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Factor analysis of waste management in Serang Regency, Indonesia

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ABSTRACT

Serang Regency, with an area of 1,467.35 km^2 in 2020 had a population of 1,622,630 people. By referring to SNI 19-3983-1995, the waste capacity produced on average is 2.25 liters per person per day, so the potential waste in Serang Regency in 2020 is around 1,212,903.7 m^3/year, while the amount of waste that can be transported to the final waste processing site (or TPA) is 98,339 m^3. Based on this data, waste services in Serang Regency have only reached 7.37%, far from the target of the Serang District Regional Policy and Strategy (Jakstrada) of 74% as stated in the Serang Regency Regulation No. 6 of 2021. On the other hand, there are still many roadside piles of waste in Serang Regency, which indicates that there is still a lack of community participation in waste management. Waste management involves several factors, including institutions or organizations, laws, regulations, management financing, technical and operational waste, as well as community attention and participation. Looking at the phenomenon, analysis of waste management factors in Serang Regency was carried out so that the dominant factors in improving waste management performance could be identified for further planning of strategies to optimize waste management, both through waste handling and waste reduction. Based on the analysis carried out using SPSS, it can be stated that factors of operational technical, organizational, legal, and regulatory, as well as factors of financing and community participation are suitable to be used as a policy combination to improve waste management performance in Serang Regency.

ABSTRAK

Kabupaten Serang dengan luas wilayah 1.467,35 km^2 pada tahun 2020 mempunyai jumlah penduduk sebanyak 1.622.630 jiwa. Dengan mengacu pada SNI 19-3983-1995, kapasitas sampah yang dihasilkan rata-rata sebesar 2,25 liter per orang per hari, sehingga potensi sampah di Kabupaten Serang pada tahun 2020 adalah sekitar 1.212.903,7 m^3/tahun, sedangkan jumlah sampah yang dapat diangkut ke luas tempat pengolahan akhir sampah (atau TPA) adalah 98.339 m^3. Berdasarkan data tersebut, pelayanan persampahan di Kabupaten Serang baru mencapai 7,37%, jauh dari target Kebijakan dan Strategi Daerah (Jakstrada) Kabupaten Serang sebesar 74% sebagaimana tertuang dalam Peraturan Daerah Kabupaten Serang Nomor 6 Tahun 2021. Sementara itu, di Kabupaten Serang masih banyak terdapat tumpukan sampah di pinggir jalan, yang mana menunjukkan bahwa partisipasi masyarakat masih kurang dalam pengelolaan sampah. Pengelolaan sampah melibatkan beberapa faktor antara lain lembaga atau organisasi, peraturan perundang-undangan, pembiayaan pengelolaan, teknis dan operasional sampah, serta perhatian dan partisipasi masyarakat. Melihat fenomena yang ada, maka dilakukan analisis terhadap faktor-faktor pengelolaan sampah di Kabupaten Serang sehingga dapat diketahui faktor-faktor yang dominan dalam meningkatkan kinerja pengelolaan sampah untuk selanjutnya direncanakan strategi optimalisasi pengelolaan sampah, baik melalui penanganan sampah maupun upaya pengurangan sampah. Berdasarkan analisis yang dilakukan dengan menggunakan SPSS, dapat diketahui bahwa faktor teknis operasional, organisasi, hukum, dan peraturan, serta faktor pembiayaan dan partisipasi masyarakat layak dijadikan kombinasi kebijakan untuk meningkatkan kinerja pengelolaan sampah di Kabupaten Serang.

Keywords: *Community participation, factor analysis, financing, laws and regulations, waste management*

INTRODUCTION

The high rate of population growth in Indonesia and urbanization in cities is highly positively correlated with the amount of waste produced (Fauziah et al., 2023; Rachmawati et al., 2024), so this requires local governments to improve services to the community, one of which is preventing or handling the cleanliness of the residential environment. According to Rizal (2011), the increase in waste production is not commensurate with the waste handling process. This problem is of concern to local governments in planning strategies for managing waste problems, because waste problems are closely related to sanitation and clean water supply (Anshari et al., 2023; Rachmawati et al., 2024; Yuswandi et al, 2024), as well as significantly contribute to green gas house emission that has been causing climate change (Priatna & Monk, 2021; Anshari et al., 2023; Faqi & Wibawa, 2023; Priatna & Monk, 2023; Priatna & Khan, 2024; Wardhani et al., 2024).

Rizal (2021) explained that Indonesia generates approximately 64 million tons of waste annually. Around 60% of waste is managed at the Final Processing Site (TPA), around 10% is recycled, and the remaining 30% is discarded into the environment, including water bodies like rivers and seas. The policies implemented by the Indonesian government regarding the waste problem are contained in Presidential Regulation of the Republic of

Indonesia number 97, issued in 2017, which concerns National Policies and Strategies for Management of Household Waste and Similar Household Waste. Efforts to manage waste through 3R (Reduce, Reuse, and Recycle) are the main steps to reduce the emergence of waste, with a target of reducing community waste by around 30% by 2025. Monk & Priatna (2022) and Priatna & Khan (2024) stated that waste management is linked to all 17 Sustainable Development Goals (SDGs). In ongoing waste management efforts, regional governments in Indonesia - encompassing provinces, regencies, and cities - are responsible for managing household and similar waste at the Final Processing Facilities, aiming to achieve 70% waste management efficiency by 2025.

