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Research Article

Study of Waste Generations and Potential Implementation of Community-Based Waste Management in Residential Area

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ABSTRACT

As Indonesia's population and community needs rise, solid waste management remains a significant issue, evidenced by Bogor city, a densely populated region near Jakarta, where despite government efforts to introduce a new waste management paradigm, residents, particularly in elite areas, persist in an outdated collect-transport-throw approach, leading to increasing waste generation since 2005 and consequent waste accumulation in disposal sites. Therefore, a study was conducted to determine the waste generated and the perception and role of community participation in managing waste, especially household waste in elite residential areas. In this study, data was collected form one of the elite residential areas in Bogor. The analysis used quantitative descriptives analysis and referring to Indonesia National Standard (SNI) 19-3964-1994 for collecting the waste in residents. This study examines household waste generation in Pakuan Regency by house size. Findings reveal small houses produce 293.25 kg of waste yearly, medium houses 372.95 kg, and large houses 533.08 kg. All house types predominantly generate organic waste from cooking and eating. Regarding waste management, small and medium houses prefer separating waste and paying fees, while large houses prefer only paying. In elite residential areas, systems generate consistent revenue, preventing free-riders. The operational and investment costs of 3R Water Treatment Facilities are offset by this revenue, suggesting the viability of 3R Water Treatment Facilities waste management in elite areas of Pakuan Regency.

Keywords : Waste Household; Residential Communities; Operational Cost of 3R; Waste Treatment Facilities

INTRODUCTION

Population growth and development of land resources in urban areas have posed problems, particularly in the increasing volume of waste (Maalouf & Mavropoulos, 2023). Based on the Indonesian Law No. 18 of 2008 on Waste Management, it is stated that waste is the residue of human daily activities and/or natural processes in solid form. The largest source of waste generation is household waste (Nwachukwu et al., 2018; Lozano Lazo et al., 2023; Riruma et al., 2021). Household waste issues originally started with the increasing development of housing and residential

construction as waste generators (Aprilia, 2021; Jereme et al., 2015; Mulasari, 2013; Prema, 2021). Waste management must be accompanied by systematic, comprehensive, and sustainable activities that include waste reduction and handling at its source (Atmanti & Kadang, 2022; Da Costa & Bowo Suharto, 2018; Elamin et al., 2018).

Bogor city, as a supporting city of the capital city, has experienced rapid housing development (Ramdahan & Hermawan, 2022). Based on data from the Bogor city government, Bogor city delivers 70% of waste or nearly 700 tons (SIPSN, 2021) directly to the landfill with the majority of waste generated from housing areas (Sa'diyah et al., 2020). The management of residential waste is mostly still using the old paradigm of collection-transportation-disposal, which needs to be improved to a new paradigm of sorting and recycling (Haswindy & Yuliana, 2018). Implementation of the new paradigm in waste management requires the role and participation of the community. Reducing waste production at its origin is the most effective strategy to solve waste accumulation in housing areas (Shen et al., 2020). Therefore, research was conducted to determine the potential for community-based waste management implementation that can be carried out in residential areas especially for elite resident. Community-based waste management activities such as Reduce Reuse and Recycle (3R) waste bank at Waste Treatment Facilities can reduce waste volume by 40%. It has been reported that the waste bank in Malang, East Java, can reduce waste by 663,729 kg/year (Pratama & Ihsan, 2017). 3R Waste Treatment Facilities also can optimize the waste of management in North Celebes (Wulandari et al., 2021).

The application of Reduce Reuse, Recycle (3R) is the best strategy in solid waste management (Al-Dailami et al., 2021). Resident participation in waste management system is vital to ensure effectiveness because residential are considered the most dominant waste producers in Municipal Solid Waste Management (Ghazali et al., 2021). Also, increasing awareness to participate for waste management should be altogether with building supportive infrastructure (Brotosusilo et al., 2022). Recycling activities in a region will be successful if the entire community and rule-makers can work and cooperate together. Waste recycling has great potential to reduce waste generation and improve the environmental quality in that area. This has been implemented in elite residential areas in Selangor, Malaysia (Jereme et al., 2015). A waste reduction system will be highly effective if residential areas have adequate waste management plans and good recycling infrastructure. A study in one of the housing estates in Shah Alam, Malaysia, revealed that a good waste management system should start from the housing developer so that residents will follow the waste management system provided (Saleh, 2018). Community should be involved in program such as recycling, composting, and an understanding of environmental responsibility (Raghu & Rodrigues, 2020).

