Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 21, No 2, 2024, 622-637
Article available at homepage presipitasi

Regional Case Study

Determination of Critical Indicators for Community-Based TPS 3R Performance

Siti Ainun[1*], Mohamad Rangga Sururi[1]

[1] Environmental Engineering Study Program, Faculty of Civil Engineering and Planning, Institut Teknologi Nasional Bandung, Jalan PHH Mustafa No.23 Bandung, Indonesia 40124

* Corresponding Author, e-mail: sitiainun@yahoo.com

Abstract

The Ministry of Public Works and Public Housing (*Kementerian Pekerjaan Umum & Perumahan Rakyat* – PUPR) has developed a guideline for assessing the performance of Waste Processing Sites in terms of Reduce, Reuse, and Recycle (*Tempat Pengelolaan Sampah Reuse, Reduce, dan Recycle* - TPS 3R) across five waste management aspects: regulations, technical technology, management institutions, finance, and community participation. The guideline includes parameters and indicators, but their definitions are not clearly specified, leading to various interpretations. This study aimed to identify the key indicators for measuring the performance of TPS 3R. The study involved defining and determining sub-indicators for each aspect using the constructive alignment concept to ensure clarity in measurement. These sub-indicators were consolidated into a set of questions for use in field data collection. The developed guidelines were applied to evaluate TPS 3R performance in West Java, using a comparative study and descriptive analysis for the evaluation. The study identified the critical indicators for each aspect as follows: (i) waste segregation for community participation, (ii) complete waste processing (sorting, organic waste processing, and inorganic waste handling) for technical aspects, and (iii) active management (waste and financial records) for management institutional aspects. These critical indicators not only influence the financial aspect but also provide economic support for the sustainability of TPS 3R.

Keywords: Performance; TPS 3R; participation; sorting; finance; complete processing

1. Introduction

According to Ministry of Environmental and Forestry, Indonesia's solid waste services has reached 66.94 percent until 2023 (waste handled at 50.27 percent and waste reduction at 16.67 percent) (SIPSN, 2024). Currently, efforts are underway to improve household waste management performance by focusing on the directives and goals outlined in the National Policy and Strategy for the Management of Household Waste and Household-like Waste (*Kebijakan dan Strategi Nasional* – Jaktranas) as detailed in Presidential Regulation of the Republic of Indonesia No. 97/2017. The primary focus of Jaktranas is to manage and reduce municipal solid waste at the source to cut transportation costs and prolong the lifespan of Final Processing Sites (TPA). Waste reduction at the source is a significant initiative in Indonesia (Ainun et al., 2016). As of 2025, the target for solid waste handling is 70%, while solid waste reduction is aimed at 30%, indicating that 100% of household and similar household waste will be treated. Waste reduction remains the central objective of waste management initiatives. The establishment of a 3R-based Waste Processing Site (TPS 3R) is considered the optimal solution for reducing waste in landfills and enhancing sorting efforts at the source.

The population of West Java Province grew at a rate of 1.11 percent between 2010 and 2020, reaching 49.86 million people in 2022 (BPS, 2024). The significant increase in population has led to a

substantial challenge in managing solid waste in the region. Currently, solid waste management in West Java relies heavily on landfill disposal, which has resulted in complicated issues such as leachate handling (Ramdhani et al., 2018; Sururi et al., 2021).To address this issue, the Ministry of Public Works (PUPR) has incorporated the TPS 3R (waste reduction, reuse, and recycle) into its community-based infrastructure program as a key initiative to improve the sanitation program of the Citarum River, which is the most polluted river in West Java Province. Enhancing the management of TPS 3R requires identifying and addressing complexities in waste reduction target achievements. Given the importance of TPS 3R in solid waste reduction, evaluating the effectiveness of the established infrastructure is necessary to ensure it meets the waste reduction targets.

Previous researchers employed various methods and parameters to assess the performance of the TPS 3R. Ningsih et al. (2020) found that 56 percent of TPS 3Rs in Jambi City were operating efficiently, with community engagement identified as the most crucial aspect. Moreover, Setyoadi (2018) highlighted that the most significant factors promoting the sustainability of community participation-based waste management were the roles of community leaders and waste management networks in the cities of Bogor and Balikpapan. However, these earlier studies did not comprehensively consider the key aspects of solid waste management as stipulated by The Ministry of Public Works and Public Housing (PUPR). Additionally, the utilization of different methodologies in previous studies has hindered the comparability of their results, making it challenging to obtain critical parameter evaluations to enhance the performance of the TPS 3R.

The national guideline from PUPR was created to evaluate the functioning of TPS 3R. It serves as the primary tool for assessing and enhancing TPS 3R performance, encompassing five integrated aspects of solid waste management (regulation, technical, institution, financial, public participation) (PUPR, 2017). This guideline provides a description of each aspect, including two to six parameters. However, the extensive parameters make it unclear and complex, allowing for different measurement methods and interpretations in the field. Performance indicators (PIs) are crucial for maintaining precision, minimizing misunderstandings, and enabling efficient data transmission, especially in areas where quick and accurate decision-making is vital. Some scholars have suggested the need to simplify the parameters due to dynamic socio-technical contexts, information scarcity, and lack of suitable instruments (Cervantes et al., 2018). However, achieving sustainable development goals and meeting set targets requires innovative ideas, research, and ongoing learning throughout the planning process (Mulvihill and Kramkowski, 2010; Steurer and Martinuzzi, 2005; Walker et al., 2013). Streamlining quantifiable and targeted criteria will be beneficial for future planning to optimize TPS 3R performance.

It has been recognized that the optimization of TPS 3R is urgently required, particularly to fulfill the primary objectives of TPS 3R. The performance indicators outlined in the guideline are currently not clearly defined and are overly general, tending to be qualitative and necessitating clear PIs. Therefore, the purpose of this study is to identify and assess performance indicators through the development of sub-indicators directly related to the aspects of waste management that need to be measured. This is intended to encompass every aspect, making it simpler to evaluate the performance of TPS 3R.

2. Methods

2.1. Study Area

The TPS 3R study site, completed in 2018–2019, is situated in region II of West Java province and was funded through the national budget (*Anggaran Pendapatan dan Belanja Negara* – APBN). Region II includes 7 TPS 3R facilities spread across Bandung City, Bandung Regency, Cimahi City, and Sumedang Regency. Figure 1 illustrates the locations of the TPS, while Table 1 offers detailed descriptions of each TPS 3R.

2.2. Sub Indicator Development

The primary data was gathered from TPS 3R in accordance with the updated technical guidelines (PUPR, 2020). There were five measurement aspects, each comprising specific parameters as follows: (1) Regulation, with a single parameter; (2) Technical Technology, which includes six parameters; (3) Institution or Managing Institution, which encompasses three parameters; (4) Finance, which consists of three parameters; and (5) Participation or Community Participation Level, which consists of four parameters. Each parameter carries a weight of 5%, resulting in a total parameter weight of 100% across all aspects. Further details regarding the weight of each element can be found in Table 2.