Serang Regency, with an area of 1,467.35 km^2, in 2020 had a population of 1,622,630 people (BPS Kabupaten Serang, 2021). By referring to SNI 19-3983-1995 (1995), the volume of waste capacity produced on average is 2.25 liters per person per day, so the potential waste in Serang Regency in 2020 is around 1,212,903.7 m^3/year, while the amount of waste that can be transported to the Final Waste Processing Site is 98,339 m^3 (DLH Kabupaten Serang, 2021). According to the data, waste management services in Serang Regency have only achieved coverage of 7.37%, which falls significantly short of the target set by the Serang District Regional Policy and Strategy (Jakstrada) at 74% (Serang Regency Regulation No. 6 of 2021). Conversely, in Serang Regency, the presence of numerous roadside waste piles suggests a potential lack of community involvement in waste management efforts.

Sudirman (2018) and Sudirman & Phradiansah (2019) identified several factors contributing to waste-related issues, including inadequate facilities, low public awareness of the importance of proper waste management, and insufficient attention from local authorities to address the problem. According to DLH Kabupaten Serang (2021), the main issue in Serang Regency is the absence of a designated Final Waste Disposal Site (TPA) to serve as the endpoint for waste management. Additionally, the region faces a limited number of waste transport vehicles and insufficient public awareness and participation, resulting in widespread illegal dumping, particularly along the roads within the area.

Waste management is considered effective when all its components operate harmoniously and support one another. Effective waste management involves several key elements, including institutions or organizations, legal and regulatory frameworks, financial support, technical and operational processes, as well as community awareness and participation. (Triani, 2017; Farid & Purba, 2020).

Considering the current waste management challenges in Serang Regency, this study analyzes the factors influencing waste management performance. The objective is to identify the dominant factors that can enhance waste management outcomes, which will inform the development of strategies to optimize waste management, including waste handling and reduction efforts.

METHODS

Research Design

This study on waste management factor analysis focuses on identifying the typology of waste management in Serang Regency and analyzing the factors influencing waste management within the region. The key factors include technical operations, organizational structure, financing, legal and regulatory frameworks, and community participation. This analysis will identify the dominant factors influencing waste management, enabling the development of more effective strategies to enhance waste management practices in Serang Regency.

Typology of waste management in Serang Regency

The study was conducted in Serang Regency, a district in Banten Province with a total area of 1,467.35 km^2, comprising 29 sub-districts and 326 villages. To identify the typology of waste management in the Serang Regency, the researchers employed interviews with the Serang Regency Environmental Agency and conducted field observations. This research falls under the category of descriptive studies, focusing on presenting data specific to waste management typologies within the region. The data collected pertains to various aspects of waste management (Damanhuri & Padmi, 2011), including:

a. Technical operational waste management such as data on waste generation, data on the number of waste management fleets, data on waste management facilities;
b. Organizations include institutions involved in handling waste management in Serang Regency;
c. Financing related to the financing required for waste management, including operations, maintenance, etc.;
d. Laws and regulations include any regulations in Serang Regency relating to waste management;
e. Community participation is how the people of Serang Regency play a role in waste management through 3R efforts (reduce, reuse, recycle) and paying waste levies.

Factor Analysis of waste management

This study employs quantitative methods (Xiao et al., 2017), specifically factor analysis, to examine waste management factors. Respondents were presented with 40 statements related to various aspects of waste management, and the responses were analyzed using factor analysis through the SPSS version 16 software. The analyzed factors (Figure 1) include waste operational techniques, financial aspects, organizational and institutional frameworks, legal and regulatory measures, and community participation.

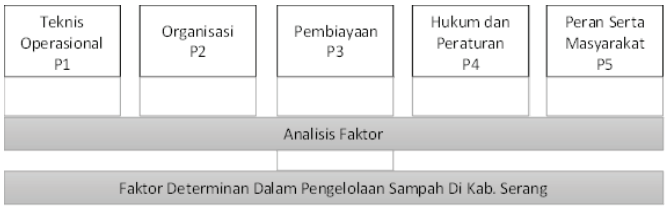

Figure 1. Factorial analysis.

The respondents for this factor analysis study will be individuals who have received waste management services from the government of Serang Regency. While Serang Regency comprises 29 sub-districts, not all communities are covered by these services. Therefore, the study's respondents are limited to the 6,041 households receiving waste management services (Table 1).

The factor analysis in this study employed a simple random sampling method, with the sample size determined using the Slovin formula at a 5% margin of error.

$$n = \frac{N}{1 + N\,e^2}$$

Where:
n = sample size
N = size of population
e = The acceptable error rate for the retrieval sample is 5%

Table 1. Determination of sample size.

Respondent	Unit (N)	e	$N/(1+Ne^2)$	Sample
Serang district community	6041	0,05	375,1591	375

The questionnaire assessed community responses in Serang Regency regarding current waste management practices, focusing on waste-related factors. The questionnaire was developed based on variables defined by the researchers and comprised closed-ended questions with response options provided on a rating scale. The collected data were analyzed using factor analysis through the SPSS 16 software. This analysis identified key factors influencing waste management, providing a foundation for developing strategic approaches to enhance waste management performance in Serang Regency.

The calibration of research instruments for factor analysis involves conducting validity and reliability tests to assess the alignment between the operational definitions and the measured research concepts. Additionally, these tests are essential for evaluating the stability and consistency of the research. Validity and reliability testing will focus specifically on non-test instruments in factor analysis.

