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

Vol 23, No 2, 2026, 625-637
Article available at homepage presipitasi

Regional Case Study

Environmental Valuation of Mobile MBBR Reactor for Wastewater Management in Non-Rural Area

Nurvita Cundaningsih[1]*, Rizka Novembrianto[1], Kabul Fadilah[2]

[1] Environmental Engineering Study Program, Faculty of Engineering and Science, Universitas Pembangunan Nasional Veteran Jawa Timur, Jalan Rungkut Madya, Gn. Anyar, Surabaya, Indonesia 60294

2 Graduate School of Science and Engineering, Saitama University, 255 Shimookubo, Sakura Ward, Saitama, Japan 338-8570

* Corresponding Author, email: nurvita.c.ft@upnjatim.ac.id

Abstract

Domestic waste remains a problem in Ngagel Rejo Village, Surabaya City, where the community is largely composed of small medium enterprises (SMEs) food traders. This study aims to assign an economic value to domestic waste management services that are not traded in the market. The benefits of deploying a mobile Moving Bed Biofilm Reactor (MBBR) will be estimated to determine the economic value of WWTP siting and to develop a retribution (user-fee) scheme for domestic waste management, particularly for the food waste consortium. A Contingent Valuation Method (CVM) will be used to elicit willingness to pay (WTP) from WWTP users as a measure of the non-use benefits of this public service and its role in reducing the impacts of domestic waste. The analysis yielded a mean WTP value of 3.6827 (as measured in the survey), which corresponds to a recommended fee of IDR 69,496.00 per month for domestic waste management services using a mobile MBBR reactor. Key factors influencing WTP include community commitment to environmental preservation programs and support for the program, consistent with the idea that public engagement strengthens the sustainability of environmental initiatives.

Keywords : Mobile reactor; valuation; wastewater; willingness to pay

1. Introduction

Surabaya is one of the largest cities in Indonesia and has the highest population density. The Environmental Agency is responsible for the environment and has initiated a program to raise awareness of the environment in residential areas. This program to raise awareness about the environment was meant to help the Ngagel Rejo Sub-district, Wonokromo District, Surabaya reach its environmental goals. Environmental awareness has been ongoing for a few years and has won several awards from institutions that work in the field. Some of the key environmental programs include waste banks and communal wastewater treatment plants (IPAL Komunal), which have become flagship programs in several neighborhood units (Rukun Warga or RW) in the Ngagel Rejo Sub-district. One neighborhood unit plans to increase environmental targets in the field of domestic liquid waste treatment, particularly for food waste consortia. This waste continues to be a problem in the densely populated area of the neighborhood unit, which is dominated by food vendors in the Micro, Small, and Medium Enterprises (MSMEs) sector.

Food waste contains high concentrations of fat and oil. According to local authorities, waste has negative impacts, including unpleasant odors and clogged drains due to grease accumulation.

Ultimately, environmental management carried out by the local government in collaboration with the community aims to achieve sustainability targets through declared circular economy activities. The recycling of domestic waste produced by SMEs food vendors and residents is part of the circular economy principle that will function to achieve long-term sustainability goals.

The environmental valuation of waste management also supports local circular economy efforts, with its benefits not being directly reflected in market transactions. During this research, a Mobile Bed Biofilm Reactor (MBBR) was placed in one of the community halls as part of an improvement to local domestic waste management. The benefit value of the mobile reactor will be calculated to obtain the economic value from the placement of the IPAL, thus establishing a fee system for managing domestic waste, particularly for reducing fatty acids in food waste.

An approach using the Contingent Valuation Method (CVM) in the form of Willingness to Pay (WTP) from IPAL users will be implemented to assess the non-use benefits of a public service aimed at reducing the impact of domestic waste. Determining the monetary value of public goods, which do not have a market price, generated through the placement of the mobile MBBR reactor, is necessary to establish an appropriate price for consumers. Payments received will be used to cover the operational costs. This monetary valuation is based on the WTP of Ngagel Rejo Sub-district, Surabaya, residents as consumers. The public goods offered include health, comfort, prestige, and cleanliness. The method used to determine the monetary value is Contingent Valuation.

Contingent valuation is an environmental economics method often used to assess the monetary value of environmental comfort (McGranahan et al., 1998). The use of this method is based on the fact that certain physical aspects of environmental comfort hinder the development of efficient markets in the private sector. This method was chosen because it provides information that can be directly compared with costs in an economic evaluation related to improving specific environmental conditions (Irawan 2019). The results of this comparison are used to determine the monetary value of public goods that lack market prices. Furthermore, contingent valuation is a highly reliable method for economic evaluation related to environmental improvement (Whittington, 2002).

