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Sustainability Evaluation of Waste Management Using RAPWASTE Method at the 3R Temporary Waste Disposal Site in Yogyakarta City

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ABSTRACT

The waste problem has become a big problem in Indonesia as the population continues to grow. The daily amount of waste generated in Yogyakarta City is 303.13 tons.day^{-1}, with the composition of the largest waste source, namely household waste, around 63.75%. This data shows that there is a need for improvements related to management; 3R Temporary Waste Disposal Sites is an alternative for reducing waste before it is transported to the final processing place. This research aims to understand performance and waste transportation management and evaluate the level of waste management and sustainability of waste management at 3R Temporary Waste Disposal Sites Nitikan Yogyakarta. This research was conducted on 99 respondents using a *purposive* sampling method; the data analysis used was the evaluation of waste transportation, analysis of incoming, managed, and unmanaged waste data, categorization of questionnaire data, evaluation of waste management performance and analysis of the sustainability of waste management using RAPFISH software. The research results show that waste volume management at 3R Temporary Waste Disposal Sites Nitikan is 941.15 kg.day^{-1}, and compost production is 190.65 kg.day^{-1}. Transport management is carried out using the Stationary Container System (SCS) and is carried out 2 times. The evaluation of waste management performance is moderate, with a total relative value of 15.4, based on studies on the technical sector, institutional sector, financial sector, and the area of community participation. Based on the attribute index in each sector, it is concluded that the sustainability status of waste sorting and management at 3R Temporary Waste Disposal Sites Nitikan is 79.03, or very sustainable.

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INTRODUCTION

Waste is defined as something that is no longer useful and unused and comes from human activities (Nainggolan 2019). The waste problem has become a big problem in Indonesia as the population continues to grow. Umbulharjo District is one of the 14 Districts in Yogyakarta with the largest area and is followed by a high population. Based on data from the Ministry of Environment and Forestry (KLHK 2022), the daily amount of waste generated in Yogyakarta City is 303.13 tons.day^{-1}, with the composition of the largest waste source, namely household waste, around 63.75%. This data shows that there is a need to improve household waste management. If waste management is not appropriate, it can cause problems for the environment. In waste management, there are 4 areas supporting waste management that synergize with each other to achieve good waste management. The four areas include engineering, institutional, financial and community participation (Ihsanudin 2022). Waste management is a field related to the control of accumulation, temporary storage, collection, transfer, transportation, processing and disposal carried out in accordance with the principles of public health, economics, aesthetics, environmental considerations and community attitudes (Amaluddin et al. 2019). Problems related to waste are regulated in Law Number 18 of 2008,

which states that waste reduction can be done by reusing waste through the 3R (*Reduce, Reuse,* and *Recycle*) system (Hidayat et al. 2020).

Regulations related to household waste management are also regulated in Presidential Regulation Number 97 of 2017 concerning National Policy and Strategy for the Management of Household Waste and Similar Household Waste, which states that 3R-based waste reduction can be carried out at 3R Temporary Waste Disposal Sites. The Yogyakarta City Government also regulates waste management in Yogyakarta City Regional Regulation Number 1 of 2022 concerning Amendments to Yogyakarta City Regional Regulation Number 10 of 2022 concerning Waste Management and Yogyakarta City Mayor Regulation Number 32 of 2023 concerning Yogyakarta City Waste Management Masterplan for 2022 – 2031 which stated that waste handling is prioritized at 3R Temporary Waste Disposal Sites. Based on 2022 KLHK data, the number of 3R Temporary Waste Disposal Sites in Yogyakarta City is 12 depots with active status, one of which is 3R Temporary Waste Disposal Sites Nitikan RT.43/RW.11, Sorosutan, Umbulharjo. RW.11, Sorosutan, Umbulharjo. 3R Temporary Waste Disposal Sites are an alternative to reduce waste before it is transported to the final processing place.