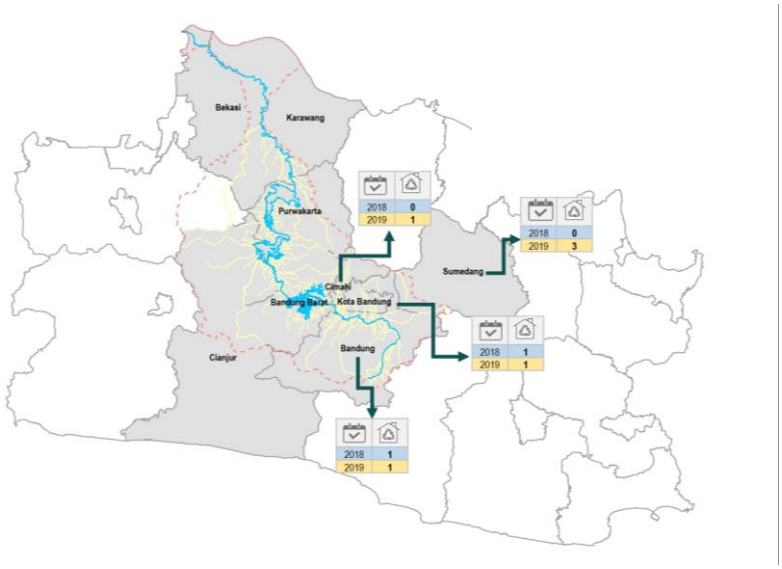

Figure 1. The Location of TPS 3R during 2018-2019 in Region II, West Java Province.

Table 1. TPS 3R Location for 2018 - 2019

Regency / City	Subdistrict	Village / Ward	TPS 3R Name
Sumedang Regency	Tanjungsari	Margaluyu	Margaluyu Maju Rahayu
Sumedang Regency	Pamulihan	Haurngombong	Haurngombong Berdaya
Sumedang Regency	Pamulihan	Cigendel	Cigendel Mandiri
Cimahi City	Cimahi Tengah	Baros	Barokah
Bandung City	Cidadap	Ciumbuleuit	Bersinar
Bandung City	Batununggal	Maleer	Saling Asih II
Bandung Regency	Katapang	Sukamukti	Bagus Berkarya

In this study, Figure 2 presents the instrument development scheme, showcasing a constructive alignment. As per the guidelines, each parameter is associated with three indicators (depicted in blue boxes); however, these indicators remain relatively general, allowing for flexibility in their interpretation by different agencies and stakeholders. The current instruments are largely qualitative, lacking specific indicators for measuring predetermined parameters. Hence, this study aimed to develop measurable indicators by creating sub-indicators (illustrated in black boxes) as performance indicators (PIs). These PIs can be used for historical performance comparisons or evaluation against predefined targets (Alegre et al., 2002; Matos et al., 2002). Integrating these PIs with each indicator and linking them to predetermined targets aims to enhance validity. Additionally, a set of questions (represented by black boxes) was formulated to serve as performance sub-indicators in the instrument development process.

2.3. Data Collection and Analysis Methods

The sub-indicators utilize various methodologies (2.2) that require the collection of primary and secondary data to produce research findings (Nugroho et al., 2018). The availability and accessibility of data are crucial for developing parameters and indicators (Septiani and Ainun, 2021), which is essential to enhance the validity and reliability of parameter and indicator measurements. The development process adhered to guidelines encompassing aspects, parameters, and indicators. Detailed information on the measuring instruments, including factors and their weights, parameters, indicators, and methodologies employed, is provided in Table 2. The five aspects have been weighted and complemented by parameters. Each indicator under each parameter was assigned a score of 1, 3, or 5 to ensure measurability. However, as mentioned previously, the indicators were challenging to measure because of their uncertainty and potential for multiple interpretations when determining the score.

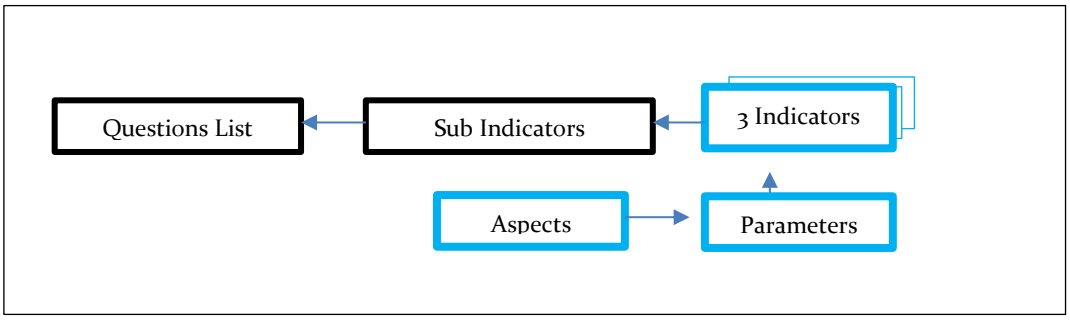

Figure 2 Scheme for Performance Sub Indicators Development, the blue box is given in the the guidance, the black box is being developed in this study.

Table 2 Brief description of instrument guideline and method

	Aspect	Parameter & Method		Indicator	Score
1	Regulation (5%)	Regional and Development Guidelines for 3R TPS (RDG) [1, 2]	1. RDG 1	There are detailed 3R implementation arrangements and development program in Waste Management Regional Regulation and in RTRW	5
			1. RDG 2	Waste Management Regional Regulations **do not** regulate the implementation of the 3Rs in detail even it's development program is available	3
			1. RDG 3	There is **no** Regional Regulation governing waste management and There is no 3R TPS development program in RTRW (*Rencana Tata Ruang Wilayah*)	1
2	Technology – Technical (30%)	Quantity of waste handled (WH) [1, 2, 5]	2. WH 1	> 80% of planned service capacity	5
			2. WH 2	60% - 80% of planned service capacity	3
			2. WH 3	< 60% of planned service capacity	1
		Infrastructures condition (IC) [2, 3, 4]	2. IC 1	The condition of the building and infrastructure is functioning properly	5
			2. IC 2	The condition of buildings and infrastructure is **partially** functioning	3
			2. IC 3	The condition of the building and infrastructure is **not** functioning	1
		Type of treatment (TT) [2, 3, 4]	2. TT 1	Sorting Process, processing of organic and inorganic waste	5
			2. TT 2	Process of sorting and processing organic waste	3
			2. TT 3	Only the sorting process	1