This study focuses on applying the CVM to assess the monetary value of the environmental benefits generated by domestic waste management (food waste composting) in a densely populated area of the Ngagel Rejo Sub-district. The novelty of this research is quite significant because it combines the concept of circular economy with an environmental economics approach through the use of Mobile Bed Biofilm Reactor (MBBR) technology for domestic waste management, which has not been widely applied in the context of densely populated residential areas in Indonesia. In addition, the use of CVM to assess the community's Willingness to Pay (WTP) for the domestic waste management system provides added value in measuring non-market benefits that are not reflected in traditional market prices (Hasbiah et al., 2018).

The community wastewater treatment plant (WWTP) studied in Central Java is called The Guyub Rukun IPAL Komunal. For the Guyub Rukun IPAL Komunal in Salatiga City to function effectively, the community needs to be involved. A SWOT analysis shows that running a communal wastewater treatment facility is a significant strength of good waste management (Wulandari et al., 2024). Ćetković et al. (2022) also discussed the importance of managing wastewater in Nov Dojran, North Macedonia, to achieve environmental benefits. This study incorporates environmental factors into conventional techno-economic assessments by measuring non-market advantages. Cecilia et al. (2024) examined approaches for assessing non-market environmental products, focusing on willingness to pay (WTP) in Indonesia, and utilized choice experiments to ascertain WTP. The findings indicated that users valued enhancements in reactor and pipe network technology, with average WTP values between 0.03–3.13 USD. In another study by Jiao (2024) in China, the WTP was between 8.14 and 9.75 CNY per month. This payment was adequate to cover 47.55% of the maintenance expenditures. This study analyzed effective

payment mechanisms for rural populations, focusing on their willingness to pay (WTP) for rural domestic sewage treatment (RDST) in rural China.

This study examines the indirect advantages that the community gains from residential waste management within the context of the circular economy, in contrast to other studies that primarily focus on market value evaluations. The Mobile Reactor is a new tool that this study employs to help communities deal with environmental problems over time and reduce the negative consequences of food waste, which is high in fat and oil. The cost scheme that emerged from this study is meant to provide a long-term financial model that can be used as a guide for other regions facing similar problems (Miłaszewski, 2021).

This environmental valuation study addresses a deficiency in the literature regarding the application of CVM in Indonesia, particularly in the management of urban residential waste. The CVM has been utilized in numerous studies to assess items not traded in markets within developing nations. This study provides novel insights into the application of the CVM technique in urban settings, particularly for the management of food wastewater in a manner that fosters a circular economy (Do and Frör, 2022; Venkatachalam, 2004). This study aimed to evaluate the economic value of non-market services rendered by a household wastewater treatment system employing a Mobile Moving Bed Biofilm Reactor. This study employs the CVM to evaluate the amount households are willing to pay for enhanced waste treatment services. This helps us determine the usefulness of MBBR technology and how to pay for it in a just way.

2. Methods

This study utilized a quantitative descriptive methodology to assess and analyze the economic value of household wastewater management services using the CVM. The research was conducted in the Ngagel Rejo Sub-district, located in the Wonokromo District of Surabaya City. We chose this location by purposive sampling because it has a lot of people living there, a lot of trash, and a number of small food enterprises (SMEs). This option is a good method for determining what people in the community think about and desire from the MBBR mobile system.

In the first step, a mobile MBBR prototype was set up at the chosen site to explain how the technology works and provide people with a real-life example to utilize when deciding if it is useful. This stage ensured that the people who participated could make smart choices about the new approach to treating wastewater that was being examined. The sampling method used was non-probability convenience sampling. This was used because there was no complete list of the population, and it was important to include people from the community who were directly involved in making food and household waste. The major targets were people who live in the area and SME food vendors who throw out a lot of fat and oil in their wastewater, which is closely related to the goals of this study.

It took approximately one month to obtain information from approximately 90 people. Ten times as many people answered as there were independent factors. The sample size was approximately 10 times the number of research variables in the multivariate analysis, encompassing both correlation and multiple regression (Sugiyono, 2016).

Primary data were obtained from the research subjects, interviews with respondents, and field observations. Secondary data were sourced from references and literature related to the research subject, which were outside the observation area. Data were collected using research instruments in the form of a questionnaire containing Likert-scale questions (Karisyawati et al., 2019). Data were collected in the field using a bidding game questionnaire format. The survey method involved providing respondents with an initial bid value for the fee, which was then adjusted up or down based on their responses.

The CVM was used to ask public goods consumers about the maximum value they would be willing to pay for the quality improvements. There are several stages in conducting CVM, including Building the Hypothetical Market; Estimating the Bid Value; Estimating the Average WTP Value;

Calculating the Bid Value Curve; Calculating the total aggregate of WTP data, and Data Processing of WTP Survey (Chotima and Aji, 2021; Hanley et al., 2009).