The research on waste management and processing has been conducted quite extensively, however there is a still a lack of focus on the potential of waste management in residential areas, especially in elite housing. According to the Pays Pollutes Principle (PPP), elite housing should implement waste management with a zero-waste concept, such as the 3R (Reuse, Reduce and Recycle) waste management system, because elite housing has the necessary resources to support it. Therefore, this research is conducted to assess data and issues related to the potential implementation of the 3R waste management system in residential areas, which is expected to serve as a basis for housing developers in constructing facilities and infrastructure like the 3R waste management system in those residential areas especially elite housing. The analysis of waste management potential in elite housing will be conducted by estimating the waste generations in elite household units according to the houses types, referring to the Indonesia National Standard (SNI) 19 – 3964 -1994. It will also evaluate the perceptions and participation of residents in Pakuan Regency housing, specifically concerning the enhancement of waste management practices using the 3R systems.

METHODS

Study Area

This research was conducted in an elite residential area located on the border of Bogor City and Bogor District (Figure 1), known as Pakuan Regency. Pakuan Regency was chosen as the research location because it has residents with a high middle – income, available resources that can be utilized, and potential for waste management development due to the presence of waste segregations activities and waste banks. Moreover, it is still in the middle of development, allowing the implementation of proper waste management. It represents elite residences that lack good facilities and infrastructure for waste management.

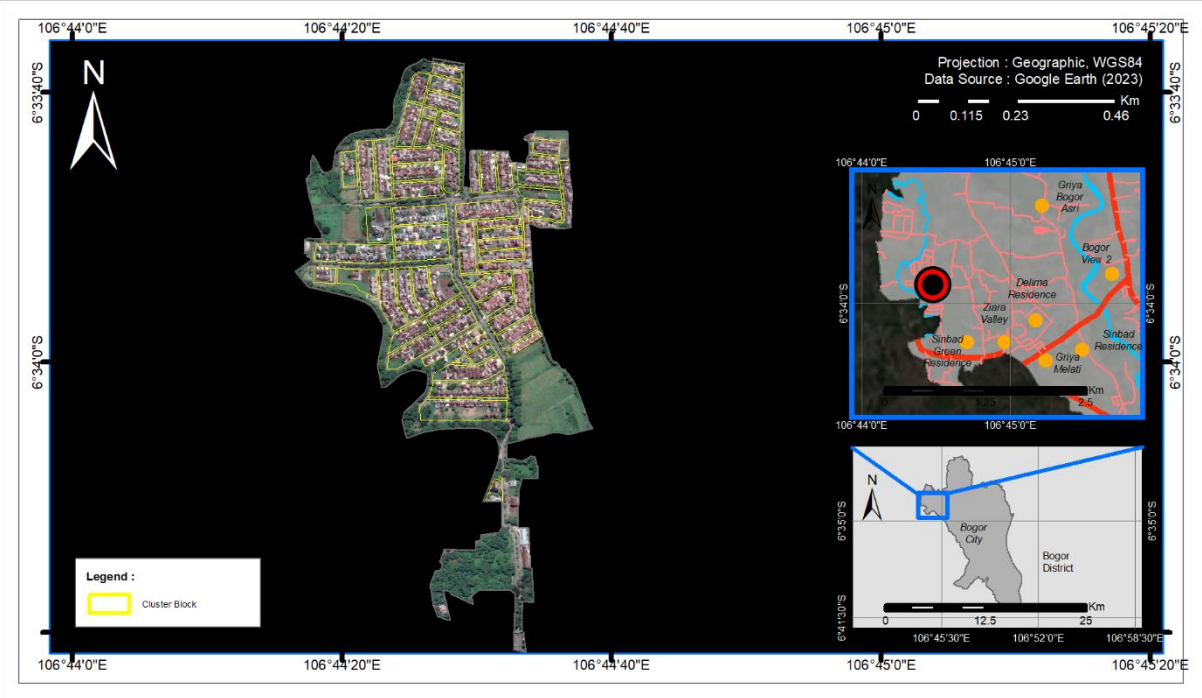

Figure 1. Study area

Data Collection Technique

The population in this study were household in Pakuan Regency. The determination of the Data was collected through field surveys and in-depth interviews with local residents and key persons. Sampling used a random cluster sampling. where the sample was selected directly by considering certain aspects, namely, residents who live with waste management carried out in the cluster area (Suharsaputra, 2012). The Slovin formula for determining the sample can be seen below (Limon et al., 2020) :