		Equipment condition (EC) [2, 3, 4]	2. EC 1	Sufficient supporting equipment and good condition	5
			2. EC 2	Sufficient supporting equipment, but **some do not** function properly	3
			2. EC 3	Supporting equipment is inadequate, and **not** functioning properly	1
		Compost production (CP) [1, 2, 5]	2. CP 1	**All** organic waste is processed into compost	5
			2. CP 2	70-99% of organic waste is processed into compost	3
			2. CP 3	<70% of organic waste is processed into compost	1
		Quantity of residual transported (RT) [1, 2, 5]	2. RT 1	< 30% of total waste managed	5
			2. RT 2	30% - 40% of total waste managed	3
			2. RT 3	> 40% of total waste managed	1
3	Institution (30%)	Management Agency (MA) [1, 2,]	3. MA 1	Non-governmental groups	5
			3. MA 2	Official/Village	3
			3. MA 3	Individual	1
		Organizational Structure (OS) [1, 2, 3]	3. OS 1	**Complete** structure and **active** functioning maintainers	5
			3. OS 2	Complete structure but less active maintainers	3
			3. OS 3	There is a structure but the organization does not work	1
		Human Resources (HR) [2, 3, 4]	3. HR 1	Competent managers, operators and sufficient manpower	5
			3. HR 2	Competent managers, operators and **less** manpower	3
			3. HR 3	Less competent managers, **less** operators **and** manpower	1
		Institutional Legality (IL) [1, 2,]	3. IL 1	**There is** a Notary Deed, a Decree of Establishment signed by the Village Head and known to the relevant SKPD, and there is AD / ART	5
			3. IL 2	The Notary Deed is still in process, the Decree of Establishment signed by the Village Head and known to the relevant SKPD, and there is an AD / ART	3
			3. IL 3	Without a Notary Deed, the Decree of Establishment signed by the Village Head and known to the relevant SKPD, and there is an AD / ART	1
		Management Administration (MA) [1, 2, 3]	3. MAd 1	**Good operational recording** of TPS 3R is carried out	5
			3. MAd 2	Operational recording of TPS 3R was carried out but it was not good	3
			3. MAd 3	No operational recording of TPS3R	1
		Local Government Facilitation of Institutions (LGF) [1, 2, 3]	3. LGF 1	There is **regular** institutional facilitation from the local government (at least 1 time / month)	5
			3. LGF 2	There has been facilitation from the local government (at least 1 time in 3-6 months)	3
			3. LGF 3	There has never been any facilitation from the local government	1
4	Financial (15%)	Financial Condition (FC) [1, 2,]	4. FC 1	Monthly financial **surplus**	5
			4. FC 2	Sufficient monthly finances (balance)	3
			4. FC 3	Monthly finance minus	1

		Financial Management (FM) [1, 2,]	4. FM 1	There is a cash book and KSM funds are stored in the bank	5
			4. FM 2	There is a cash book, but the KSM funds are held by the treasurer	3
			4. FM 3	Finances are recorded sober	1
		Local Government Financial Assistance (LGFA) [1, 2]	4. LGFA 1	There is operational funding assistance as needed	5
			4. LGFA 2	There is modest operational funding assistance	3
			4. LGFA 3	No operational funding assistance	1
5	Participation (20%)	Community waste segregation (CWS) [2, 3]	5. CWS 1	The whole community sorts waste	5
			5. CWS 2	Only some people sort waste	3
			5. CWS 3	No waste sorting in households	1
		Waste retribution in community (WR) [1, 2,]	5. WRC 1	100% pay the levy on time	5
			5. WRC 2	60% - 99% pay the levy on time	3
			5. WRC 3	< 60% pay the levy on time	1
		Economic Impact (EI) [1, 2,]	5. EI 1	There is an addition of economic value at the community level (beneficiaries)	5
			5. EI 2	There is an Economic Value Addition in the 3R TPS Manager	3
			5. EI 3	No Economic Value Added	1
		User development (UD) [1, 2,]	5. UD 1	Customer Addition ≥ 100%	5
			5. UD 2	Customer Addition by 50% - 99%	3
			5. UD 3	Customer Addition of < 50%	1

Note: 1: searching and browsing on documents; 2: interview; 3: observation; 4: field Testing (validation); 5: field measurement.

The primary data was obtained through direct observation, in-depth interviews with the community of users, maintenance manager (KPP), TPS 3R manager, and the local City/Regency Environmental Service. In addition, a literature review was conducted to gather relevant data and legal documents. Direct field measurements at TPS 3R were taken to assess waste quantity, along with descriptive observational research. These methods are further detailed in Table 2. Data collection utilized the methods outlined in Table 2 and a set of questions designed to evaluate the sub-indicator performance.

Scoring and assessment were performed using predetermined weights. The assessment process involved calculating parameter scores from questionnaire/interview data processing, determining criterion values by multiplying the total parameter score by the weight of each criterion, and calculating the performance level value by summing the aspect values. Performance level categories were determined based on reference guidelines outlined in Table 3. A higher performance level corresponds to a higher score.

Critical parameters influencing TPS 3R performance were identified through a gap analysis. These findings were further analyzed using sub-indicators to identify key parameters for improving TPS 3R management effectiveness. These critical parameters highlight distinct performance aspects among TPS 3Rs in West Java and will provide guidance to the solid waste authority in enhancing TPS 3R performance.

Table 3 Assessment category TPS 3R performance

No	Total Value for all aspect	Performance Level
1	> 19,0	Highly Performed
2	14,3 < N ≤ 19,0	Well Performed
3	9,5 < N ≤ 14,3	Less Function
4	≤ 9,5	Not Working Properly

3. Result and Discussions

3.1. Sub Indicator Development

The sub-indicators are designed to provide simple, easy-to-read, and dependable metrics for monitoring various systems, including waste management services (United Nations, 2007). These sub-indicators can be found in Table 4, with varying numbers for each parameter to ensure objective assessment in the field. Some sub-indicators include equations, particularly for quantitative parameters such as the Quantity of Waste Handled (WH), Equipment Condition (EC), Compost Production (CP), Quantity of Residual Transported (RT), Human Resources (HR), Financial Condition (FC), waste redistribution in the community (WR), and user development (UD).

Other sub-indicators are highlighted with specific requirements. For instance, to evaluate the Regulation Aspect, the available parameter is the Regional and Development Guideline, which requires the presence of regional guidelines and the TPS 3R development plan. These sub-indicators address the existing guidance gaps by offering clear information for measuring TPS 3R performance, efficiency of processes, activities, and service systems, thereby serving as a crucial tool for decision-making and strategic planning (Matos et al., 2004).

3.2. Assessment of TPS 3R Performance

Standardizing performance assessment is crucial in light of the increasing diversity of TPS 3R management and its varying location characteristics. Performance indicators (PIs) are essential for defining the efficiency and effectiveness of an organization's service delivery (Deb & Cesario, 1997). PIs also play a key role in providing information for quantitative performance assessments (Larsson et al., 2022). The assessment was conducted across seven TPS 3R sites in West Java Province using a set of developed subindicator questions. The analysis involved examining the processes, comparing activities, and evaluating the achievements of waste processing and management in TPS 3R based on specific aspects and parameters outlined in the guidelines.