The analytical method used in the modeling was based on survey data collected by surveyors and subsequently coded. In this data analysis, descriptive analysis was used on the processed data, employing measures of central tendency and data dispersion, skewness, and kurtosis. The analysis was then continued with the willingness to pay of the respondents.

The first step in the analysis was to clean and organize the data to ensure its validity and accuracy. The next analysis used binary logistic regression with a logit model, utilizing R software to derive a binary logistic regression model for determining the basic fee rate. The logit model is a non-linear regression model in which the dependent variable is categorical and nominal data. This is particularly useful for dichotomous (yes or no) scale data (Firdaus et al., 2021).

The response variable used was the level of approval, while the independent variables were divided into categories of qualitative and quantitative input data. The independent variables classified as qualitative input data included educational level, gender, organizational experience, and income sources. The independent variables categorized under quantitative input data include offers, age, opinions on the mobile MBBR reactor as an improvement in domestic waste management, the role of the mobile reactor in the environmental care program of Ngagel Rejo Subdistrict, the relationship between residents behavior and the environmental care program in Ngagel Rejo, and the willingness to support the environmental care program in Ngagel Rejo. To calculate the average WTP, the following formula (1) can be used:

$$E(WTP) = -\frac{\propto+\Sigma(\beta_i \underline{y}_i)}{\beta_1} \quad \textbf{(1)}$$

In this equation, α represents the constant term, β denotes the slope coefficient, ȳ refers to the mean of the independent variables, and β_1 indicates the slope coefficient of the primary variable. The independent variables used are suitable for the model and are related to the dependent variable.

After obtaining the WTP value from the community through the CVM survey, the next step is to determine the rate to be applied. The rate is set by considering the average or a certain percentile of the WTP, so that it reflects the community's ability and willingness to pay for wastewater management services.

3. Result and Discussion

This study was conducted in the Ngagel Rejo Subdistrict to assess the environmental valuation of a waste management system using a mobile MBBR reactor. In the research process, a questionnaire was used as the main research instrument, and a pilot survey was conducted to examine the validity and reliability of the instrument employed. The questionnaire items were evaluated for clarity and consistency to ensure that the data collected adequately represented the larger population (Hutagalung & Rachman, 2023; Irawan et al., 2021; Wulandari et al., 2024).

This study utilized response variables and predictor factors. The response variable is the bid or WTP offer price. The predictor variables included education level (Q2), gender (Q7), age (Q8), membership in an environmental organization (Q10), and income source (Q11). These variables were used as demographic data to support the analysis. Other predictor variables to explain citizen decision-making at WTP are perception of MBBR technology's suitability for wastewater treatment in the region (Q14), belief in MBBR as a viable solution for environmental enhancement (Q15), community engagement in domestic waste management (Q16), assessment of the MBBR waste management program's efficacy (Q17), and public endorsement of the wastewater treatment improvement initiative (Q18). Furthermore, demographic data were collected, encompassing the individual's status as an entrepreneur or permanent resident and their monthly salary.

The validity and reliability tests performed included the Kaiser-Meyer-Olkin (KMO) test, Bartlett's Test of Sphericity, and Cronbach's alpha.

Table 1. Results of validity and reliability tests for the pilot questionnaire

Test Type	**Variable/Item**	**Result**
KMO (Overall MSA)	-	0.80
KMO (per item)	MBBR Suitability Perception (Q14)	0.80
	Perceived Right Solution (Q15)	0.83
	Commitment (Q16)	0.78
	Opinion (Q17)	0.79
	Support for Program (Q18)	0.80
Bartlett's Test of Sphericity	-	$\chi^2(15) = 83.01$, p-value $= 1.96 \times 10^{-11}$
Cronbach's α (Overall)	-	0.84
Cronbach's α (if item deleted)	-	0.55 - 0.89

Note KMO = Kaiser-Meyer-Olkin; MSA = Measure of Sampling Adequacy; $\chi^2(15)$ = chi-square at 15 degrees of freedom (df). KMO values of 0.80–1.00 indicate adequate sampling; a significant Bartlett's test ($p < 0.05$) indicates suitability for factor analysis; and Cronbach's $\alpha > 0.70$ is commonly considered acceptable internal consistency (Shrestha, 2021).

Table 1 shows the results of the KMO (Kaiser-Meyer-Olkin) test, which is used to measure the adequacy of the sample, a crucial first step in testing the validity of a questionnaire (Shrestha, 2021). Based on the test results, the overall MSA value was 0.8. According to Shrestha (2021), the KMO value range is as follows: ≥0.90 = Excellent; 0.80 – 0.89 = Good; 0.70 – 0.79 = Acceptable; 0.60 – 0.69 = Fair; and <0.60 = Poor. The pilot test results showed an overall KMO value of 0.8, which falls within the range of ≥0.70, indicating that the data are suitable for factor analysis.