To test the validity of non-test instruments, item analysis in this study was carried out by calculating the correlation coefficient for each item through a simple correlation test. The score for each item is X, and the total score minus X is Y. The formula used is Pearson Product Moment (PPM), namely:

$$r_{xy} = \frac{n\,\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\{n\Sigma X^2 - (\Sigma X)^2\}\{n\Sigma Y^2 - (\Sigma Y)^2\}}}$$

To determine whether an item can be used for data collection, the correlation coefficient (r) is calculated and compared with the critical value of the Pearson Product-Moment correlation (r-table). If the calculated r-value (r-count) is greater than or equal to the critical r-value (r-table), the item is deemed suitable for data collection. Conversely, if the r-count is less than the r-table, the item is considered unsuitable for data collection.

For the reliability testing of non-test instruments, the reliability coefficient was calculated only for the valid items—those that were deemed suitable for data collection based on the results of the validity test. The formula used is Cronbach's Alpha as follows:

$$\alpha = \frac{n}{n - 1}\left(1 - \frac{\Sigma Si^2}{St^2}\right)$$

Where:
α = Reliability coefficient
n = Number of item (valid only)
Si^2 = Number of variance of scored item
St^2 = Total of variance

Factorial analysis of waste management using SPSS through the following stages:

1. Open a new SPSS worksheet, then in the variable view, fill in the Name, label, and measure. In the waste management factor analysis research, names are filled with the codes TO1, O2, P3, H4, and PE5, which are codes for Technical Operations as variable 1, Organization variable 2, Financing variable 3, Laws and Regulations variable 4, Community Participation variable 5. In the label column, fill in the aspects of waste management outlined in the questionnaire (technical operations, organization, financing, laws and regulations, and community

participation). In the measure column, use the scale method;

2. Next, return to the datasheet view and enter the numbers/data from the questionnaire results from 5 aspects into columns 1 to 5. The table is filled in according to the number of respondents, in this case 375 samples;
3. From the SPSS menu, analyze, dimension reduction, then factor;
4. Then the factor analysis dialog box appears and moves the data from the left column to variables, then click descriptives;
5. In the dialog box, "Factor analysis descriptives are marked with the initial solution, KMO and Bartlett's test, and anti-image";
6. Next, click extraction and check the unrotated factor solution and scree plot;
7. Next, click rotation, activate Varimax, check the rotation solution, and continue;
8. Then click scores, and a dialog box will appear and activate save as variable. Then, click continue and OK to proceed with the factor analysis process.

Interpretation of the process results in factor analysis using SPSS is as follows:

1. In the SPSS application, analyze KMO and Bartlett's Test. The output of the KMO and Bartlett's Test results is used to determine whether a variable is appropriate and whether the factorial analysis process can be continued. The way to find out is by checking the value of the KMO MSA (Kaiser-Meyer_Olkin Measure of Sampling Adequacy). If the KMO MSA value obtained is greater than 0.50, this factor analysis can be processed further.
2. Anti-image Matrices are used to determine what variables are appropriate/worth using in a factor analysis. The numbers with the letter code (a) in the table are the Measure of Sampling Adequacy (MSA) results.
3. Total Variance Explained Table. This table presents the values for each variable analyzed in the study. Five variables were identified in the factor analysis of waste management, corresponding to five components for analysis. SPSS provides two types of analyses to explain the variance: Initial Eigenvalues and Extraction Sums of Squared Loadings. The Initial Eigenvalues analysis identifies the factors that are formed.
4. The Scree Plot provides a visual representation of the number of factors generated. Factors with Eigenvalues greater than 1 are identified and categorized as the factors extracted through the factor analysis process, labeled sequentially as Factor 1, Factor 2, and so on.
5. Then, to determine which factor the variable being analyzed falls into, this can be done by looking at the largest correlation value between the variables and the factors (components) formed.

RESULTS

Typology of Waste Management in Serang Regency

According to the 2020 Regional Policy and Strategy Study (Jakstrada) Waste Management Document, Serang Regency is one of the regencies in Banten Province, located at the northwestern tip of Java Island (DLH Kabupaten Serang, 2021). It covers an area of 1,467.35 km² and comprises 29 sub-districts and 326 villages. Geographically, Serang Regency lies between coordinates 105°7′ – 105°22′ East Longitude and 5°50′ – 6°21′ South Latitude. Serang Regency Boundaries are as follows:

North	: borders the Java Sea/Banten Bay
South	: borders Lebak Regency and Pandeglang Regency
West	: borders Cilegon City and Sunda Strait
East	: borders Tangerang Regency

In Serang Regency, waste management is governed by Serang Regent Regulation No. 21 of 2021, which amends Regulation No. 93 of 2017 regarding delegating certain regent authorities to subdistrict heads. Under this regulation, responsibility for waste management is not solely held by the Environmental Agency; it is also delegated to 15 subdistricts. The institutions responsible for waste management are as follows: a. Environmental Agency and UPT Waste management; b. Anyar District; c. Cinangka District; d. Kramatwatu District; e. Ciruas District; f. Kragilan District; g. Kibin District; h. Cikande District; i. Baros District; j. Pabuaran District; k. Ciomas District; l. Padarincang District; m. Tanara District; n. Tirtayasa District; o. Pontang District; and p. Waringin Kurung District.

From a technical and operational standpoint, the waste storage system in residential areas of Serang Regency is poorly managed. In some households, waste is stored in trash bins; in others, it is piled on the ground and subsequently burned. Each household is responsible for providing its waste storage system.