Table 4. Development of sub-indicators

No	Aspect	Parameter	Sub-Indicators
1	Regulation	1.RDG	There are 4 sub-indicators for Regional and Development Guidelines (RDG) for TPS 3R. TPS 3R minimum has at least 2 types of regulations regarding waste and includes a TPS 3R development plan in both.
2	Technical	2. WH	Quantity of waste handled has 2 sub-indicators. Waste handled (WH) is comparison between waste capacity planned (wcp) in kg/day and existing waste managed (ewm) in kg/day. These are calculated using data of the plan for served families in the RKM (Community Work Plan) document and the existing number of served families. Each of them are converted into waste volume using waste generation (kg/person/day) WH (%) = wcp (kg/day) / ewm (kg/day) x 100%
		2. IC	Infrastructure Condition (IC) has 2 sub-indicators each for building and facilities of 9 items, and 4 items for infrastructures, in total there are 22 sub-indicators. Observational descriptive research towards buildings, facilities and infrastructures at TPS 3R. Taking notes, documentation and field testing if necessary during observation to all of TPS 3R's infrastructures which consists of two sub-indicators namely (1) physical conditions and (2) functionality. There area 9 items to be assessed which consists of buildings, dropping area, waste segregation area, composting area, screening & packaging area, stall goods (economic valuable waste) storage area, residue buildup area, offlice area. In this section assessment also held for 4 items of infrastructures which are clean water infrastructure, drainage channels, road access, electricity infrastructure.
		2. TT	Type of treatment (TT) has 3 sub-indicators which are activity of waste sorting, organic waste treatment and anorganic waste treatment. Observational descriptive and taking notes, documentation and field testing if necessary to identify those activities.
		2. EC	Equipment Condition (EC) has 2 sub-indicators each for TPS 3R equipment of 6 items, and 4 indicators for infrastructures, in total there are 22 sub-indicators. Observational descriptive and taking notes, documentation and field testing for validation towards equipment conditions and its fuctionality (log book if any) towards organic shredding machine, sieving machine, press machine, inorganic shredding machine, waste cart, waste collection motorbike. Sufficient (S) mean capacity of the equipment is equal to its waste managed (ewm). Equipment capacity (EC) is calculated by the extraction of number (n), operational capacity (oc) and operational hour (oh). EC (kg) = n x oc (kg/hour) x oh (hour) S (%) = EC (kg) /ewm (kg) x 100%
		2. CP	Compost production (CP) has 2 sub-indicators. It is a comparison between daily organic waste received (owr) in kg/day and composted waste (cw) in kg/day. Field measurements needs to be done to enhance the data validity. Weight both of the organic waste and composted waste onsite with anykind of container available at TPS 3R. Compare if necessary with the log book, if available. CP (%) = owr (kg/day) / cw (kg/day) x 100%
		2. RT	Quantity of residual transported (RT) has 2 sub-indicators. It is comparison between daily total waste received (owr) and waste residue (rw), both in kg/day. Field measurements needs to be done to enhance the data validity. Weight both of the total waste and waste residue onsite with anykind of container available at TPS 3R. Compare with the log book, if available. RT (%) = rw (kg/day) / owr (kg/day) x 100%
3	Institution	3. MA	There is only 1 sub-indicators fot Management Agency (MA), either it si manage by individuals, departments/villages or self-help groups (Kelompok Swadaya Masyarakat)
		3. OS	Organizational Structure (OS) has 2 sub-indicators which are completeness and activeness of all or part of the organizational structure, in detail can be seen at Appendix 1 (KPI Score Guidance)

		3. HR	Human Resources (HR) has 2 sub-indicators (Sufficient manpower and Competency Level). Sufficient Manpower (SM) is determined by using data of working hour (woh) and human resources avalaibility (hra). Optimal work hour is 8 hour/day with minimum 2 person thus the minimum total work load is 16 manhours. SM (manhour) = woh (hour) x hra (man) Competency levels is measured by the number of related trainings completed
		3. IL	There is only 1 sub-indicators for Institutional Legality (IL) which is the presence of a notary deed.
		3. Mad	Management administration (MA) have 4 sub-indicators and related to TPS 3R operation especially to waste recording. Good MA is shown by completeness of routine waste recording activitis on (1) incoming waste (2) treated waste (3) waste comes out
		3. LGF	Local Government Facilitiation of institutions (LGF) has 2 sub-indicators. It is about (1) identify the existence of institutional facilitation from the OPD and (2) regular frequency of facilitation implementation
4	Finance	4. FC	Financial condition (FC) has 3 sub-indicators. The first indicator is to identify monthly financial condition, the second one is to identify the average amount of income (ai) and the last one is identify the average amount of expenditure (ae) FC (Rp/month) = ai (Rp/month) - ae (Rp/month) if FC = + : Surplus; if FC = 0 : Balance, if FC = - ; Minus
		4. FM	Financial Management (FM) has 2 sub-indicators. The first indicator is ownership of the cash book by the manager and the second one is fund location storage.
		4. LGFA	Local government financial asistant is having 2 sub-indicators. The first indicator is the existence of operational funds for TPS 3R from the government / department and the second one is the sufficiency and appropriateness of the allocated funds.
5	Participation	5. CWS	There is only 1 sub-indicators for Community Waste Segregation (CWS) which is to identify how many people do the sorting
		5. WRC	Waste Retribution in community (WR) has 2 sub-indicators. Interview is done to identify number of families who consistently make their contributions on time (nfpc) compare it with number of total family served (nfs). WR(%) = nfpc / nfs x 100%
		5. EI	Economic impact (EI) have 2 sub-indicators. Interview is done to gather information about the economic value addition to managers and the communities served
		5. UD	User development (UD) are employ 4 sub-indicators. The first sub-indicator is the number of domestic client after 3 month operation (ndt), the second one is the number of existing domestic client (nedc). The third indicator is the number of non domestic client after 3 month operation (nndt), the last one is the number of existing non domestic client (nendc). UD (%) = (nedc + nendc) - (ndt + nndt) / (ndt + nndt) x 100%

3.2.1. Regulation Aspect

The first criterion for evaluating the functionality of TPS 3R was regulation, which serves as the legal framework for TPS 3R operation and development. This criterion included two parameters: the presence and specifics of regulations and planning for TPS 3R development. Figure 3 illustrates the results of the assessment of the regulatory criterion for the 7 TPS-3Rs. In the Bandung Regency region, there already exists a waste regulation that governs TPS 3R (TPS 3R Bagus Berkarya), along with the Spatial Planning (RTRW) document that outlines the program plan for TPS 3R development. However, based on the literature review, RTRW in other cities and districts do not include plans for TPS 3R development, and the regulations do not address TPS 3R. This indicates the low commitment of local governments to support TPS 3R, despite the crucial role of government assistance in ensuring the sustainability and continuous improvement of TPS 3R.