3R Temporary Waste Disposal Sites is a place for collecting, sorting, and recycling waste on a regional or communal scale (Aprizon 2019, Rizki Aziz 2019). The waste transportation process using a transfer system (TPS/TPS 3R) can be carried out using an indirect system or using a Hauled Container System (HCS) lifting container system or a Stationary Container System (SCS) fixed container system (Fauziah et al. 2022). The 3R Temporary Waste Disposal Sites program is aimed at supporting environmental policies so that they can create sustainable *development*. 3R Temporary Waste Disposal Sites is a communal scale waste management approach that requires participation from the government and community. Waste management with the 3R system emphasizes reducing, utilizing, and processing waste starting from the source (residential areas, commercial areas, office areas, educational areas, tourist areas, etc.). Waste handling with the 3R system must also be supported by the availability of good waste transportation. The availability of waste transport and waste transport management greatly influences waste management (Prdiftha 2020). This opinion is in accordance with the statement (Gusti et al. 2019) that the waste transportation process is an important stage in waste management. So, adequate transportation facilities are needed to transport waste from upstream (waste source) to downstream (final disposal site). This research aims to understand performance and waste transportation management and evaluate the level of waste management and sustainability of waste management at 3R Temporary Waste Disposal Sites Nitikan.

MATERIALS AND METHODS

The type of research used in this research is descriptive with a qualitative approach. Qualitative research is intended to understand phenomena that occur and are described in the form of words. The application of qualitative research in this study was used to comprehensively explain the performance of waste management at 3R Temporary Waste Disposal Sites Nitikan, Umbulharjo, Yogyakarta City. The research was conducted from February to May 2024.

The sampling technique in this research used the purposive sampling method. Sample determination was carried out using the Slovin Formula. The respondents selected were residents who had lived in the area for ≥ 5 years. The selection of these criteria was carried out with the hope that respondents would have a good understanding of regional conditions. The population of Sorosutan Village is 15,397 people. Based on sample calculations using the Slovin formula, the sample used was 99 respondents. The data collection phase is collected through two methods, namely primary and secondary data. Primary data was obtained through interviews, observations, and questionnaires at 3R Temporary Waste Disposal Sites Nitikan in Sorosutan

Table 1: Types and Sources of Data.

No	Data	Data Type	Data source
1.	Exiting condition of 3R Temporary Waste Disposal Sites Nitikan	Secondary	3R Temporary Waste Disposal Sites Nitikan Manager
2.	3R Temporary Waste Disposal Sites Nitikan Performance (Technical and Institutional Aspects)	Secondary	Data on Temporary Waste Disposal Sites3R facilities and infrastructure and organizational structure
3.	The volume of waste generation	Secondary	Yogyakarta City Environmental Service
4.	Waste transportation patterns and vehicle types	Secondary	3R Temporary Waste Disposal Sites Nitikan Manager
5.	Data on community participation in the management and transportation of 3R Temporary Waste Disposal Sites Nitikan waste	Primary	Questionnaires and interviews

Village, Umbulharjo District, Yogyakarta City, regarding waste management and transportation. Details of primary and secondary data in this research are presented in Table 1.

Data Analysis

Waste transportation: 3R Temporary Waste Disposal Sites waste transportation is analyzed based on SNI 19-2454-2002 regarding Operational Technical Procedures for Urban Waste Management.

Analysis of incoming managed, and unmanaged garbage data: In waste management at 3R Temporary Waste Disposal Sites Nitikan, data regarding incoming and managed waste

Table 2: Dimensions and Attributes.