The waste transportation from households receiving waste management services is carried out by institutions or individuals designated by the community. Waste is first transported to Temporary Storage Sites (TPS) and subsequently transferred by the waste management fleet to the Final Processing Site (TPA). As of 2018, the Serang District Government had constructed 172 TPS units. Since 2019, the responsibility for TPS development has shifted to village governments, which

manage construction based on local needs.

Waste management facilities such as TPS3R and TPST are operational in several villages and sub-districts. Serang Regency hosts four TPS3R units and one TPST unit (Table 2). Waste management at TPS3R facilities includes sorting economically valuable waste and processing organic waste through composting or maggot cultivation. The TPST unit in Serang Regency employs an incineration processing method and converts household waste into processed fuel (BBJP) using Refuse-Derived Fuel (RDF) technology. For final waste disposal, Serang Regency collaborates with the Bagendung Final Waste Processing Site (TPSA) in Cilegon City, as it lacks a landfill facility following the territorial division between Serang Regency and Serang City.

After the Serang Regency Regent's Regulation No. 93 of 2017 issuance, Serang Regency Regent's Regulation No. 21 of 2021 was enacted to amend the former regulation. The amendment pertains to delegating authority from the Regent to District Heads for waste management within Serang Regency. As a result, 15 districts have been granted delegated authority and allocated budgets, personnel, and infrastructure, such as vehicles (Table 3), to facilitate waste management within their respective jurisdictional areas.

Table 2. Waste management facilities.

No	Location	Unit	Info
1	Anyer District: Grogol Indal Village	1	TPS3R
2	Ciruas District: Pelawad Village	1	TPS3R
3	Bojonegara District: Margagiri Village	1	TPS3R
4	Kibin District: Ciagel Village	1	TPS3R
5	Kibin District: Kibin Village	1	TPS3R

Table 3. Waste vehicle in Serang Regency.

No	Institution	Number of Vehicles		
		Dump truck	Arm roll	Cator
1	Environmental Agency	12	12	7
2	Anyer District	2	1	2
3	Cinangka District	2	1	3
4	Kramatwatu District	2	3	6
5	Ciruas District	2	2	4
6	Kibin District	4	1	4
7	Kragilan District	3	1	5
8	Cikande District	2	5	0
9	Pontang District	1	1	2
10	Baros District	1	1	3
11	Waringin Kurung District	1	1	2
12	Padarincang District	1	1	2
13	Ciomas District	1	1	2
14	Pabuaran District	1	1	2
15	Tanara District	1	1	2
16	Tirtayasa District	1	1	2
	Total	**37**	**34**	**48**

The waste management budget allocated to the Environmental Agency of Serang Regency is utilized for various expenditures, including labor costs, vehicle maintenance, fuel, and waste processing fees (tipping fees) at the TPSA Bagendung facility in Cilegon City. Additionally, the budget supports waste management operations at the Kibin TPST, public outreach and education initiatives, the development of waste banks, and the monitoring of waste management activities.

Serang Regency itself also issues regulations and policies related to waste management. These regulations include, among others:

a. Serang Regency waste management master plan 2014.
b. Serang Regency Regional Regulation number 3 of 2019 concerning waste management.
c. Serang Regent Regulation number 6 of 2021 concerning regional policies and strategies in managing household waste and similar types of household waste.
d. Serang Regent's Regulation number 21 of 2021 concerning Amendments to Serang Regent's Regulation number 93 of 2017 concerning Delegation of Part of the Regent's Authority to the District Head regarding waste management in Serang Regency.
e. Regent's Circular Letter Number 3 of 2024, dated January 29, 2024, concerning Village Waste Management.

Community participation in Serang Regency encompasses two main forms: contributing to cleaning fees and engaging directly in waste management through local waste banks. Despite these efforts, the level of community involvement requires significant improvement. Of the 326 villages in Serang Regency, only approximately 43 waste bank units have been established. Table 4 is a comprehensive list of waste banks operating in Serang Regency.

Table 4. Waste banks in Serang Regency.

No	Waste Banks	Districts
1	Ratu Lestari	Cikuesal
2	Mawar Putih	Gunung Sari
3	Mangga	Gunung Sari
4	Berkah bhayangkara	Kramatwatu
5	Cahaya Wali	Carenang

6	Mawar Desa	Tirtayasa
7	Cikande Permai RW 9	Cikande
8	BS Pamarayan	Pamarayan
9	Bersih Berseri Sejahtera	Pabuaran
10	Sambilawang	Waringin Kurung
11	Sadanta	Cikeusal
12	Gupi Mandiri	Anyar
13	SDIT Bina Insani Clean	Waringin Kurung
14	Cikande Permai RW 2	Cikande
15	Nuansa Tani	Kibin
16	Anugrah Ciagel TPS3R Kibin	Kibin
17	Gardenia	Ciruas
18	Cinta Alam	Waringin Kurung
19	SMA 1 Petir	Petir
20	SMA 1 Gunung Sari	Gunung Sari
21	Sukamanah	Baros
22	Sukaindah	Baros
23	SukaCai	Baros
24	Taman Krakatau	Waringin Kurung
25	Mawar Desa	Pontang
26	Anggrek	Pamarayan
27	Power In Ranger	Pulo Ampel
28	Resik Jelinger	Pulo Ampel
29	Greenland	Kramatwatu
30	Flamboyan	Ciruas
31	Gemas	Ciruas
32	Panyaripan	Baros
33	Bina Insani II Clean	Waringin Kurung
34	Cerita Harjatani	Kramatwatu
35	Lestari Liga	Kramatwatu
36	Sabar Subur	Kramatwatu
37	Semut Merah	Kramatwatu
38	KPS TPSSP	Anyar
39	Paku	Anyar
40	Pangandaran	Anyar
41	Gudang Arang	Anyar
42	ASA	Cikande
43	Kareo Mandiri	Jawilan