Bartlett's Test of Sphericity was used to test whether the correlation between variables was significant enough to proceed with Exploratory Factor Analysis (EFA). Data are considered suitable for factor analysis if the *p*-value is < 0.05 (Shrestha, 2021). Based on the analysis results in Table 1, the Bartlett test for the questionnaire shows a *p*-value of $1.962278e^{-11}$, which is smaller than 0.05, concluding that the data can proceed to the factor analysis.

Based on the results of the instrument stability analysis presented in Table 1, a minimum alpha value of 0.30 was considered sufficient to indicate that the questionnaire items were acceptable for use. The KMO values for each item in this research instrument ranged from 0.78 to 0.83. In addition, the overall alpha value was high at 0.84. This indicates that the questionnaire has good reliability and is statistically valid and suitable for use in the main data collection process (Izah et al., 2023). It also shows that the people who answered the poll questions fully, which reduced the chance of bias in the evaluations.

After the questionnaire test, the first set of data for the environmental assessment of the mobile MBBR reactor control was gathered. A total of 95 people from all RW (neighborhood groups) in the Ngagel Rejo Subdistrict were asked to fill out the survey. The basic information of the participants who filled out the questionnaire is shown below:

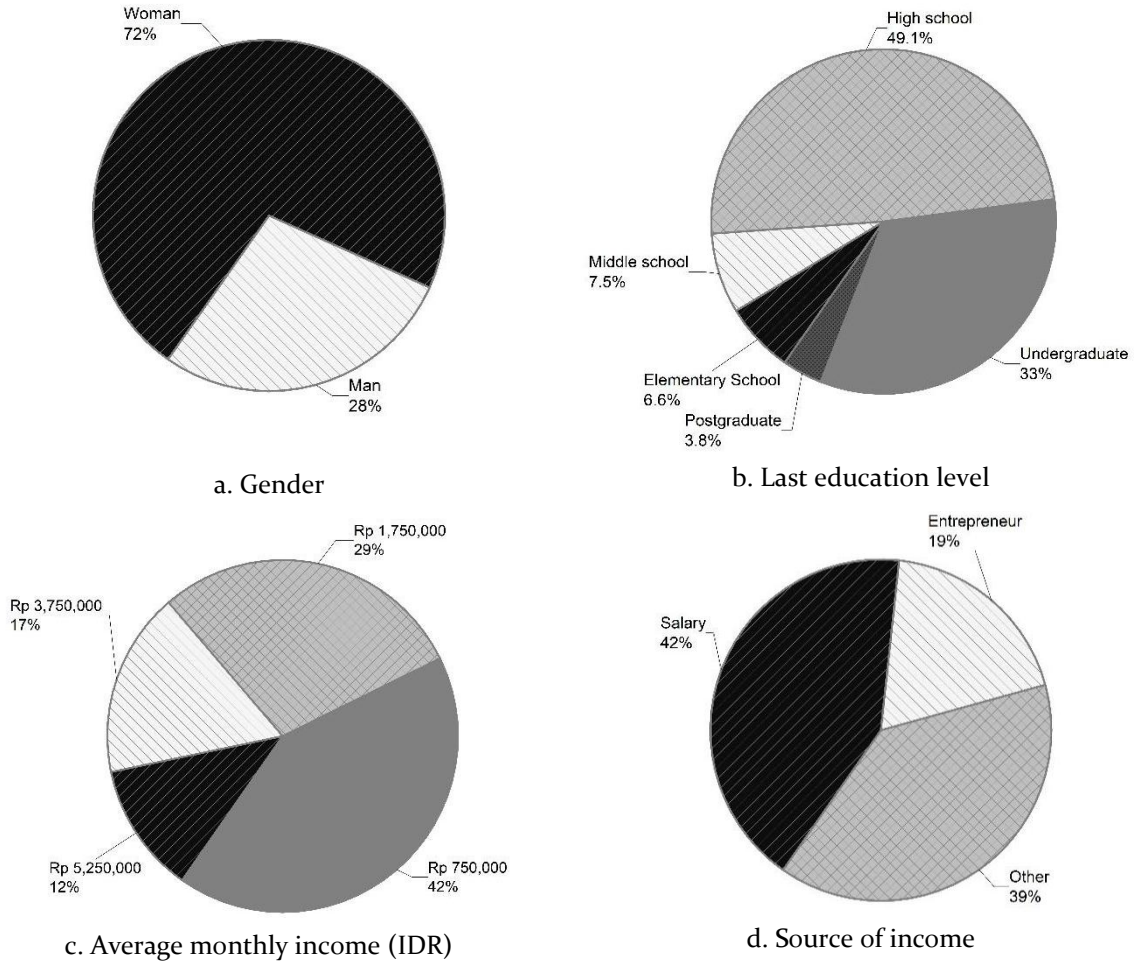


Figure 1. Demographics of the Ngagel Rejo Subdistrict

Figure 1 shows the demographics of the people interviewed in the Ngagel Rejo Subdistrict group. Seventy-two percent of the 95 people who took part were women, and the other 38% were men. Ninety-three percent of them were married, while 7% were single or not married. Fifty-two percent of those who answered had finished high school, while only 1% had finished grade school. The people in the neighborhood who were interviewed said that 51% did not belong to or work for environmental groups, while 49% did belong to or work for environmental groups. The average monthly pay was IDR 750,000.00 (42%). The most popular ways to earn money were through salaries (42%), other sources (39%), and starting one's own business (19%). The fact that most of the respondents were women and most of the households had low incomes shows that gender and income may have a significant impact on how willing people are to pay for environmental improvements. Similar findings have been reported in urban home wastewater studies across Southeast Asia (De et al., 2022).

3.1 Development of Willingness to Pay Model for Mobile Reactor MBBR Management

The model was developed using a binary logistic regression model in which several variables were initially included. Respondents were given two options: willing to pay or unwilling to pay. Those willing to pay were then offered several bid-value options to indicate the amount they would be willing to contribute. This study developed an appropriate model to identify the factors influencing community decisions regarding payment for the operational costs of a wastewater treatment program using mobile MBBR reactor technology. The initial hypothesis proposed that several factors affect residents' decisions. These factors included education level, level of agreement, gender, respondent age, marital status, membership in community organizations, source of income, and several questions related to perceptions