Variables/ Dimensions	Score	Good	Bad	Attribute	Indicator
Technical	0;1;2	2	0	• Waste management	(0) < 60% of planned capacity
		2	0		(1) 60 - 80% of planned service capacity
		2	0		(2) > 80% of the planned capacity
				• Condition of facilities and infrastructure	(0) The condition of the buildings and infrastructure is not functioning
					(1) The condition of the buildings and infrastructure is partially functional
					(2) The condition of the buildings and infrastructure is functioning well
				• Management type	(0) Just a sorting process
					(1) The process of sorting and processing organic waste
					(2) Sorting process, processing of organic and inorganic waste
Institutional	0;1;2	2	0	• Management institution	(0) Individual
		2	0		(1) Department/Village
					(2) Community self-help groups
				• Legality of the institution	(0) Without a notarial deed, the establishment decree is signed by the Village Head, and it is known that the relevant SKPD and there are AD/ART.
					(1) There is a notarial deed still in place, the establishment decree signed by the Village Head, the relevant SKPD is known, and there is AD/ART.
					(2) There is a notarial deed, an establishment decree signed by the Village Head, and the relevant SKPD is known, and there is AD/ART.
				• Management administration	(0) TEMPORARY WASTE DISPOSAL SITES 3R operations were not recorded
					(1) TEMPORARY WASTE DISPOSAL SITES 3R operational records were carried out, but they were not good
					(2) TEMPORARY WASTE DISPOSAL SITES 3R operational records were carried out properly
Society Participation	0;1;2	2	0	• Waste sorting	(0) There is no waste sorting in the household
		2	0		(1) Only some people sort waste
					(2) The whole community sorts waste
				• Retribution	(0) 60% pay contributions on time
					(1) 60 - 90% pay contributions on time
					(2) 100% of people pay contributions
				• Waste management	(0) Waste management into compost and sorting according to type of waste
					(1) Just sorting waste
					(2) Not carrying out management and sorting
Economy	0;1;2	2	0	• Government assistance	(0) There is no operational funding assistance
		2	0		(1) There is minimal operational funding assistance
					(2) There is operational funding assistance as needed
				• Economic improvement	(0) There is no added economic value.
					(1) There is additional economic value in managing TEMPORARY WASTE DISPOSAL SITES 3R
					(2) There is additional economic value at the community level.
				• Waste reduction	(0) There is no economic improvement
					(1) Recycle
					(2) Recycling and sustainability in production and consumption
Ecology	0;1;2	2	0	• Concern about waste management	(0) No concern appears
		2	0		(1) Community service program
		2	0		(2) Active concern
				• Waste sorting	(0) Disrupts environmental aesthetics
					(1) Reduces waste accumulation
					(2) Protecting the environment
				• Environmental Health	(0) Environmental pollution and disease
					(1) Awareness of maintaining sanitation
					(2) Sanitation and reducing piles of rubbish

is recorded every month (kg.month^{-1}). Management involves separating organic and inorganic waste, as well as making compost from organic waste. This data is used to calculate the 3R Temporary Waste Disposal Sites Nitikan Recovery Factor value using the formula:

$$\text{Recovery Factor} = \frac{(garbage\ in - unmanaged\ waste)}{garbage\ in} \times 100\%$$

Categorization of questionnaire data:

a. Scoring

Scoring is used to determine the maximum and minimum scores on a question or item.

Y = *highest score likert scale x number of questionnaire items*

X = *lowest score likert scale x number of questionnaire items*

b. Intervals

Intervals used to determine distance class classification or categorywhich will be used.

$$I = \frac{(Y)-(X)}{number\ of\ categories}$$

c. Percentage Index

Index percentage used for percentage value in determining category class.

$$\text{Index\%} = \frac{total\ score}{Y\ x\ 100}$$

Evaluation of Waste Management Performance

The evaluation was carried out based on the 2020 3R Temporary Waste Disposal Sites Technical Guidelines, using 5 areas, namely supporting regulations, technical, institutional, financial, and community participation. Each field has indicators with the same assessment value, namely 5, 3, and 1. Each field has a certain percentage weight. The scores for each field are added up to get a total score, which is then categorized as very good, good, poor, or poor based on predetermined evaluation criteria.

Analysis of the Sustainability of Waste Management

The sustainability of waste management will be analyzed using *RAPWASTE*. In this research, researchers will analyze and evaluate the sustainability of waste management at 3R Temporary Waste Disposal Sites Nitikan in terms of technical, institutional, community participation, economic, and ecological aspects. The dimensions and attributes in detail can be seen in Table 2.