Factor Analysis of Waste Management

The factor analysis conducted in this study utilized scores derived from responses to 35 statements distributed among 375 participants. These 35 statements were categorized into five distinct variables: (1) technical operations, (2) organization, (3) financing, (4) laws and regulations, and (5) community participation. The factor analysis was performed on the scores obtained from the 375 respondents for each of the 35 statements. Before the analysis, the data underwent validity and reliability testing, excluding five statements from the initial 40.

The initial stage of the analysis involves evaluating the output of the KMO table and Bartlett's Test to assess the suitability of variables for factor analysis using SPSS. This process relies on the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO MSA) values. If the KMO MSA value exceeds 0.50, it indicates that factor analysis can proceed. SPSS version 16 is employed for the factor analysis related to waste management. The following Table 5 shows the results of the KMO test and Bartlett's Test.

Table 5. KMO table and Bartlett's Test to test the suitability of variables.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.668
Bartlett's Test of Sphericity	Approx. of Chi-Square	585.002
	df	10
	Sig.	.000

Based on the results presented, the KMO Measure of Sampling Adequacy (MSA) value is 0.668, which exceeds the minimum threshold of 0.50 (0.668 > 0.50). Additionally, Bartlett's Test of Sphericity yielded a significance value (p-value) of 0.000, which is below the accepted threshold of 0.05. These findings confirm that the necessary prerequisites for conducting factor analysis in the study of waste management in Serang Regency have been satisfied, allowing the analysis to proceed.

The second stage involves examining the output of the Anti-image Matrices table (Table 6). This step aims to identify feasible and appropriate variables for inclusion in the subsequent factor analysis process.

Table 6. "Anti-Image Matrices," determines feasible research variables.

Anti-image Matrices						
		Operational Technical	Organization	Financing	Law and Regulations	Community Participation
Anti-image Covariance	Operational Technical	.547	-.275	.014	-.113	.019
	Organization	-.275	.489	-.030	-.186	.002
	Financing	.014	-.030	.618	-.039	-.349
	Law and Regulations	-.113	-.186	-.039	.608	-.112
	Community Participation	.019	.002	-.349	-.112	.599
Anti-image Correlation	Operational Technical	.683a	-.531	.024	-.196	.033
	Organization	-.531	.670a	-.054	-.342	.003
	Financing	.024	-.054	.596a	-.063	-.574
	Law and Regulations	-.196	-.342	-.063	.790a	-.186
	Community Participation	.033	.003	-.574	-.186	.590a

a. Measures of Sampling Adequacy (MSA)

The letter code (a) in the table denotes the Measures of Sampling Adequacy (MSA) value. The MSA values obtained from the table are as follows:

1. Operational Technical 0.683
2. Organization 0.670
3. Financing 0.596
4. Laws and Regulations 0.790
5. Community Participation 0.590

A second crucial requirement for factor analysis is a Measure of Sampling Adequacy (MSA) value exceeding 0.50 for all variables. The results indicate that all variables in this study meet this criterion, thus enabling the continuation of the analysis. The third stage involves

examining the Communalities Table (Table 7) to assess the extent to which the variables can be explained by the underlying factors.

Table 7. Communalities grouping factor suitability based on extraction values.

Communalities		
	Initial	**Extraction**
Operational Technical	1.000	.759
Organization	1.000	.787
Financing	1.000	.791
Extraction Method: Principal Component Analysis.		

Communalities		
	Initial	**Extraction**
Law and Regulations	1.000	.651
Community Participation	1.000	.802
Extraction Method: Principal Component Analysis.		

As indicated in the communalities table, all variables exhibited an extraction value exceeding 0.50. This threshold value of 0.50 is considered a benchmark for a variable's ability to explain related factors. Given these results, it can be concluded that the variables employed in this research on waste management factors in the Serang Regency are suitable for explaining the underlying factors.

The fourth stage involved analyzing the explained variance for each variable, as detailed in the Total Variance Explained table below.

Table 8. Total variance explained.

Total Variance Explained						
Component	Initial Eingenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.433	48.565	48.565	2.433	48.565	48.565
2	1.358	27.166	74.822	1.358	27.166	74.822
3	.496	9.921	85.743			
4	.383	7.661	93.405			
5	.330	6.595	100.000			

Extraction Method: Principal Component Analysis

Table 8 presents the variable values subjected to factor analysis. This waste management factor analysis involves five variables, corresponding to five components. Two types of analysis were conducted: Initial Eigenvalues and Extraction Sums of Squared Loadings.

Initial Eigenvalues analysis identifies the factors formed in the process. When summed, all factors equal the total number of variables (2.433 + 1.358 + 0.496 + 0.383 + 0.330 = 5). A factor is considered significant if its Initial Eigenvalue exceeds 1. Based on the table, only components 1 (2.433) and 2 (1.358) meet this criterion. Therefore, only these two components can be used to explain the observed variation form.