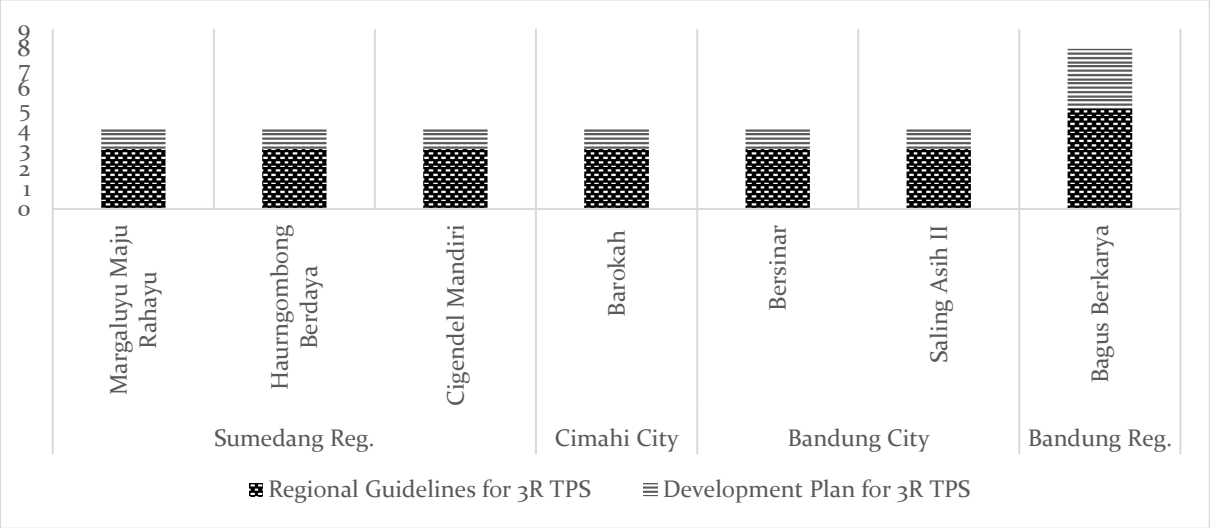

Figure 3 Results of scoring aspects of regulation governing TPS 3R

3.2.2. Technology – Technical Aspect

The technology technical aspect has six parameters which describe the TPS 3R operational system. The parameters on this aspect consists of (1) the quantity of waste being managed, (2) the condition of existing buildings and infrastructure, (3) the type of processing, (4) the condition of the equipment, (5) the production of compost and (6) the quantity of residue from the TPS transported to the landfill. According to Setiawan (2018), the average service level of TPS 3R is between 23% and 85%, whereas the PUPR targets waste management at 80% of its service capacity.

Based on direct measurements, as shown in Figure 4, TPS 3R Margaluyu, Barokah, Bersinar, Saling Asih dan Bagus Berkarya were able to manage the waste quantity according to PUPR target. Furthermore, on the parameters of building and infrastructure conditions, based on field observations, only TPS 3R Barokah, Bersinar, Saling Asih dan Bagus Berkarya achieved the maximum score, because the condition was good and could function properly. This demonstrates that the building's condition parameter affects the quantity of waste that can be accommodated at TPS 3R, although the technical discussion will focus on waste reduction at each TPS 3R.

The restricted amount of TPS 3R leads to this high PUPR objective. It is hoped that the inclusion of TPS 3R will significantly reduce waste at the source. Other parameters related to waste quantity and its reduction target were compost production and the quantity of residue transported to the landfill. Compost production as a percentage of total managed waste generated reached 80% only at TPS 3R Barokah and Bersinar, despite the fact that the highest percentage of waste was obtained also at TPS 3R Margaluyu, Saling Asih, and Bagus Berkarya. Unfortunately, these three TPS 3R could only produce less than 40% compost. This demonstrates the significance of the processing parameters and the condition of

the TPS 3R equipment. Waste reduction can still occur under the limited conditions of existing equipment with more comprehensive types of processing carried out (sorting, organic, and inorganic processing). The equipment in all TPS 3R was in poor condition (score 1); however, processing could still be performed. TPS 3R Barokah, Bersinar, and Saling Asih operate organic and inorganic processing types, whereas TPS 3R Margaluyu only performs organic processing, even at TPS 3R. The facts described above result in a very low level of waste reduction at TPS 3R Bagus Berkarya.

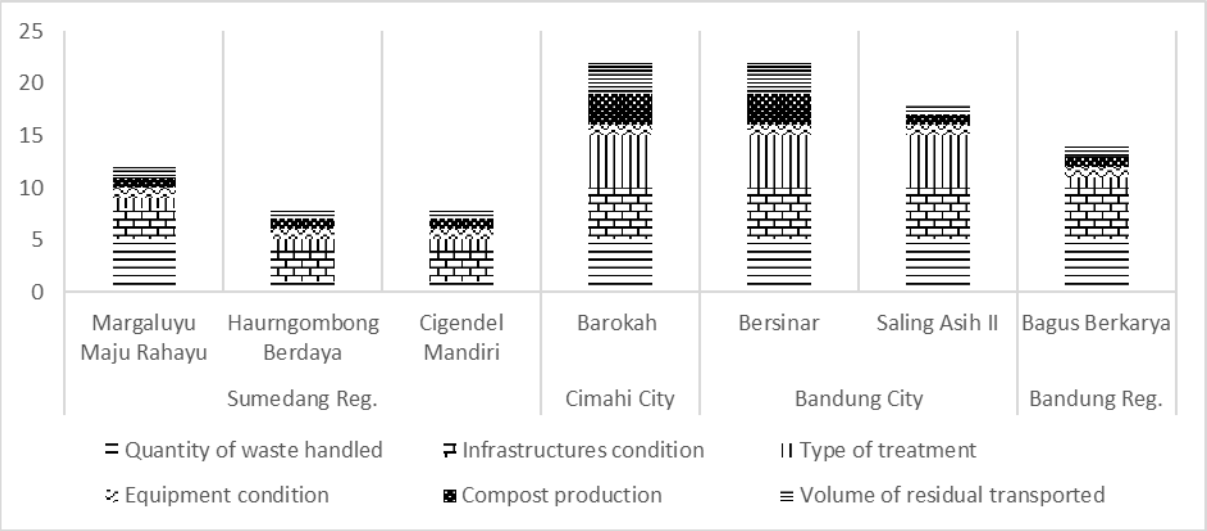

Figure 4 Technical scoring results - TPS 3R Technology

When compared to the reduction rate from TPS 3R, which ranges from 1.68% to 2.85% (Setiawan, 2018), and with service levels ranging from 23% to 85%, the level of waste processing at TPS 3R Barokah, Bersinar, Margaluyu, and Saling Asih (12%-40%) demonstrates a relatively high achievement. However, the percentage of residual waste transported to landfills is substantial (75%). This underscores the necessity for direct field measurements when assessing operational efficacy and ensuring the validity of waste-reduction metrics. Despite the capacity of TPS 3R to manage significant quantities of waste, a notable portion of the residue continues to be transported to landfills (TPA).

This situation is attributed to insufficient community participation in sorting waste at the source. The effectiveness of TPS 3R depends on waste separation at the source; the higher the level of waste sorting, the more waste can be processed. According to Habib et al. (2021), the primary risk impeding waste management at TPS 3R is inadequate waste segregation at the source. This aligns with Damanhuri's (2019) recommendation that implementing and enforcing regulations on waste segregation at the source is crucial for enhancing waste reduction at TPS 3R and ensuring its sustainability.