RESULTS AND DISCUSSION

Analysis of Waste Transport and Management Performance Factors

Aspects of Regulations and Development Plans

Regulations related to waste management and 3R Temporary Waste Disposal Sites are regulated in Yogyakarta City Regional Regulation Number 1 of 2022 concerning Amendments to Yogyakarta City Regional Regulation Number 10 of 2012 concerning Waste Management and Yogyakarta Mayor Regulation Number 32 of 2022 concerning Yogyakarta City Waste Management Masterplan for 2022 – 2031.

Technical aspects: Waste volume management at 3R Temporary Waste Disposal Sites Nitikan is planned to be able to accommodate 10 tons of waste per day, based on data from the Yogyakarta City Environmental Service. 3R Temporary Waste Disposal Sites Nitikan manages 941.15 kg.day^{-1}, meaning this amount is >80% of the planned capacity. Compost production at 3R Temporary Waste Disposal Sites Nitikan is 190.65 Kg.Day^{-1}, which means 70 – 99% of organic waste is processed into compost. Organic waste at 3R Temporary Waste Disposal Sites Nitikan consists of slurry, leaf material, and maggot feed. Furthermore, the indicator for the residual volume of waste to the landfill is 2,242,582.00 of the total segregated waste of 343,519.74, which indicates that there is processing of <40% of the total waste managed.

Institutional aspects: 3R Temporary Waste Disposal Sites Nitikan is managed by the Department/Village of the 3R Temporary Waste Disposal Sites Nitikan area. The management of 3R Temporary Waste Disposal Sites is equipped with an organizational structure and functions actively.

Financing aspects: The financing or financial aspects at 3R Temporary Waste Disposal Sites Nitikan receive operational funding assistance from the government according to needs.

Aspects of Community Participation

The 3R Temporary Waste Disposal Sites Nitikan customer community actively participates in membership. This active participation is demonstrated by awareness of sorting waste, even though not all people do this. Then, in terms of community contribution indicators, around 60 – 90% of people pay their contributions on time. Regulations related to the Yogyakarta City Regional Waste Levy are regulated in Yogyakarta City Regional Regulation Number 21 of 2012 Cleaning Levy. Payment of waste levies, especially for 3R Temporary Waste Disposal Sites Nitikan, is IDR. 2,500 – Rp.

3,000 for private parties who collect waste using carts. The economic impact felt due to the existence of 3R Temporary Waste Disposal Sites Nitikan is in the form of added value or the increase in value of goods whose benefits have been lost, then added value is given so that they have use value (Amalia 2020). The results of this study are in accordance with research conducted by (Oyebode & Abdulazeez 2023), which states that the community does not carry out proper sorting. In addition, most correspondents prefer the inclusiveness of scavenger garbage collectors for various reasons ranging from laziness to not having time.

Waste Transport Patterns in Nitikan Village, Umbulharjo District, Yogyakarta Special Region

The waste collection process is carried out by collecting waste from waste sources using transport vehicles such as waste carts to the Transfer Depo or waste containers, and then the collected waste will be transported by dump trucks or armroll trucks to 3R Temporary Waste Disposal Sites Nitikan. The availability of waste transportation and waste transportation management greatly influences waste management (Pradiftha, 2020). Based on data from the Yogyakarta City Environmental Service, the amount of waste transported to the landfill was 181.37 tonnes.day^{-1}. Garbage transportation in Nitikan Village, Umbulharjo District, is carried out using several vehicles such as pick-ups, arm roll cars, and dump trucks. Transportation using the *Stationary Container System* (SCS) system is influenced by the number of officers on duty during transportation (Putri et al. 2023, Gustiabani et al. 2023). Transport vehicles with a lifting system (Hauled Containared System) have advantages over fixed system transport vehicles (Stationary Containared System) in terms of transport time per trip (Dzakwan et al. 2020).