Based on the Extraction Sums of Squared Loadings values, Component 1 accounts for 48.656% of the total variance, while Component 2 explains 27.166%, resulting in a combined total variance of 75.822%. Consequently, only two factors were identified in this study.

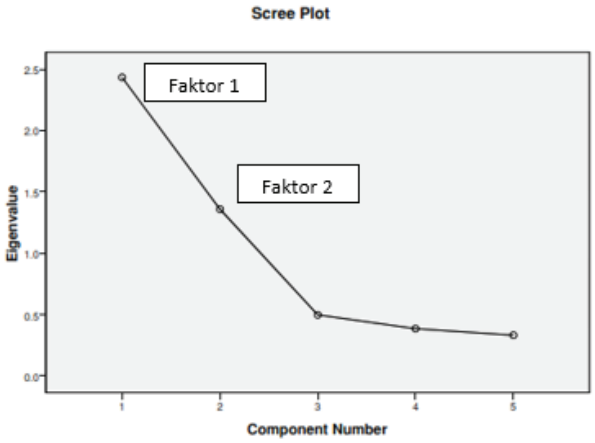

Figure 2. Scree plot shows the number of factors formed.

The scree plot indicates that only two components have Eigenvalues greater than 1 (>1) (Figure 2). Consequently, this research identifies two principal factors in waste management within Serang Regency. The subsequent phase involves analyzing the correlation or relationships between the variables—operational techniques, organizational structure, financing, legal frameworks, and community participation—and the identified factors.

The relationship between these variables can be shown in the component matrix table and rotated component matrix table.

Table 9. Correlation of each variable with the two components formed through the component matrix.

Component Matrix[a]		
	Component	
	1	**2**
Operational Technical	.725	-.483
Organization	.792	-.400
Financing	.560	.691
Law and Regulations	.794	-.146
Community Participation	.579	.683
Extraction Method: Principal Component Analysis		
a. 2 components extracted.		

Table 9 presents the strength of the relationship between each variable and the two components constituting the factor. Subsequently, we will conduct a detailed analysis of the grouping of variables into

components or factors as defined by the Rotated Component Matrix.

Table 10. The magnitude of the correlation between variables with the components forming Factor 1 and Factor 2.

Rotated Component Matrix[a]		
	Component	
	1	2
Operational Technical	.871	-.014
Organization	.883	.092
Financing	.098	.884
Law and Regulations	.747	.306
Community Participation	.118	.888

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 3 iterations

To ensure that a variable falls into which category or group of factors, it can be done by analyzing the value of the largest correlation between the variable and the factor (component) formed. Table 10 can explain as follows:

1. Operational Technical Variables. The numerical value of the variable correlation with Factor (Component) 1 = 0.871 and Factor (Component) 2 = 0.014. The correlation value of factor 1 is > that of factor 2, so the Operational Technical variable is included in the Factor 1 group;
2. Organizational Variables. The numerical value of the variable correlation with Factor (Component) 1 = 0.883 and Factor (Component) 2 = 0.092. The correlation number value for factor 1 > than factor 2 means that the Organization variable belongs to the Factor 1 group;
3. Financing Variables. The value of the variable correlation number for Factor (Component) 1 = 0.098 and Factor (Component) 2 = 0.884. The value of the correlation number for factor 2 > that of factor 1 can be categorized as a Financing variable belonging to the Factor 2 group;
4. Legal and Regulatory Variables. The value of the variable correlation number with Factor (Component) 1 = 0.747 and Factor (Component) 2 = 0.306. The correlation value of factor 1 is > that of factor 2, so the Law and Regulation variable is included in the Factor 1 group;
5. Community Participation Variables. The value of the variable correlation number for Factor (Component) 1 = 0.118 and Factor (Component) 2 = 0.888. The correlation value of factor 2 is > that of factor 1, indicating that the Community Participation variable is included in the Factor 2 group;

Table 11. Factors and variables.

Factors	Variables
1	Operational variables
	Organizational
	Law and regulations
2	Financing
	Community Participation

Based on the factor analysis calculation pattern using SPSS above (Table 11), determining waste management in Serang Regency can be considered as the main factors: operational technical, organizational, legal, and regulatory variables. Meanwhile, what is included in factor 2 is financing and community participation.

The final step is to calculate the transformation matrix to show that the two factors can explain existing variables such as technical operational waste, financing/funding, laws and regulations, organization/institution, and community participation. The following is a matrix transformation table resulting from SPSS analysis (Table 12).

Table 12. Transformation matrix.

Component Transformation Matrix		
Com	1	2
1	.841	.541
2	-.541	.841

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

The component transformation matrix shows that Component 1's correlation value is 0.841 > 0.5, and Component 2's correlation is 0.541 > 0.5. This means that the two factors produced can be concluded as suitable for summarizing the five waste management variables analyzed

METHODS

Typology of Waste Management in Serang Regency

Based on the findings from interviews and observations, Serang Regency employs a distinct waste management policy governed by Serang Regent Regulation No. 21 of 2021, which amends Serang Regent Regulation No. 93 of 2017. This regulation delegates a portion of the Regent's authority to district heads concerning regional waste management. Additionally, the presence of Waste Storage Sites (TPS) at multiple locations highlights the adoption of a communal waste management system in Serang Regency (Hendra, 2016). The absence of Transfer

Depots or Intermediate Transit Stations indicates that waste under this communal system is transported directly to the Final Processing Facility.