3.2.3. Institutional Aspect

Implementing a waste management system requires an institution to oversee its operation (PUPR, 2017). This condition also applies to the management of TPS 3R. The institutional aspect for measuring TPS 3R performance includes six parameters (Table 2). TPS 3R implementation by Non-Governmental Community Organizations (KSM) to enhance functioning will result in high value. To facilitate the analysis process, the institutional aspect was divided into one external factor parameter (institutional facilitation by the local government) and five internal factor parameters.

Human resources were found to be lacking in 5 out of the 7 TPS 3Rs (Figure 5), with managers being perceived as incompetent. Only Haur Ngombong and Barokah have competent managers and sufficient operators and workers. According to the parameter score for legality, 3 of the 7 TPS 3R locations have high scores as they already have a notary deed. Fitriani (2017) defines legality as an identity that

legalizes/authorizes management, allowing for larger community recognition. Providing legal recognition for TPS 3R managers can facilitate positive development of TPS 3R operations.

Institutional facilitation, as support from the local government, was noted to be quite good, with continual facilitation at least two times per year for all existing 3R TPS, as stated by Setyoadi (2018). Local government facilitation is a driving factor in the sustainability of community-based household waste management. This institutional facilitation is a form of government participation, as authorities are fully aware of their responsibility to reduce waste generation (Afifah et al., 2021). Measurement of management administration parameters revealed that 5 of the TPS 3R did not maintain operational records (waste and financial records), hindering the development of the TPS 3R. TPS 3R Bersinar has not been wholly and routinely recorded, while TPS 3R Saling Asih has a complete record of its operations, aiding in business plan development. According to Luthfi (2013), waste management can be sustainable if it is supported by two primary factors: (1) the level of concern from citizens, and (2) the residents' desire to manage waste. This study reveals some intriguing facts, such as TPS 3R Margaluyu, which has a separate management agency, but a complete and active organizational structure. This study reinforces previous research (Luthfi and Kasmini, 2013) by demonstrating that, in addition to the two main factors, the role of individuals affects the functioning and activeness of the TPS 3R organization. An individual's role indicates the potential for TPS 3R to be professionally managed, potentially generating profits (confirmed in section 3.4). Furthermore, this study emphasizes the significance of human resource capabilities in the administrative process of TPS 3R management, particularly in waste and financial data recording and collection.

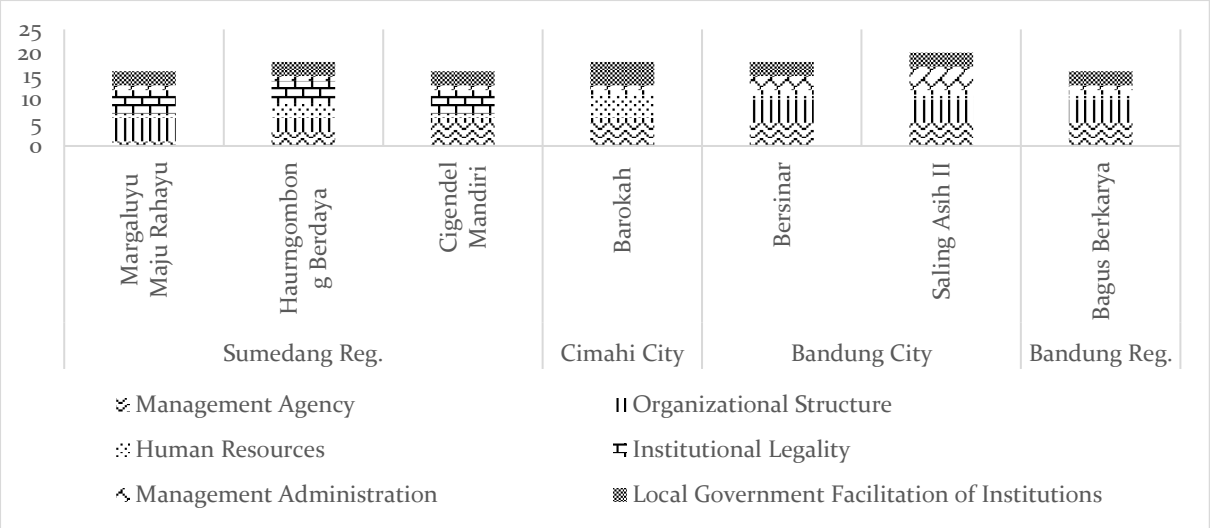

Figure 5 The results of the TPS 3R management institutional aspect scoring

3.2.4. Finance Aspect

The financial aspect is critical to both the concept of integrated solid waste management (Tchobanoglous et al., 2000) and the long-term viability of TPS 3R systems. As illustrated in Figure 6, the financial aspects of assessing TPS 3R sustainability include financial condition, financial management, and local government financial assistance. A surplus financial condition was observed solely at TPS 3R Saling Asih, while the presence of a treasurer's cash book was noted at TPS 3R Margaluyu, Haurngombong, and Cigendel. This highlights one of the frequent challenges TPS 3R facilities encounter in maintaining their operational systems over time. According to Damanhuri (2019), another strategy to enhance operational efficiency, identified through SWOT analysis, is to optimize the mentoring/training package, particularly the financial management module. TPS 3R facilities receiving local government assistance and operating at levels that meet their needs were found only in Cimahi and Bandung.

Assistance from the local government is crucial for TPS 3R operations before they can become established and self-sufficient.

3.2.5. Participation Aspect

Community participation is essential for sustainable waste management. Measuring the level of community involvement is crucial for this assessment. The parameter scoring of community waste sorting levels (Figure 7) indicates that four out of seven TPS 3R facilities achieved a score of 3, signifying that the majority of their communities engage in waste sorting. In contrast, the other three TPS 3R facilities do not have communities sorting waste at the source.TPS 3R Bagus Berkarya and TPS 3R Margaluyu Maju Rahayu exhibit the highest retribution parameters, with 100% and over 60% retribution payments covering their service communities, respectively. Conversely, for the remaining five TPS 3R facilities, less than 60% of the service community makes retribution payments.

TPS 3R Saling Asih II and TPS 3R Margaluyu Maju Rahayu also attain the highest scores for the economic impact parameter, with a value of 3, indicating that the TPS 3R managers have observed an increase in economic value. However, the other five TPS 3R facilities did not report any addition to economic value. The conditions of the retribution and economic impact parameters suggest that the operational systems at these TPS 3R facilities have not been developed sustainably, as evidenced by the low scores for customer development parameters across all TPS 3R facilities. According to Afifah et al. (2021), waste reduction programs rely on the active participation of both the community and waste managers.