$$n = \frac{N}{1+ Ne^2} \quad (1)$$

where n is the number of samples required, N is the number of population and e is the amount of error taken by researcher. In this research, researcher took 10% as amount of error. Based on eq. (1), the sample amount is the number of population N and e as a critical value. Pakuan Regency housing population in 2020 is 1109 households with an error of 10%. Then the number of respondents for perceptions for filling out the questionnaire was obtained from as many as 92 families among the entire cluster. Households were grouped into house with small type, medium type and large type. The calculation of waste generation in household samples was referred to SNI

– 19 – 3964 – 1994 on Methods of Collection and Measurement of Samples of Generation and Composition of Urban Waste. The load count analysis method is a way to measure the quantity (either in weight or volume) of waste that enters the transfer station, such as 3R Waste Treatment Facilities (Safira et al., 2021)

The data used in this study comprises primary data that includes data on waste generation analysis, household participation in waste sorting and willingness to Pay (WTP) for the 3R Waste Tretament Facilities plan. While the secondary data was obtained from data related to household waste management in Bogor area and Pakuan Regency.

Waste Generation Analysis

Waste generation is the volume or weight of waste generated from certain sources from a certain area per unit time (Suciutami et al., 2022). Waste generation is caused by the large amount of residue or results from daily human activities at a certain time with units of weight (kg) and volume (L) (Demirarslan & çelik, 2018).

Methods and timing of collection of data on solid waste generation is referred to SNI 19 – 3964 – 1994 concerning Methods for Taking and Measuring Samples of Generation and Composition of Municipal Solid Waste. Data collection will be carried out seasonally, namely on weekends and weekdays. Garbage collection will be carried out within 8 consecutive days.
Respondents for this waste collection will be taken as many as 36 households from the previous questionnaire respondents based on eq. (1), distinguished by clusters that have not managed waste and the types of houses owned will be named as large, medium and small sizes. Then to determine the types of large, medium and small houses seen from the shape of the house occupied, namely (Isnaeni & Dewi, 2018):

a. Large Type, has a land area of and has 2 floors
b. Medium Type, has a land area of ± 100 m2 and has 1 – 2 floors
c. Small Type, has a land area of less than±100 m2 and has 1 floor,

The calculation of the average waste production will refer to SNI 19-3964 – 1994. The unit for the amount of waste generation per house is kg/day. The average waste generation is the division between the total waste generation per day in all samples to the number of wastes generating units. The calculation of the average waste generation for each household is as follows:

$$RT_S = \frac{\sum B_S}{\sum U_S} \quad (2)$$

Where RT_S is the average waste production (kg/house/day), B_S is the weight of waste in a day (kg/day) and U_S is the number of waste generating Units (Houses). After obtaining the average household waste generation, the total waste generation calculation is carried out. Total waste generation shows waste generation in the entire household population in each category. Calculation of estimated waste generation is as follows:

$$TT_S = (RT_S)_i \times KK \quad (3)$$

Where TT_S is the Total Waste generation (kg/day), RT_S is the average waste generation based on the category (kg/house/day), KK is the total number of households for each waste generating category (house). Waste generation in one years is obtained by calculating the total waste generation with the number of days in a year. The equation used to calculate waste generation per year is as follows:

$$T_S = TT_S \times d \quad (4)$$

Where d, is the number of total days in a year (365). In addition to waste generation, the

composition of solid waste is also calculated. Measurement of waste composition is a sorting based on the components of solid waste, such as plastic, metal, paper, glass and other components. According to SNI 19-3964 – 1994, the composition of waste is measured by weighing each component of the waste that has been sorted. Once the weight of the waste components is obtained, it is then divided by the total weight of the waste as a whole. The formula for calculating the composition of waste is as follows.

$$\%Composition: \frac{B_i}{TB_i} x\ 100\ \% \quad (5)$$

Where *Bi,* is the total weight of each component of *i*-household waste (kg) and *TBi* is the total waste of *i*-household (kg).