Evaluation of Waste Transport Performance

The amount of waste entering 3R Temporary Waste Disposal Sites Nitikan in 2023 is 2,700,947.75, with an average of 225,078.98 and a total of 7,399.86 kg.day^{-1}. Then, the amount of residual waste was 6,144.06 kg.day^{-1}, and the total segregated waste was 941.15 kg.day^{-1}. The amount of waste generation that enters 3R Temporary Waste Disposal Sites Nitikan, if it is assumed that using 1 m^3 of waste is ¼ ton of waste, then the waste generation at 3R Temporary Waste Disposal Sites Nitikan is 29,600 m^3 or around 81 m^3.day^{-1} and the potential for waste accumulation is 38,429.5 L.day^{-1}.

Waste Management Performance Evaluation

Evaluation of waste management performance at 3R Temporary Waste Disposal Sites Nitikan was carried out in several areas, namely regulatory, technical, institutional, and community participation in accordance with research conditions. Each indicator has the same assessment level, namely 5.3 and 1. Then, the scores for each aspect will be added up into the categories Good (>19.0), Medium ($\leq$19.0-9.50), and Bad (< 9.5). Relative scores in waste management evaluations are used to determine areas in the good, medium, or poor categories. The relative value is obtained by multiplying the field value and the weight. In the regulatory sector, the relative value is 0.8 points, the technical sector is 7.8 points, the institutional sector is 4.6 points, the financial sector is 0.25 points, the community participation sector is 1.95 points, and the total relative value is 15. 4. So, the evaluation of waste management performance is included as Medium.

Percentage of Waste Processing and Transport Indicators

The age level of respondents in this study was dominated by people aged 20-30 years. At this age, people tend to use their time more often to read and develop their intellectual abilities. This is as per the results of research by Suwaryo et al. (2017), which states that at the age of 20 - 35 years, individuals will play a more active role in society.

The waste management indicator shows a good category with a percentage of 82%. Public knowledge regarding waste management can be influenced by information obtained regarding how to process organic and inorganic waste (Dalimuthe & Nasution 2022). Then, research conducted by (Agyustia 2022) with a percentage related to waste knowledge of 80% shows that there is a need to increase information regarding household waste management through socialization.

The public knowledge indicator shows a good category with a percentage of 84%. This is in line with research conducted by (Nurin et al. 2021), where 90% of people actively participate in waste sorting, which means that people are aware of the impact that waste will have on the environment and health. The waste processing facilities indicator gets a percentage of 84% and is included in the good category. The results of this research are as per the research conducted by (Niskiya & Zalmita 2023), which states that in the waste management process, which involves the utilization and use of facilities and infrastructure, the government provides facilities in the form of placing waste containers for organic and inorganic waste, moving and transporting waste and processing waste to processing. In the waste transportation indicator, the percentage value is 83% and is included in the good category.

Waste Incoming, Managed, and Residue at 3R Temporary Waste Disposal Sites Nitikan

3R Temporary Waste Disposal Sites Nitikan received 2,700,947.75 rubles with a monthly average of 225,078.98 kg.month^{-1}. Total incoming waste is 225,078.98 kg.month^{-1}, residual waste is 186,881.83 kg.month^{-1}, and total segregated waste is 28,626.64 kg.month^{-1}. The recovery factor value is obtained from waste that can be composted and resold. Based on the calculation results, the recovery factor for 3R Temporary Waste Disposal Sites Nitikan is 16.9% of the total incoming waste for 1 year. The recovery factor can be used as a form of waste reduction as well as increasing the use value and economic value of waste (Syafrudin et al. 2020).

Analysis of the Sustainability of Waste Transportation and Management at 3R Temporary Waste Disposal Sites Nitikan

Technical dimensions: RAPWASTE analysis of the sustainability index in the technical dimension produces a value of 73.09 with a *Stress value* of 0.32. This value is included in the quite sustainable category because, based on the index value, it is between 50 -75. Meanwhile, the results of *the Leverage of Attributes* sustainability analysis in the technical dimension show that the waste management attribute value has the highest value, namely 15.18. The results of this research are in accordance with research conducted by (Gifari et al. 2023), which states that 72% of people have reduced the volume of waste (Fig. 1).

