of barriers that receive influence from other barriers. Based on Figure 1, the order of the scores of the most influential barriers is as follows B8>B11>B5>B12>B1>B9>B6>B3.

The barrier 'lack of policies and regulations on waste (B2)' has the highest (*D-R*) value among other barriers at 1,522. The lack of policies and regulations on waste (B2) is the most influential barrier to the success of the "Zero Waste North Lombok" program. It can be seen that (B2) has an influence on the entire group of affected barriers. Policies and regulations on waste are the first foundation in implementing waste management activities. These regulations and policies serve as instructions as well as protection in the implementation of waste management activities. North Lombok Regency already has several regulations and policies governing waste management, but they are not detailed enough to regulate all aspects.

The barrier 'lack of collaboration between stakeholders (B4)' is the second most influential barrier with a (*D-R*) value of 0,7273. Barrier (B4) influences the entire group of affected barriers. Waste management is an activity that requires the collaboration of all lines of government, private sector, and community. Cooperation between stakeholders can realize waste management activities more comprehensively. The cooperation between stakeholders that has not gone well in North Lombok Regency is one of the barriers to the success of the "Zero Waste North Lombok" program.
The barrier 'uncertainty about circular economy targets and strategies (B7)' is the third most influential barrier with a (*D-R*) value of 0,7021. Barrier (B7) influences the entire group of affected barriers. The circular economy in waste management is still a very new thing in North Lombok Regency. The concept of circular economy in waste management, which sees waste as raw material that can be reprocessed and ultimately reduces the residue produced, can support the success of the zero waste program. Stakeholders of waste management in North Lombok District are familiar with the concept of circular economy and its relation to the success of the zero waste program, but its implementation is not yet underway.

The barrier 'inadequate sanctions and fines (B10)' occupies the fourth position as an influential barrier with a (*D-R*) value of 0,6589. Inadequate sanctions and fines (B10) only influence the barrier ‘lack of environmental awareness (B3)'. Sanctions and fines for waste management violations have been regulated in the North Lombok Regency Regional Regulation Number 3 of 2018 concerning Waste Management, but the amount of the fine has not been explained in detail. In addition, the local government's supervisory function on waste management violations is also still lacking. This has an impact on public awareness of the environment. The large amount of illegal waste generation in North Lombok Regency is partly influenced by these two barriers. The success of the "Zero Waste North Lombok" program can be hampered by inadequate sanctions and fines.

Based on Figure 1, in the group of barriers that are affected, the largest score is in the barrier 'lack of temporary shelters (B8)' with a value (*D-R*) of -0,7538. This shows that the lack of temporary shelters is the barrier that is most affected or influenced by other barriers. The barrier ‘lack of environmental awareness (B3)' has a (*D-R*) value of -0.2125. Compared to the other barriers in the same group, lack of environmental awareness has the lowest affected score. Meanwhile, the interaction value of barrier (B3) has the highest score, which is a (*D+R*) value of 10,9128. This shows that the barrier receives influence from all barriers in the affected group.

CONCLUSION

Barriers in the "Zero Waste North Lombok" program were identified to determine the influence between barriers that could affect the achievement of the program. Based on the results of the study, of the 12 barriers observed, 2 groups of barriers were obtained, namely influential barriers and barriers that received influence. The influential barriers preventing the success of the "Zero Waste North Lombok" program are the lack of policies and regulations on waste, lack of collaboration between stakeholders, uncertainty about circular economy targets and strategies, and inadequate sanctions and fines.The barrier that has the highest influence value is the lack of policies and regulations on waste with a score of 1,522.

The barriers that received influence consisted of 8 barriers: lack of environmental awareness, inadequate recycling techniques, inadequate methods for sorting, transporting, and recycling waste, lack of financial and economic support, lack of advertising and media coverage for waste management, lack of adequate areas for waste collection and sorting, lack of awareness about environmental protection and lack of temporary shelters. The barrier that received the most influence was the lack of temporary shelters with a score of -0,7538. While the barrier that has the highest interaction value, or is influenced by all barriers is the barrier of lack of awareness of the environment with a score ($D+R$) of 10.9128.

In the barrier of the lack of policies and regulations regarding waste, it is necessary to make further regulations governing the program activities such as organizational aspects, targets and objectives, implementation aspects, financing aspects, operational technical aspects, infrastructure, and socialization to the community. On the barrier of lack of cooperation between stakeholders, the government needs to make regulations that regulate cooperation between stakeholders in supporting the success of the zero waste program. For example, cooperation between the Environmental Agency and the Civil Service Police Unit in the implementation of supervision and order in waste management in the field. Furthermore, on the uncertainty of circular economy targets and strategies, the local government can collaborate in terms of regulations and stakeholder participation in setting targets and strategies. Lastly, in terms of inadequate sanctions and fines, the local government can review existing regulations and collaborate with other agencies and non-governmental organizations to provide appropriate sanctions and fines for violators. These four influential barriers need to be considered and addressed so that the goals of the "Zero Waste North Lombok" program can be achieved.

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