of the technology used. This method allows for a robust estimation of how demographic and attitudinal factors influence WTP probability.

Table 2 presents the results of the logistic regression analysis for the model developed to explain decision-making related to pay (WTP) among the residents of Ngagel Rejo. The first model, which included a large number of factors and variables, had an AIC value of 60.78. According to Cavanaugh and Neath (2019), a lower AIC value, particularly one below 100, indicates a good predictive quality. As the AIC value increases and approaches 100, the model is more likely to be overfitted.

In this study conducted in the Ngagel Rejo Subdistrict, the AIC value of 60.78 indicates that the model is reasonably good at representing the variables involved. The AIC value in this first model was further supported by the validity and reliability tests of the research instrument, which met the required standards. Therefore, the potential for multicollinearity and overfitting could be minimized from the beginning.

The regression model was evaluated based on the p-values of each variable included in the analysis. The variables representing community agreement to pay and community perceptions of the MBBR technology had p-values below 0.05, indicating that these variables were statistically significant. This finding is consistent with similar studies on wastewater management, which suggest that community perceptions and attitudes are stronger determinants than income or education level in shaping WTP decisions (Mariel & Arata, 2022; Qian et al. 2019).

Table 2. Determining WTP through the results of 1st logistic regression analysis

Predictor	**β**	**SE**	***z***	***p***
Intercept	−0.44	7.03	−0.06	0.95
Education level (Q2)	0.29	0.84	0.34	0.73
Approval of MBBR Program (Q5b)	4.73	1.29	3.68	<0.001***
Gender (Q7)	0.20	1.08	0.19	0.85
Age (Q8)	0.04	0.06	0.65	0.52
Community Membership (Q10)	0.64	1.08	0.60	0.55
Source of Income (Q11)	−0.25	0.71	−0.36	0.72
MBBR Suitability Perception (Q14)	3.65	1.46	2.50	0.01*
Perceived Right Solution (Q15)	−0.47	1.57	−0.30	0.77
Commitment (Q16)	−0.59	1.74	−0.34	0.73
Opinion (Q17)	−0.55	0.93	−0.59	0.56
Support for Program (Q18)	−2.52	1.87	−1.35	0.18

Model fit. Null deviance = 79.44 (df = 94), residual deviance = 34.78 (df = 82), AIC = 60.78.

Note. β = coefficient (log-odds); SE = standard error

Based on the results of the initial modelling, the model was found to be overly complex, which made interpretation difficult. Therefore, variable selection was performed by removing variables that were not statistically significant. On this basis, several variables were excluded: Education Level (Q2), gender (Q7), Community Membership (Q10), Source of Income (Q11), Perceived Appropriate Solution (Q15), and opinion (Q17). These variables had very high p-values. The updated model is presented in **Table 3**.