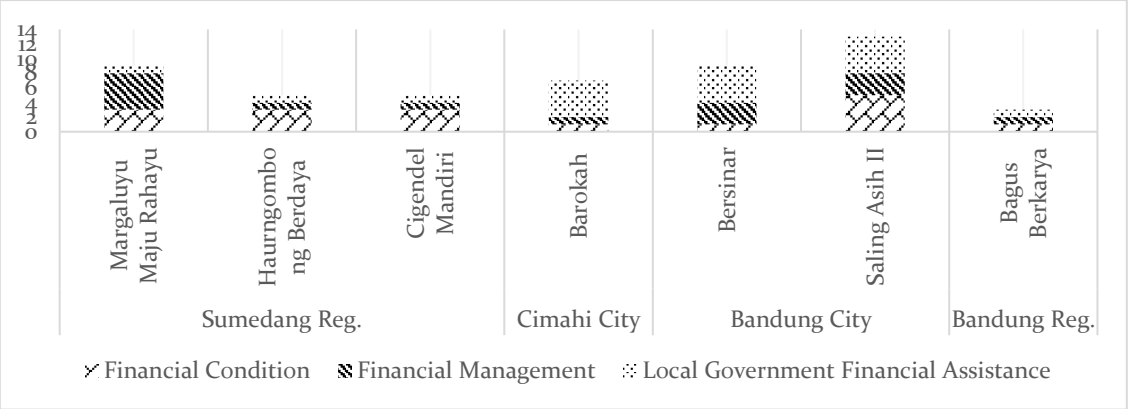

Figure 6. TPS 3R financial scoring results

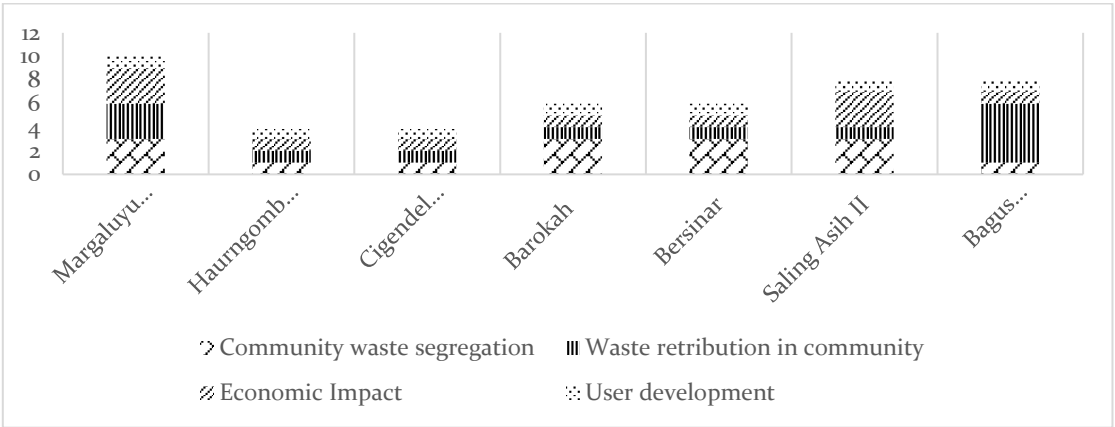

Figure 7. The TPS 3R participation aspect scoring results

3.3. Critical Parameters Identification

TPS 3R performances are evaluated based on regulatory product support, technical-technological, management institutional, financial, and participation aspects. Figure 8 presents the results of the TPS 3R functionality assessment.

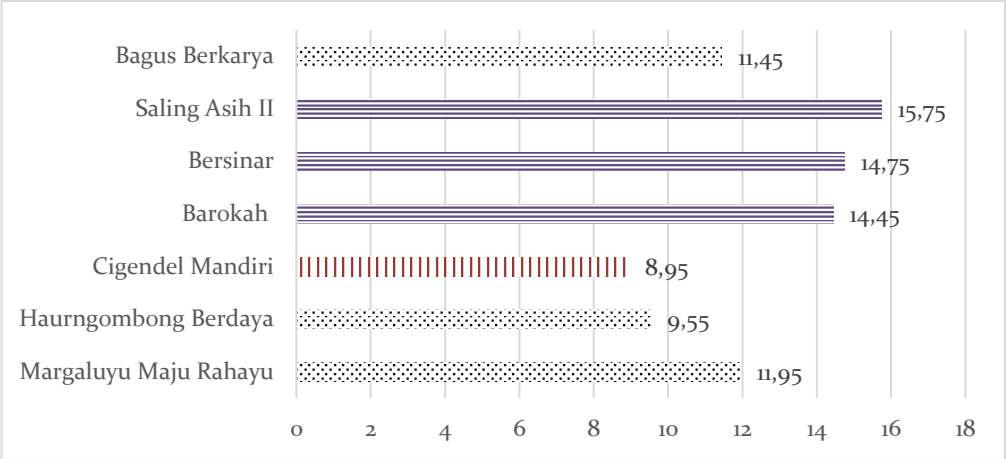

Figure 8. TPS 3R Functionality Level / TPS 3R Performance

None of the TPS 3R functions very well (score > 19), with the highest score falling in the range of 14.45 – 15.75. The TPS 3R Saling Asih II, TPS 3R Bersinar, and TPA 3R Barokah obtained scores of 15.75, 14.75, and 14.45, respectively, indicating well-functioning TPS 3R categories. The institutional, financial, and community participation aspects at these three TPS 3Rs were highlighted as contributing to their well-functioning status. The lessons that stand out from TPS 3 R with well functioned categories were discussed in the following discussion:

The regulatory aspects, commitment, and support from local government, as well as technical and operational regulations, are critical for the smooth operation and long-term viability of TPS 3Rs. While the three TPS 3Rs have received institutional support from the local government, facilitation for future development and strategic planning has not been provided. This observation aligns with the findings of Ningsih et al. (2020), who identified local government support as a key factor influencing TPS 3R performance. However, more comprehensive technical and operational regulations are necessary for the sustainable operation of TPS 3R.

Externally, the three TPS 3Rs have received institutional support from the local government, but there is a lack of facilitation for future development and strategic planning. When analyzing the internal parameters, TPS 3R Bersinar and Saling Asih II have complete and active organizational structures, whereas TPS 3R Barokah possesses competent and sufficient human resources (HR). TPS 3R Bersinar and TPS 3R Saling Asih have demonstrated effective administrative management by maintaining operational records, which are essential for guiding the development of their business plans. This underscores the importance of HR competencies in the management of TPS 3R, highlighting the necessity for each TPS 3R to have access to these benefits.

The three TPS 3Rs have parameters for good building and infrastructure conditions in their technical technology aspects, which influence the capacity for waste management. These parameters support waste reduction and processing, with the potential to produce a compost production ratio of up to 80% of the total waste managed. However, the residue transported to the TPA remains high despite reaching a 40% waste processing rate at the three TPS 3Rs.

In terms of community participation, TPS 3R Saling Asih II has the highest community participation value among the other three TPS 3R, with the economic impact felt by TPS 3R managers making the difference. Andina (2019) stated that segregation at the source was the key to effective waste management, whereas Susanto and Rahardyan (2016) stated that the main impediment to the waste

management process was low revenue from waste retribution. The sorting parameters that affect the technical aspects of operations and the retribution parameters that affect the financing aspects greatly influence the functioning and sustainability of the TPS 3R, according to previous researchers (Andina, 2019, Susanto et al., 2016). The low level of community participation in waste sorting and retribution shown in all study sites in the area was an impediment to the operation of the TPS 3R.