Institutional dimensions: RAPWASTE analysis of the sustainability index on the institutional dimension produces a value of 83.98 with a stress value of 0.29. This value is included in the very sustainable category because, based on the index value, it is between 75 - 100. Meanwhile, the results of the Leverage of Attributes analysis of sustainability in the institutional dimension show that the attribute value of the management institution is (12.72), the legality of the institution is (12.16), and management administration is (6.79) (Fig. 2). In this institutional dimension, for management institutions, collaboration between institutions such as the private sector and environmentally concerned communities is needed, which can encourage improvements in the quality of public services (Sukwika & Noviana 2020). Apart from that, the opinion of Gifari et al. (2023) stated that laws and regulations have an important role in making waste management decisions. The existence of national laws and regional regulations that apply should be strictly implemented so that they can have an impact on the amount of waste produced, the irresponsible use of various single-use plastic products, and the mixing of various types of waste (Latugan et al. 2024).

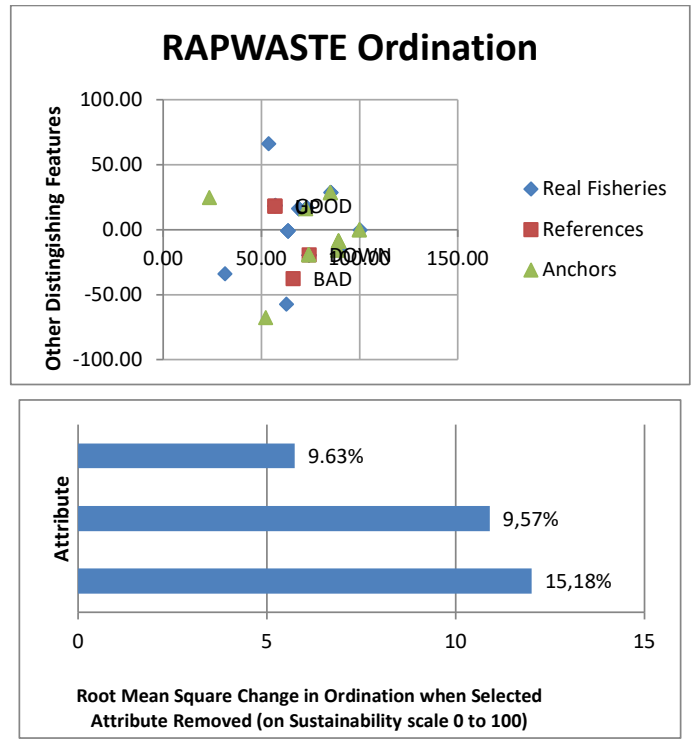

Fig. 1: RapWaste Graph and Leverage of Attributes on Technical Dimensions.

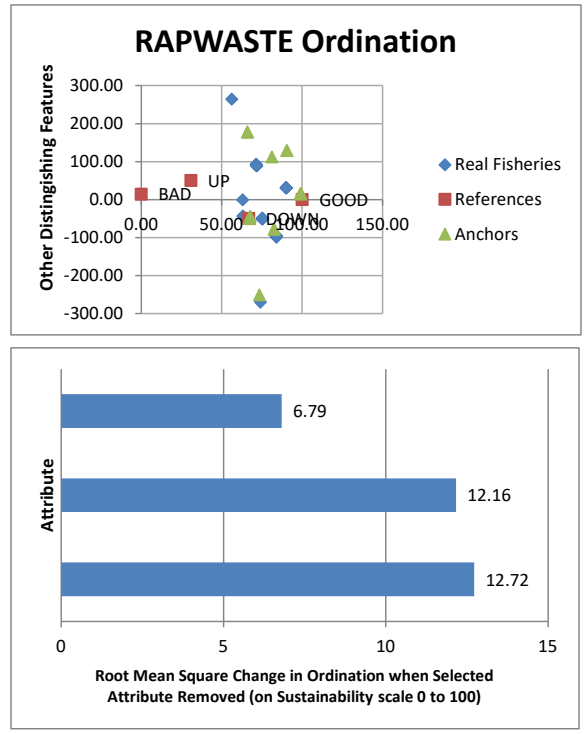

Fig. 2: RapWaste Graph and Leverage of Attributes on Institutional Dimensions.