Table 3. Result of 2nd logistic regression analysis for determining Willingness to Pay

Predictor	**β**	**SE**	***z***	***p***
Intercept	3.45	3.75	0.92	0.36
Approval of MBBR Program (Q5b)	4.76	1.25	3.80	**<0.001*****
MBBR Suitability Perception (Q14)	3.35	1.30	2.56	**0.01****
Commitment (Q16)	−0.86	1.09	−0.79	0.43

Predictor	**β**	**SE**	***z***	***p***	
Support for Program (Q18)		−3.31	1.44	−2.31	**0.02***

Note. β = log-odds coefficient; SE = standard error; $p < 0.05$ (*), $p < 0.01$()**, $p < 0.001$(*)**

After the new model was created, multicollinearity among the predictor variables used to construct the model was examined. Multicollinearity was checked using the Variance Inflation Factor (VIF) value to determine whether multicollinearity existed between the variables. Multicollinearity can make the model unstable and affect the interpretation of the coefficients (Senaviratna and Cooray, 2019). If there are variables with a VIF > 5 or 10, it is necessary to consider removing one of the highly correlated variables. Based on **Table 4**, the VIF values for the approval variable, MBBR Suitability Perception (Q14), commitment (Q16), and support (Q18) are 1.99, 3.35, 3.05, and 3.37, respectively, all of which are smaller than 5, indicating that there is no multicollinearity. Similar findings were reported by Li et al. (2025), who found that VIF values ranging from 1.17 to 3.94 indicate no multicollinearity among predictor variables in a WTP model for carbon offset behavior. Likewise, Tan et al. (2025) confirmed that VIF values below five represent stable and valid predictors in modeling public willingness to pay for low-carbon initiatives. The results show that the model is strong and does not have any problems with multicollinearity.

Table 2 shows that the AIC value of the first model is higher than that of the second model after model reduction (Tables 3 and 4). This decline in the AIC value (from 60.76 to 46.97) indicates that the model reduction was successful in simplifying the model, thereby improving the balance and stability of its predictive ability. Knowledge related to the technology and its management is not yet adequately reflected in the respondents' answers, meaning that these variables should have been further broken down or specified in greater detail in the model. This may be explained by the fact that such perceptions and opinions are not supported by respondents' educational backgrounds.

In the revised model, only a limited number of factors were significant. The model identified variables such as approval of the MBBR program, perceptions of the suitability of MBBR technology, community commitment, and community support for the program as key explanatory variables influencing WTP decision-making among Ngagel Rejo residents. This result is consistent with that of Paudel et al. (2023). They stated that reducing the size of a model by eliminating factors that are not important leads to higher model precision and lower AIC values, which makes the model easier to understand and more accurate in predicting what will happen in WTP studies for environmental programs.

Table 4. Model fit statistics for 2nd logistic regression results

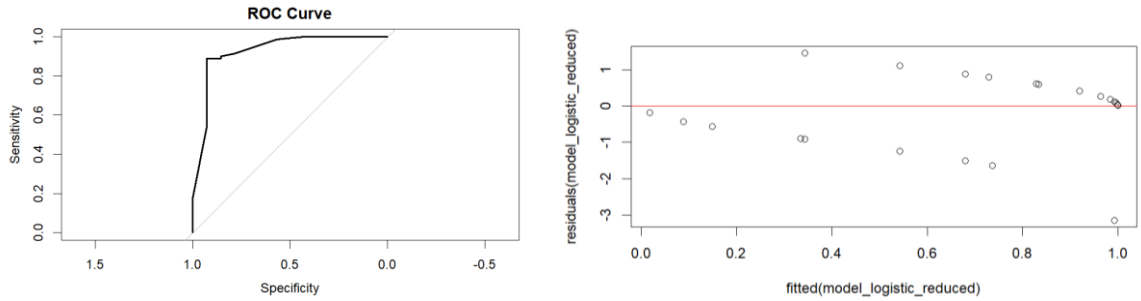
Model Fit Statistics	**Value**
Null Deviance (df = 94)	79.44
Residual Deviance (df = 90)	36.97
AIC	46.97
VIF Range	1.99 - 3.37
AUC (Model Accuracy)	0.93

Note. AIC, Akaike information criterion; VIF, variance inflation factor; AUC, area under the ROC curve.

Positive coefficients for each predictor variable in the model indicate an increased likelihood of being willing to pay, whereas negative coefficients indicate a decreased likelihood. The coefficient for the variable Approval of MBBR Program (Q5b) was 4.76, and for MBBR Suitability Perception (Q14), it was 3.35. This means that the likelihood of someone being willing to pay (WTP) is influenced by the approval factor 4.76 times and by their opinion that MBBR technology as a mobile reactor is suitable for domestic waste management, 3.35 times. However, for variables with negative coefficients, Commitment (Q16) has −0.86, and Support for Program (Q18) has −3.31. These negative values are interpreted to mean that the community's commitment to paying (WTP) decreases by 0.86 times, and their support for payment decreases by 3.31 times.

This indicates that there is a degree of community commitment to environmental preservation through financial contributions made by the community itself. However, the program for implementing mobile reactor MBBR technology is still perceived as insufficiently necessary to warrant financial support. This may be because, from the community's perspective, the perceived benefits of environmental conservation efforts have not yet outweighed the more immediate priority of sustaining their daily livelihoods. In urban communities with relatively low per capita income, such as those in Indonesia, financial expenditures for environmental preservation or conservation are still not considered a primary concern.