Willingness to Pay

The value of willingness to pay (WTP) or household willingness to pay for fees related to the implementation of 3R waste management in Pakuan Regecny using the Contingent Valuation Method (CVM) is determined. CVM is an economic valuation method through direct questioning of an individual's willingness to pay where the WTP value obtained comes from personal choice of individuals each of which has a variable characteristic of price or cost (Fauzi, 2014). The stages of determining the WTP value are as follows:

1. Construction of a Hypothetical Market

The waste management system in Pakuan Regency Housing is currently using the collection-transport-disposal system, it is expected to be directed towards sustainable waste management, namely waste management with 3R Waste Treatment Facilities. Household waste can be processed and utilized at the 3R Waste Treatment Facilities, where organic waste from food leftovers can be processed into temporary fertilizer, and inorganic waste can be recycled or sold.

A hypothetical market is created based on the scenario that all residents agree to have 3R Waste Treatment Facilities. The purpose of establishing these facilities is to reduce the amount of waste so that the landfill does not quickly accumulate. The benefits of 3R Waste Treatment Facilities in residential areas also include making the environment cleaner and healthier, as waste will be processed and reused at the facilities. Furthermore, the management of waste through 3R Waste Treatment Facilities can increase the participation and awareness of residents in managing waste in their own homes. The existing suboptimal waste banks can also develop well in line with the establishment of 3R Waste Treatment Facilities. The implementation of these facilities in residential areas will be beneficial for housing developers in terms of the value of the properties, as residents or prospective residents will be confident that the chosen housing adheres to the zero waste concept, where waste is processed at its source before entering the landfill.

2. WTP Value Offer

The method used to obtain the WTP value offer was a bidding game (WTP auction), where households are repeatedly asked whether they want to pay a certain amount or not and this value can be raised or lowered (Fauzi 2014). The initial offering price is IDR 10,000.00/month with a bidding increment/decrement of IDR 5,000.00 and a maximum limit of IDR 50,000.00/month, which is obtained from the current monthly sanitation fee.

3. Estimating the Average WTP

The WTP value obtained was then averaged with the following calculation formula (Nurpagi et al., 2022):

$$EWTP = \frac{\sum_{i=1}^{n} Wi}{n} \quad (6)$$

Where *EWTP* is the estimate of WTP average, *Wi* is the WTP value of respondent *i*, *n* is the number of total respondents and *i* is the number of *i*-respondent who is willing to pay retribution for the 3R Waste Treatment Facilities plan in Pakuan Regency.

RESULTS AND DISCUSSION

Waste generation in residential area is on the increase due to increase in waste sources caused by population growth and developing area. The waste management carried out in Pakuan Regency Housing is very diverse, but generally what is carried out is a transport-disposal system without any collective selection. In addition, based on the direct interview there are several houses that implement organic waste management by composting, and for inorganic waste it is collected in a waste bank.

Waste Generation in Pakuan Regency Housing

Table 1 shows that the residential waste analyzed in Pakuan Regency Housing focuses on solid waste. The highest waste generation value comes from large houses with 1.46 kg/house/day, whole of the smallest waste generation value comes from small houses with 0.8 kg/house/day, with an average of 0.2 kg/person/day. It is observed that waste generation in residential areas primarily focuses on solid waste. Measurements and calculations conducted on different types of houses revealed that smaller houses produce the least amount of waste compared to larger and medium-sized houses. Waste generation measurements are influenced by the consumer behavior of residents residing in Pakuan Regency on a daily basis and are expressed in kilograms per day. The larger the house type and the number of residents, the more waste is generated, both organic and inorganic (Brigita & Rahardyan, 2013). The more residents there are, the more organic and inorganic waste produced (Fadhullah et al., 2022). The amount of household waste generated in Pakuan Regency is less than household waste in Babakan Village which is 0,31 kg/person/day (Nurpagi et al., 2022) and also is less than household waste in Rungkut District, Surabaya which is 0,27 kg/person/day (Ratya & Herumurti, 2017).