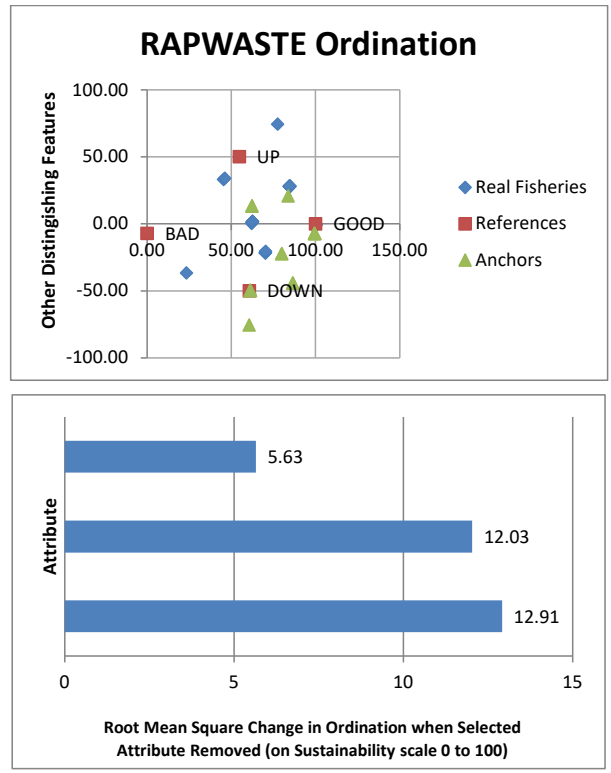

Fig. 3: RapWaste Graph and Leverage of Attributes on Dimensions of Community Participation.

Dimensions of community participation: RAPWASTE analysis of the sustainability index on the community participation dimension produces a value of 100 with a stress value of 0.27. This value is included in the very sustainable category. Meanwhile, the results of the Leverage of Attributes analysis of sustainability in the institutional dimension show

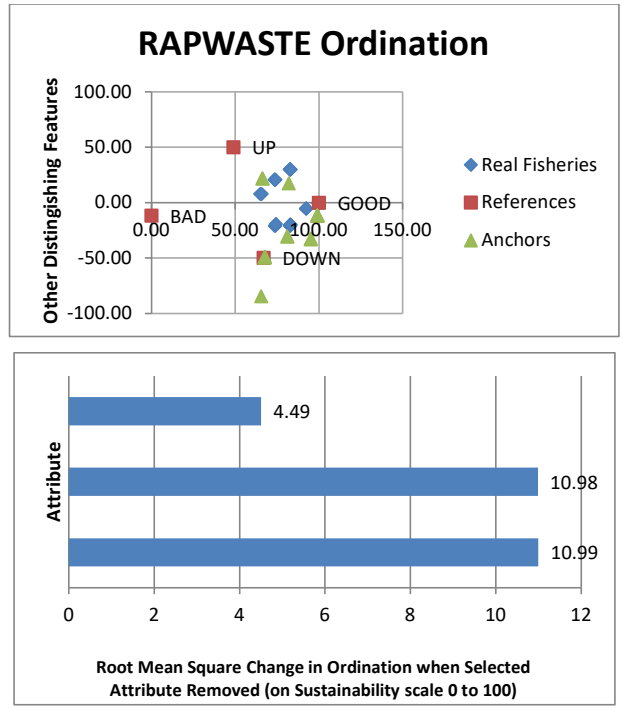

Fig. 4: RapWaste Graph and Leverage of Attributes on Economical Dimensions.