Based on **Table 4**, the AUC of the model was 0.9281, and the curve referenced is shown in **Figure 2(a)**. The ROC Curve demonstrates the model's ability to separate the two categories or response variables being modelled. A higher Area Under the Curve (AUC) indicates a better model. Ideally, an AUC > 0.8 indicates a very good model (Marzban, 2004). Similar evaluation metrics have been widely used in environmental valuation and behavioral modeling studies to assess model discrimination accuracy and predictive strength, particularly in the willingness-to-pay models (Qiao et al., 2022). This means that the reduced logistic regression model, with insignificant variables removed, shows good performance and predicts that the predictor variables are linearly related to the community's willingness to pay.



(a) (b)

Figure 2. (a) ROC Curve of the reduced logistic model for WTP. (b) Residuals vs Fitted Curve of the reduced logistic model.

The final process in testing this model was a diagnostic test with residual analysis. Residual analysis was used to check for any unidentified patterns or outliers that needed to be addressed (Fernandez, 1992). This analysis helps identify potential issues in the model that cannot be explained by existing variables. In **Figure 2(b)**, the residuals vs. fitted curve shows that some outliers need to be addressed to improve the model's ability to depict the relationship between the studied variables. However, similar to other contingent valuation studies, community approval or perceived suitability of environmental technologies are consistently found to be stronger determinants of WTP than purely demographic attributes such as age or education (Ho et al., 2024; Wang et al., 2018). In this study, residual analysis will not be continued because the reduced logistic regression model (the second model) that has been developed is sufficient to explain the relationship between the willingness to pay (bid) and the existing predictor variables.

Based on the analysis results from the logistic regression to the obtained model and the steps taken in the model evaluation, the final model is as follows (Equation (2)):

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i \quad \textbf{(2)}$$

$$WTP = 3.4483 + 4.7558(Q5b\_Agreement) + 3.3536(Q14\_MBBR\_suitable) - 0.8591(Q16\_Commitment) - 3.3138(Q18\_Support)$$

The final improved model is consistent with the study by Ćetković et al. (2022), which states that in the context of communal wastewater management, there is a behavioral gap between environmental awareness and the willingness to contribute financially. This implies that in community-based

wastewater management, environmental knowledge and willingness to provide financial support for wastewater treatment may be inversely related. In other words, people may recognize the importance of protecting the environment through wastewater treatment efforts; however, this awareness is not necessarily accompanied by a willingness to provide financial support for such initiatives.

In the case of Ngagel Rejo Subdistrict, public approval (Question Q5b) and perceptions of the suitability of MBBR technology (Q14) significantly increased the probability of willingness to pay (WTP). In contrast, factors related to a lack of commitment and financial support act as barriers to domestic wastewater management in the area.

After obtaining the analyzed WTP formula, it was applied to each respondent, resulting in the average WTP value and the WTP value in Indonesian Rupiah. Based on the calculation results, the average WTP was 3.6827, the average WTP value in Rupiah was IDR 69,496.00, and the aggregate WTP for the entire sample was IDR 6,602,131.00. Therefore, the community is recommended to pay for the environmental services of domestic waste management using the mobile MBBR reactor in the form of a fee of IDR 69,496.00 per month.

To explain the relationship between the price willing to be paid and the respondents' WTP, a Bid Value Curve (BCV) was created, as shown in **Figure 3**. The Bid value (IDR) represents the payment options offered (ranging from IDR 10,000, 20,000, 30,000, 40,000, 50,000, and 60,000). The WTP value is the average WTP of each respondent multiplied by the chosen bid value. The Bid Value Curve (BCV) illustrates how changes in price or bids affect a community's willingness to pay.