Table 1. Residential Waste Generation per Day

House Type	Waste Generation (kg/house/day)
Small House (SH)	0.8
Medium House (MH)	1.02
Large House (LH)	1.46

The measurement results in Table 2 indicate that the estimated average total weight of waste generated per household, according to house types in Pakuan Regency Housing, is 1,199.28 kg per year. Of this, 58% of household waste consists of organic waste, including food waste, leaves, and branches, while the remaining 42% is inorganic waste. Food waste, as a type of organic waste, constitutes the largest portion of waste generated in each household, reaching 693.55 kg per household per year, or 57.8%. In terms of inorganic waste, the largest category is plastic waste, amounting to 229.38 kg per household per year, or 19.1%. The percentage of organic waste is greater than the percentage of inorganic waste. However, based on the type of waste, large houses have the largest percentage of overall waste.

Table 2. The Estimation of the Average Waste Generated in Residential Per Year

Waste Classification	The Average Household's waste (kg/houses/year)			Total average waste
	Small House	Medium House	Large House	(kg/houses/year)
	kg	kg	kg	kg
Inorganic				
Plastic	61.34	65.38	102.67	229.38
Paper	38.66	57.08	81.43	177.17
Rubber	0.18	0.04	0.00	0.22
Metal	5.88	5.64	7.87	19.39
Glass	0.85	3.39	5.36	9.60
Textile	1.32	1.08	0.00	2.40
Hazardous waste	21.66	2..29	20.17	65.13
Total (a)	**129.90**	**155.90**	**217.49**	**503.30**
Organic				
Food waste	162.18	215.89	315.47	693.55
Leaves/non-food waste	1.17	1.15	0.11	2.44
Total (b)	**163.35**	**217.05**	**315.58**	**695.98**
Total waste	**293.25**	**372.95**	**533.08**	**1,199.28**

Various factors can affect the total waste generated. In this study, household income level, number of family members, and waste disposal and management practices are among the factors influencing waste generation. The more family members living in a household, the more waste is generated as a result of more activities that needs fulfillment and lifestyle improvements (Ruslinda et al., 2012). Additionally, larger households tend to have more family members than smaller households. Plastic and food wastes tend to be more abundant in households with larger families based on interviews conducted by researchers with some households that contributed to daily waste collection. Moreover, residents of larger households also employ household assistants which leads to increased waste production due to the use of plastic bags to store food and increased cooking activities. Online shopping also contributes to the total amount of plastic and paper wastes generation (Pratama et al., 2017).

Willingness to Pay (WTP) Analysis

Table 3 shows the household's willingness to pay for the proposed increase in the waste management fee related to the implementation of the 3R Waste Treatment Facilities in the residential area. The results indicate that almost all the respondents are willing to pay the fee, with only a small percentage of them expressing reluctance. Liu et al., (2019) stated that the unwilling and the willingness can be influence from the relationship between environment and the behavior of the community with their waste. Respondents who are not willing to pay the higher fee argue that the current waste management cost is already sufficient and the implementation of the Waste Treatment Facilities 3R is unnecessary.

Table 3. Respondent's Willingness to pay for the implementations of Waste Treatment Facilities 3R in Pakuan Regency

Willingness	Respondents					
	Small House		Medium House		Large House	
Willing	28	88%	29	97%	30	100%
Unwilling	4	13%	1	3%	0	0%
TOTAL	**32**		**30**		**30**	

Based on the two main stages of CVM, which are the construction of a hypothetical market and the provision of WTP values, the next stage is to estimate the average WTP (EWTP) of households in the residential area.

Table 4. Distribution of the average WTP value of household respondents

Respondents	WTP (IDR/household)	Total Respondent (household)	Total WTP (IDR)	EWTP (IDR/month)
	(a)	(b)	d = (axb)	e = (d/c)
Small House	10,000	22	220,000	13,571
	25,000	4	100,000	
	30,000	2	60,000	
	35,000	0	-	
	50,000	0	-	
Total (c)		**28**	**380,000**	
Medium house	10,000	5	50,000	25,172
	25,000	15	375,000	
	30,000	5	150,000	
	35,000	3	105,000	
	50,000	1	50,000	
Total (c)		**29**	**730,000**	
Large House	10,000	10	100,000	26,000
	25,000	6	150,000	
	30,000	4	120,000	
	35,000	6	210,000	
	50,000	4	200,000	
Total (c)		**30**	**780,000**	
Total EWTP		**87**	**1,890,000**	**21,724**