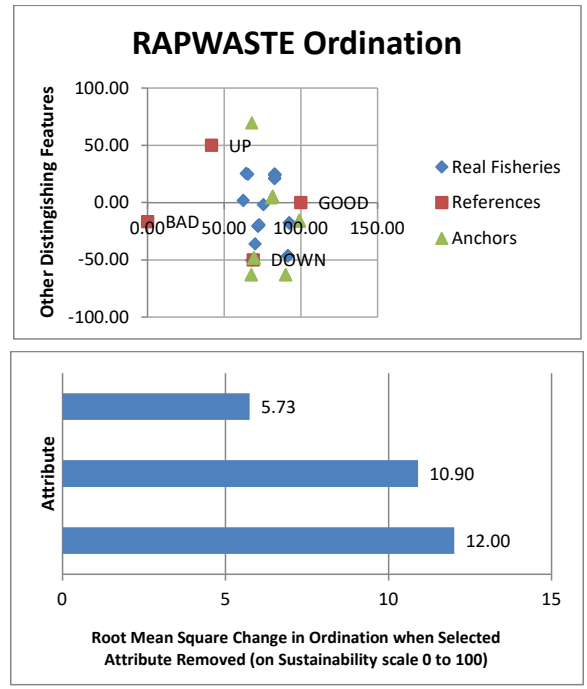

Fig. 5: RapWaste Graph and Leverage of Attributes on Ecological Dimensions.

the attribute values for waste sorting by the community (12.91), retribution (12.03), and waste management (5.63) (Fig. 3). Amalia (2020) stated that the main factor driving people to recycle is the internal motivation of the individual. So, it is important to carry out programs to form and support this program.

Economic dimensions: RAPWASTE analysis of the sustainability index in the economic dimension produces a value of 73.73 with a stress value of 0.29. Leverage of Attributes sustainability in the dimensions of government assistance (10.99), economic improvement (10.98), and waste reduction (4.49) (Fig. 4). This waste reduction activity is included in a circular economy with the principles of reducing waste and pollution, preserving used products and materials as long as possible, and regenerating natural systems (Otivriyanti et al. 2023).

Ecological dimensions: RAPWASTE analysis of the sustainability index in the economic dimension produces a value of 64.39 with a stress value of 0.32. As for the results of the Leverage of Attributes analysis of sustainability in the dimensions of awareness of waste management (12.00), waste sorting (10.09), and waste reduction (5.73) (Fig. 5). Based on the two most prominent attributes, namely concern for waste management and waste sorting. The community is one of the important elements in realizing this concern (Idris et al. 2023).

CONCLUSIONS

The conclusion of this research is that performance in technical aspects consists of waste management, condition of facilities and infrastructure, type of management, condition of equipment, compost products, and volume of waste residue. Waste volume management at 3R Temporary Waste Disposal Sites Nitikan is 941.15 $kg.day^{-1}$. The type of management is the process of sorting and processing organic and inorganic waste with sufficient supporting equipment. Compost production at 3R Temporary Waste Disposal Sites Nitikan was 190.65 $Kg.Day^{-1}$. Institutional aspects: 3R Temporary Waste Disposal Sites Nitikan is managed by the Department/ Village in the 3R Temporary Waste Disposal Sites Nitikan area. In the aspect of community participation, some people are active in sorting waste and paying fees, and there is an economic impact in the form of added economic value. Waste transportation management at 3R Temporary Waste Disposal Sites Nitikan is carried out using *a Stationary Container System* (SCS) and carried out in 2 cycles. The evaluation of waste management performance is moderate, with a total relative value of 15.4. Each indicator in the regulatory sector has a relative value of 0.8 points, the technical sector is 7.8 points, the institutional sector is 4.6 points, and the financial sector is 0.25 points. The area of community participation is 1.95 points. The average sustainability status of waste sorting and management at 3R Temporary Waste Disposal Sites Nitikan is 79.03, or very sustainable. The technical attribute index is 73.09, the institutional attribute is 83.98, the community participation attribute is 100, the economic attribute is 73.73, and the ecological attribute is 64.39.

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