TPS 3R Saling Asih II has a prominent financial aspect when compared to other TPS 3R. When we compare the values of these three aspects of TPS 3R in greater detail, finance emerges as the distinguishing criterion (Figure 6). Only at the location of the 3R Saling Asih TPS did the financial situation show a surplus. On the other hand, assistance from the local government was one of the most important factors in the TPS 3R's operation before it became established and self-sufficient

4. Conclusion

Existing standards predominantly focus on qualitative indicators, which can lead to misinterpretations when measuring the performance of TPS 3R in the field. It is necessary to refine these indicators into sub-indicators that serve as performance metrics to accurately assess and compare the performance of TPS 3R facilities. Performance comparisons are conducted to identify key factors that can be leveraged to enhance TPS 3R performance in the future. Aspects such as community participation, operational techniques, and institutional support significantly influence the performance of TPS 3R in West Java. The critical parameter for the community participation aspect is the extent of community involvement in waste sorting at the source. For the operational technical aspect, the critical parameter is the completeness of solid waste treatment facilities, including container-transportation units for segregated waste, organic waste processing, and inorganic waste handling. In the institutional aspect, the critical parameters are the activeness of the manager in accurately recording the mass balance of waste and maintaining financial accountability. These critical parameters form the foundation for the sustainability of TPS 3R.

The community participation aspect must be supported by the readiness of operational technical aspects, from the storage stage to transportation to the TPS 3R. However, no direct relationship exists between the presence of facilities and infrastructure and the level of waste reduction at TPS 3R. Comprehensive equipment is most effective when supported by institutional aspects, including an active organizational structure, competent human resources, administrative management (waste recording and finance), and local government support for the development of TPS 3R.

This study confirms that a crucial parameter in the functioning of TPS 3R is the complete solid waste processing (sorting, processing of organic waste, and handling of inorganic waste), which must be supported by functioning infrastructure. The study also found that even TPS 3R equipped with comprehensive facilities do not necessarily guarantee effective solid waste processing. The two primary aspects that hinder the development of TPS 3R are institutional factors, particularly parameters such as managerial activity, competent human resources, and administrative records, and financial factors, including retribution payment parameters.

To optimize all existing TPS 3R, it is essential to enhance, strengthen, and develop the institutional aspects, including building the capacities of human resources responsible for operations, especially in administrative and financial domains. Additionally, it is crucial to ensure the development, preservation, and maintenance of TPS 3R operations with appropriate equipment for processing all types of waste, including organic and inorganic materials.

Acknowledgement

The authors would like to thank the Sanitation Directorate, the Ministry of Public Works and Public Housing, as well as the National Institute of Technology Research and Community Service Institute.

References

Afifah, T.L., Soemirat, J., Ainun, Siti, 2021. Penyusunan alat ukur partisipasi birokrat dalam program pengurangan sampah di kota bandung. Jurnal Reka Lingkungan, 2 (09), 84-94.

Ainun, S., Hartati, E., Amandasari, H. N., 2016. Evaluation of Waste Reduction Sustainability. IPCB, 195

Alegre, H., Baptista, J. M., Cabrera Jr, E., Cubillo, F., Duarte, P., Hirner, W., ... & Parena, R., 2016. Performance indicators for water supply services. IWA publishing.

Badan Pusat Statistik., 2024. Provinsi Jawa Barat Dalam Angka 2023. BPS Provinsi Jawa Barat.

Damanhuri, E., 2019. Analisa Strategi Keberlanjutan tps 3r dalam upaya minimasi pengangkutan sampah ke tpa (studi kasus: program tps 3r kabupaten bandung, provinsi jawa barat. Jurnal Teknik Lingkungan, 25(2).

Deb, A., Cesario, L., 1997. Water distribution systems performance assessment. In Proc., IWSA Workshop on Performance Indicators for Transmission and Distribution Systems.

Fitriani, R., 2017. Aspek hukum legalitas perusahaan atau badan usaha dalam kegiatan bisnis. Jurnal Hukum Samudra Keadilan, 12(1), 136-145.

Habib, M. A. F., Mahyuddin, M., 2021. Evaluasi pengelolaan teknologi tps 3r di desa wisata religi Gunungpring Kabupaten Magelang. Journal of Islamic Tourism, Halal Food, Islamic Traveling, and Creative Economy 1 (1), 1-34.

Larsson, M., 2002. Process Benchmarking in the Water Industry: Towards a worldwide approach. IWA.

Luthfi, A., Kismini, E., 2013. Partisipasi masyarakat dalam sistem pengelolaan sampah di TPA Sukoharjo Kabupaten Pati. Jurnal Abdimas 17 (1), 13-20.

Matos, R., Cardoso, A., Ashley, R. M., Duarte, P., Molinari, A., Schulz, A., Eds., 2003. Performance indicators for wastewater services. IWA publishing

Ningsih, W., Jalius, J., Hadi, S., 2020. Analysis of factors related to 3r-based waste management site in Jambi City. Jurnal Pembangunan Berkelanjutan 3 (2), 60-66.

Nugroho, S. T. A., Akmalah, E., Ainun, S., 2018. Pengembangan indikator waste (sampah) pada penerapan konsep green campus di Itenas. RekaRacana: Jurnal Teknil Sipil 4 (1), 122.

P.U.P.R., 2017. Petunjuk Teknis Pelaksanaan TPS 3R. Kementrian pekerjaan umum dan perumahan rakyat direktorat jendral cipta karya direktorat Sanitasi.

Ramdhani, M. Y., Sururi, M. R., Ainun, S., 2018. Leachate Treatment from Sarimukti Landfill using ozone with sludge from water treatment plant as a catalyst. Paper presented at the MATEC Web of Conferences.

Setyoadi, N. H., 2018. Faktor pendorong keberlanjutan pengelolaan sampah rumah tangga berbasis masyarakat di kota Balikpapan dan Bogor. Jurnal Sains & Teknologi Lingkungan, 10(1), 51-66.

Septiani, P., Ainun, S., 2021. Penentuan daerah prioritas di wilayah pelayanan bandung utara berdasarkan parameter fungsi dan nilai daerah. Jurnal Reka Lingkungan, 1(09), 58-70.

Stiawan, A., 2018. Evaluasi Operasional dan Pengembangan TPS 3R di Kecamatan Denpasar Selatan, Kota Denpasar. Institut Teknologi Sepuluh Nopember.

Sururi, M. R., Fadiyah, M. A., Saleh, S. A., Dirgawati, M., 2021. Pengaruh laju aliran udara terhadap efisiensi penyisihan organik di dalam air lindi dengan menggunakan teknik oksidasi lanjut (O_3/H_2O_2). Jurnal Teknologi Lingkungan, 22(1), 009-017.

Susanto, I., Rahardyan, B., 2016. Analisis Penerimaan Retribusi Sampah oleh masyarakat dalam upaya peningkatan pelayanan pengelolaan persampahan di kota bandung bagian timur. jurnal perencanaan wilayah dan kota. Journal of Regional and City Planning. 27(3), 219-235.

Tchobanoglous, G., Vigil, S., 2000. Integrated solid waste management: engineering principles and management issues.