Table 4 shows that the Estimated Willingness to Pay (EWTP) value for households with medium-sized houses is higher (Rp 25,172) compared to the EWTP values for small and large houses (Rp 13,571; Rp 26,000). The difference in EWTP values is based on the willingness to pay for fees shown in Table 3, where households with medium-sized houses have a higher willingness to pay compared to other house types. The fee rates issued are in accordance with the Minister of Home Affairs Regulation No. 7 of 2021, where households in the medium category are required to pay a waste bill amounting to Rp 13,495. The proposed fee for residential area is higher than a regular households (Nurpagi et al., 2022). Regular households are willing to pay a fee of around IDR 14,761 as there is no set fee for them, while the residential areas have a set rule for monthly fees, ranging from IDR 30,000 to IDR 50,000, compared to the fee for regular households that ranges from IDR

5,000 to IDR 10,000. This suggests that household's willingness to pay is affected by the type of house they reside in and the regulations that apply to them.

Potential for 3R Waste Treatment Facilities Implementation in Pakuan Regency

The 3R Waste Treatment Facilities (TPS) can be implemented if the incoming funding is sufficient. The estimated cost of implementing the 3R Waste Treatment Facilities consists of the initial investment cost and operational costs. The initial investment cost includes 1) building construction expenses; 2) infrastructure construction expenses; 3) equipment procurement expenses (Ministry of Public Works, Republic of Indonesia, 2013). The investment cost is derived from the funds allocated by the Directorate General of Housing and Urban Development, Ministry of Public Works and Housing in 2021 for Community-Based Infrastructure Activities in the Sanitation Sector. Each location of the urban 3R Waste Treatment Facilities received a total of Rp. 600,000,000.00. The operational costs include labor wages, fuel costs, facility and machine maintenance for waste shredding in the 3R Waste Treatment Facilities. These costs are adjusted based on the waste capacity that the 3R Waste Treatment Facilities can handle, which is 1 ton per day, with service coverage for 500-1000 households in new residential area (Minister of Home Affairs Regulation PUPR, 2021). The operational costs will be covered by the fees collected from the beneficiary households. The investment and operational costs of the implementation and operation of the 3R Waste Treatment Facilities can be seen in Table 5.

Table 5. Estimated investment and operational costs of the planned 3R Waste Treatment Facilities

No	Cost Type	Detail	Cost (IDR)
1	Investment Cost [4]		600,000,000
Total Investment Cost (20 years operational) [4]			600,000,000
2	Operational costs		
	a. Labor force	6 individuals @IDR. 1.500.000[2]	108,000,000
	b. Fuel	Motorcycle 3 unit @IDR 100.000,00[3]	7,200,000
		Chopping Machine 3 unit @IDR 100,000[3]	3,600,000
	c. Maintenance	5% from the investment cost	
		Motorcycle 3 units @(IDR 38,000,000)[1,4]	7,500,000
		Chopping Machine 3 units @(IDR.50,000,000)[1,4]	5,700,000
	d. water, electricity and other operational	@IDR.350,000/month	4,200,000
Annual Operational Costs			136,200,000

Sources: [1] = 3R Betoyoguci Gresik; [2]= 3R Griya Melati Bogor; [3]= 3R Griya Wana Karya Kota Bogor; [4]= Technical Guidelines for the Implementations of Labor-Intensive Activities of the Director-General of Human Settlements 2021

The estimation of the waste management cost for 3R Waste Treatment Facilities is calculated based on the WTP of households with different types of houses. Table 6 shows the estimated revenue of IDR 249,287,054/year based on the value of the EWTP for the 3R Waste Treatment Facilities plan, which is more sufficient to cover the annual operational costs of IDR 136,200,000 of the 3R Waste Treatment Facilities Plan (Table 5). The amount of revenue was obtained from the retribution of 1033 households willing to pay the amount of EWTP. The estimation of the annual revenue can be seen in Table 6.