Waste management initiatives in Serang Regency are categorized into two primary strategies: waste reduction and waste treatment. Waste reduction efforts are implemented through TPS3R and Waste Bank programs. Meanwhile, waste treatment is conducted at TPST facilities utilizing methods like incineration and Refuse-Derived Fuel (RDF) processing and waste management at the final disposal site (TPA) (Figure 3). The results of the study by Fauziah et al. (2023) shows that ash and water content can reduce the calorific value of RDF mixed with paper and garden waste.

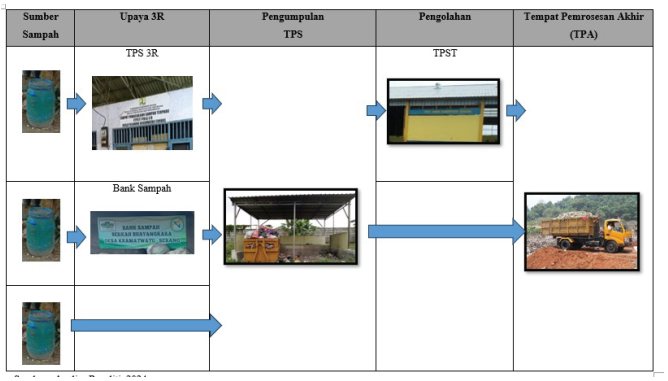

Figure 3. Typology of waste management in Serang Regency.

Factor Analysis of Waste Management in Serang Regency

Based on the results of factorial analysis conducted using SPSS, two key factors influencing waste management in Serang Regency were identified: Factor 1 and Factor 2. Factor 1 encompasses variables related to operational techniques, organizational aspects, and legal and regulatory frameworks. Factor 2 comprises variables related to financing and community participation. Among these, the operational technical variable demonstrated a high correlation of 0.871, indicating a strong association with effective waste management performance in Serang Regency. According to SNI 19-2454-2002 (2002) operational techniques for waste management include:

1) Service Area;
2) Service Level;
3) Technical Operations from container system, storage/collection pattern, transfer/transfer of waste, waste transportation system, waste sorting and processing, and final waste processing.

Service areas are designated as priority zones for waste management. According to Farid (2016), the prioritization of service areas and levels should consider key regions such as main or protocol areas, city centers, commercial districts, and areas marked for development under the RTRW framework. Additionally, the population density of existing settlements is crucial in determining service priorities.

According to planning, waste storage can be done individually or collectively/communally. According to Nafurbenan (2022), containerization can be carried out according to the type or characteristics of waste, such as:

1) Organic waste containers for storing waste such as vegetable scraps, food scraps, fruit scraps, and leaves can use dark containers;
2) Inorganic waste containers accommodate waste such as paper, cardboard, metal, bottles, glass, and other plastics. This trash container can use bright colors.

Meanwhile, according to Nafurbenan (2022), waste collection will consist of 2 types: waste collection to be taken directly to the Final Processing Site (TPA) and waste collection for processing and recycling on a household scale. The types of waste collection/storage consist of several patterns as follows:

1) Indirect Individual Pattern is usually carried out from house to house.
2) Direct individual pattern using trucks usually used for road waste and public facilities.
3) The direct communal pattern is usually applied to waste from markets and commercial areas.
4) Indirect communal patterns are often used for residential or dense housing.

The waste processing and recycling process at TPS, better known as TPS3R, can be done by composting small-scale organic waste and collecting inorganic waste for recycling. 3R waste management can also be carried out by forming a Waste Bank group.

The transfer or transfer of waste can be carried out at collection locations or integrated TPS if the distance between the TPS and TPA is very far, so effective and efficient transportation time is required. Waste processing, according to SNI 19-2454-2002 (2002), is carried out using several processing techniques:

1) Making compost
2) Environmentally friendly incineration/burning of waste
3) Recycle waste
4) Reducing the volume of waste through chopping and pressing/compaction processes
5) Biogasification (Utilization of energy from processing waste)

Utilizing waste as an alternative mixed fuel through Refuse Derived Fuel (RDF) is one way to overcome the waste problem. One type of waste process that can produce RDF products is biodrying. According to Cherul, 2020, biodrying is one part of Mechanical-Biological Treatment (MBT) technology that aims to reduce humidity or water content in waste through the use of heat produced from the activity of

microorganisms in degrading organic material so that it is hoped that it can increase the calorific value. According to Chaerul & Wardhani (2020), biodrying takes 7 to 15 days.

The final waste processing is the main facility needed in technical and operational waste management, as the estuary of waste processing. According to Ginting et al. (2018), there are two types of environmentally friendly final processing sites: Sanitary Landfill and Controlled Landfill. Sanitary Landfill is a mechanism for final waste processing through piling and compacting, then covering it with soil as the top layer of cover. This process is continuous and carried out according to the established plan. Covering the waste with covering soil is carried out daily towards the end of operations.

Meanwhile, a controlled Landfill is an open dumping system or increased waste accumulation. Controlled Landfill is a transitional final processing system between open dumping and sanitary landfill processes. Waste is closed in controlled landfills using a layer of soil after the Landfill is full of solidified waste or after a certain period. In other words, the covering of land in this process is not carried out daily but over a longer period.

The current emergency status for waste in the Serang Regency is because the Serang Regency Government does not have a final processing site (TPA). Since the formation of the City of Serang, the Cilowong TPA facility has changed ownership to become the property of the Serang City Government. In 2022, the people of Serang City will reject waste processing at the Cilowong TPA. Furthermore, the Serang Regency Government is collaborating with the Bagendung TPA, Cilegon City, until January 2024, the people of Cilegon City also refuse. Serang Regency is in a waste emergency status and is having difficulty disposing of waste at the Landfill.