Table 6. The estimation of the annual revenue for 3R Waste Treatment Facilities Implementation in Pakuan Regency

Household Respondents	WTP Respondent (IDR/month)	Total Population	Estimated Income (IDR/month)	Estimated Income (IDR/year)	Estimated 3R Facilities operational cost (IDR/year)	Covering cost (%)
	(a)	(b)	(c=axb)	(d=cx12)	e	f=(dtot/e)*100%
Small House	13,571	459	6,215,714	74,588,571	136,200,000	183.03
Medium House	25,172	442	11,126,207	133,514,483		
Large House	26,000	132	3,432,000	41,184,000		
Total		1033		249,287,054		

According to Table 5, presents the estimated revenue based on household willingness to pay (WTP) for the 3R Waste Treatment Facilities (TPS) plan, amounting to Rp249,287,054 per year. In terms of financing components, the implementation of the 3R Waste Treatment Facilities plan in this housing area has the potential to be carried out because the revenue from household fees can cover the operational costs of the 3R Waste Treatment Facilities, with a service coverage of more than 1109 households (KK), in line with the existing operational costs of 3R Waste Treatment Facilities in Bogor City. Waste management fees are obligatory fees paid as reciprocal services for the services provided by the local government in waste management. The realization of the implementation of the 3R Waste Treatment Facilities requires the involvement of developers in providing a minimum of 200 square meters of land. Developers can collaborate with the Bogor City Environment Agency (DLH) in planning the construction of the 3R Waste Treatment Facilities building, according to the specifications of the Technical Guidelines for 3R Waste Treatment Facilities, issued by the Ministry of Public Works and Housing, Directorate General of Housing and Urban Development (Manupada et al., 2019; Setyoadi, 2018). Therefore, it is recommended to establish a socially acceptable charge that most individuals are willing to pay to prevent the free riding (Yasin, 2021).

It is important to encourage behavior change among households through continues, long – term socialization and education efforts to increase awareness and promote a mature mindset. Socialization and education can be effectively carried out through various media, including the internet and social media such as Whatsapp group, Instagram or Facebook also community activities such as Community Healthcare Center Programs weekly (Posyandu), religious events, weekly meeting of household stakeholders, and many more (Nurpagi et al., 2022). This approach and suggest that such activities can increase community understanding and involvement in waste management (Fadhullah et al., 2022). In addition to community participation, local government commitment and developer are also essential including providing land, infrastructure and facilities in residential.

CONCLUSION

In this residential area, the majority of the waste generated is organic waste from food leftovers. The waste output from large house types is higher compared to small and medium house types. This can be attributed to the fact that larger house types tend to have higher income and consumption levels, resulting in a greater amount of waste compared to smaller house types.The amount of waste generated by households in Pakuan Regency Housing for small house types is 293,25 kg/household/year, 372,95 kg/household/year for medium house types and 533,08 kg/household/year for that of large house types with an organic waste being more dominant than inorganic waste. There is difference in the composition of the waste produced by the house types, where the small house types produced inorganic waste (42.91%) more than medium house types (40.79%) and large house types (39.74%) but for organic waste, large house types produced organic

waste (60.29%) more than small house types (57.09%) and medium house types (54.21%). The implementation of 3R Waste Treatment Facilities (TPS) in Pakuan Regency Residential has shown promise, thanks to the willingness of households to participate and pay for the services. The operational costs can be covered through the community's willingness to pay. However, there may be challenges such as limited land availability or insufficient funding from the Ministry of Housing and Human Settlements of Indonesia. To address these challenges, it is essential to introduce a compulsory waste retribution system and conduct effective socialization and educational programs. By addressing these obstacles and ensuring proper waste management, the 3R Waste Treatment Facilities implementation can contribute significantly to creating a sustainable and environmentally friendly living environment in Pakuan Regency Residential.

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The author thanks the informants in the research area who agreed to be interviewed in this study.

DECLARATIONS

Conflict of Interest

The authors declared that they had no known competing interests.

Ethical Approval

The research has been approved by the Research Committee of IPB University. All research was carried out in accordance with IPB University research ethics guidelines applicable when human participants are involved.

Informed Consent

On behalf of all authors, the corresponding author states that all participants have been given informed consent and agreed to take part in this study.

DATA AVAILABILITY

Data used to support the findings of this study are available from the corresponding author upon request.

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