The current condition of Serang Regency is in line with the results of Waste Management Factor Analysis research, which shows that the main determinant factor in waste management is the operational technical factor. In this case, the absence of a final processing site in Serang Regency causes waste performance to be hampered and cannot be appropriately implemented.

The following variable influencing Factor 1 is the Organizational Variable with a component value of 0.883. Organizational or institutional variables in waste performance also play a vital role because these organizations or institutions regulate and implement instruments in the operational technicalities of waste management. According to the Ditjen Ciptakarya (2023), the criteria for institutional or organizational aspects are as follows:

1) Institutions must be separate between regulators and implementers in waste management; for example, the Environmental Agency forms a Technical Implementation Unit, or BLUD acts as a waste management operator, while DLH acts as the regulator.
2) Many personnel and good-quality human resources must support the waste organizational structure. This is important considering that cleaning Staff must also follow technological developments in waste management.
3) The organizational structure must be clear, and there are divisions of duties and authority, including the authority to collect levies.

In Serang Regency, the organization authorized to carry out waste management is the District Environmental Agency, which has 1 Waste Management UPTD as a waste management operator. The Serang Regent also has a policy following Serang Regent Regulation number 21 of 2021 that the Serang Regent delegates some of the authority to handle waste to the sub-district head. This is done because Serang Regency has a reasonably large area with 29 sub-districts, so if everything is centralized to the Waste Management UPTD, it will take longer to handle the waste. Apart from that, the sub-district can also determine which priority points require more waste handling. Delegation is currently being carried out to 15 sub-districts.

Based on the research of Puspasari & Mussadun (2017) regarding the role of institutions in waste management in Trenggalek Regency, institutions play an essential role in increasing public awareness, developing waste technology, utilizing waste, ensuring the availability of waste facilities and facilities, and facilitating waste management in Trenggalek Regency. The role of government is 35.54%, the highest compared to the role of society, NGOs, and the private sector.

Variable three strongly influences Factor 1, formed by the Law and Regulation variable. As a legal umbrella in Indonesia, the government has issued Law no. 18 of 2008 concerning Waste Management. Ditjen Ciptakarya (2023) stated that the laws and regulations expected in waste management are as follows:

1) Regional governments have regional regulations, which consist of regional regulations on the establishment of institutions/institutions, regional regulations on provisions related to waste management strategies, and regional regulations on cleanliness levies where the material of the regional regulations must cover the whole, have firmness and can be implemented for the long term;
2) The implementation of these regulations needs to begin with socialization and implementation trials. Apart from that, there is also a need for readiness from law enforcers to anticipate violations;
3) Monitoring and evaluation of the Regulations must be done periodically to test their suitability and feasibility.

The legal and regulatory aspects of waste management have been implemented, starting from the Regional Regulation related to the structure of the Environmental Agency, the Regional Regulation on Waste Management, and the Regional Regulation on Retribution for Cleaning Services. This also includes a Regent's Regulation regarding Regional Policies and Strategies in Waste Management and a Regent's Regulation regarding delegating some authority to the sub-district head in handling waste. The Regent of Serang also issued a circular so the Village Government can play a role in waste management by using village funds.

Wahongan & Pontoh (2022) explained that the presence of Waste Management legislation is necessary for:

1) As a step in the context of harmonizing environmental law to support sustainable development;
2) As a way to control environmental impacts;
3) As a way of structuring and enforcing the law;
4) Increase the capacity and ability of organizations and human resources; and
5) Increasing active awareness of the community so that they care and play a role in managing the environment.

The variables that correlate with Factor 2 are the Financing variable and the Community Participation variable. The Financing variable has a matrix component value of 0.884, while Community Participation is 0.888. Financing variables related to waste management, according to the Director General of Human Settlements, include:

1) Adequate investment according to the needs of facilities and facilities, human resource capacity, socialization, counseling and education in the waste sector.
2) Waste operational costs and maintenance of waste utilities.
3) Waste levy rates are prepared based on regional capabilities and community capabilities.
4) Implementation of incentives and disincentives for communities involved in waste management.
5) Income derived from levies must be reinvested for waste management purposes.

According to Febyanti et al. (2021), forms of active community participation and concern for waste management include:

1) Caring for and keeping the environment clean;
2) Active in reduction activities such as waste banking, collection and processing at source, sorting, transporting, and processing waste; and
3) Providing input, suggestions, proposals, and opinions in improving waste management.

CONCLUSION

Based on this research can be concluded as follows:

1. The typology of waste management in Serang Regency is the direct communal waste collection type. This can be seen from the delegation of authority to the sub-district head, indicating that the type of communal management is regionally appropriate. Meanwhile, it is said to be directly communal because direct transportation is carried out from each Waste Storage Site (TPS) directly to the Final Processing Site without any waste transfer.
2. The factor analysis results on waste management performance in Serang Regency produced two determining factors—factor 1 with component variables: Operational Technical, Organizational, Legal, and Regulatory. Meanwhile, the factor 2 component variables are Financing and Community Participation. Based on the analysis that has been carried out using SPSS and the analysis carried out, it can be stated that these two factors are suitable to be used as a policy combination to improve waste management performance in Serang Regency.

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