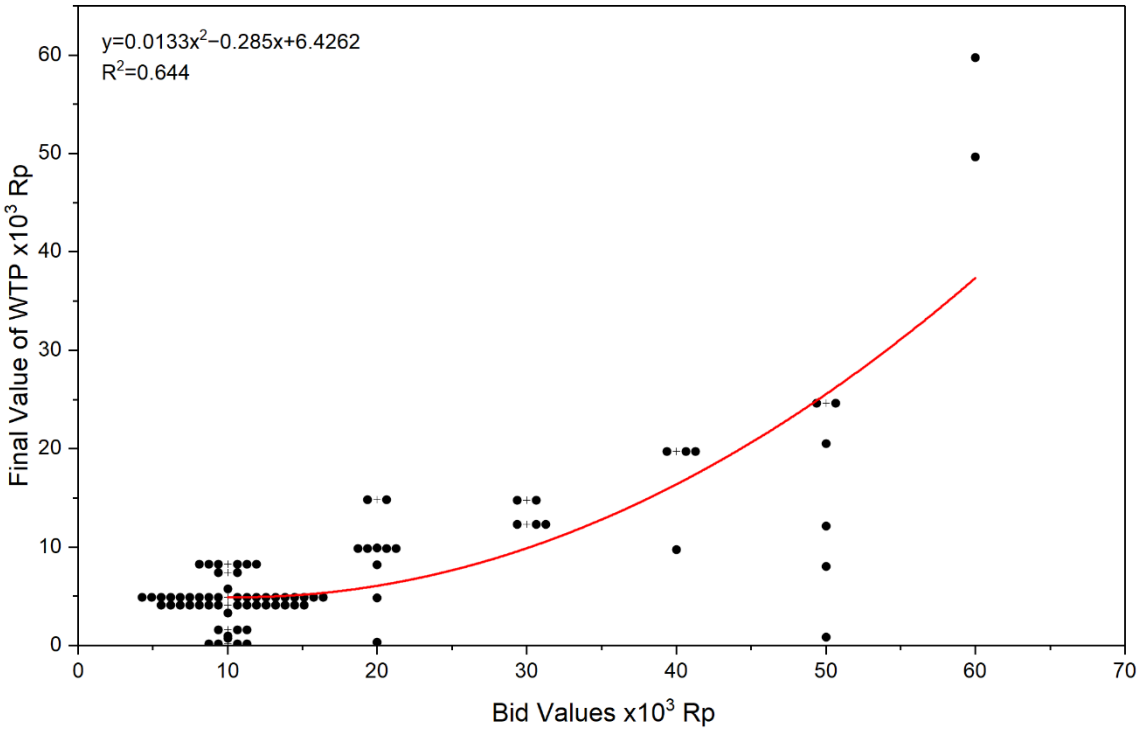


Figure 3. Relationship between bid value offered to respondents and final value of WTP for domestic wastewater management

In the context of managing household waste, this curve shows the price elasticity and market readiness. The curve has an R^2 value of 0.6445, which equals 64.45%. This means that the regression model used to describe the relationship can only explain 64.45% of the variation in data. This means that the model cannot explain approximately 35.55% of the variation. This suggests that the WTP value could be affected by factors that are not included in the model. They are related in a good way: "Bid" and "WTP Value." When the bid value increases, the WTP value usually increases as well.

The R^2 value was relatively moderate, indicating that the model had not yet captured most of the overall variation in the data. To improve the predictive performance of the model, the variables included in the model must be re-evaluated. In the developed model, the final WTP value is influenced by an increase in Bid Values. As the Bid Values increase, the final WTP value also increases, following the pattern of the curve.

3.2 Determination of the Fee Scheme and System Evaluation

Survey data collected from the community were used to estimate the average willingness to pay (WTP) for environmental management. The resulting value reflects the community's capacity to contribute financially, without imposing an excessive economic burden on households. A similar approach was reported by Wulandari et al. (2024), although in a different national setting with distinct socioeconomic and cultural conditions. The study also applied a tiered financing structure, in which the proposed fee level varied according to the volume of waste generated.

Sustained community participation in waste management is essential for maintaining long-term treatment efforts at the community level. Based on the present study, a contribution of IDR 69,496.00 per month was identified as an acceptable amount to support the sustainability of waste management in the Ngagel Rejo Subdistrict. In the future, periodic reassessment of the community's willingness to pay will be necessary to ensure that the tariff remains relevant to changing economic conditions.

The WTP value identified for the Ngagel Rejo community is part of a broader effort to improve environmental quality. In principle, this finding is consistent with Jiao (2024), who emphasized the concept of "polluter pays but fair participation" in community-based sanitation improvement initiatives. In addition to encouraging residents to contribute to the management of their waste, supporting studies are also needed in the Ngagel Rejo community to assess the potential for incentive schemes for residents who actively participate in environmental management.

4. Practical application and future perspectives

The findings indicate that the residents of Ngagel Rejo Subdistrict are willing to make a financial contribution toward the operation of MBBR technology for the treatment of their kitchen wastewater. This finding is expected to provide useful input for local policymakers in determining an appropriate user fee or service charge for the management of MBBR-based treatment facilities. Nevertheless, the Ngagel Rejo community still requires further education and outreach regarding domestic wastewater management in residential environments. This study relied on stated willingness-to-pay data obtained through a bidding format. Therefore, respondents' answers may not fully reflect actual payment behavior in real-world implementation settings. For future research, the scope of the communities under study should be expanded.

5. Conclusions

The study conducted in Ngagel Rejo Subdistrict on the environmental valuation of domestic wastewater treatment technology implementation shows that the key determinant of residents' willingness to pay (WTP) is the community's commitment to environmental conservation. Community support for the implementation of wastewater treatment technology is also essential to ensure the sustainable operation of the treatment system. Going forward, greater public education is needed to strengthen community support and commitment to environmental protection. Ngagel Rejo Subdistrict, Surabaya City, has human resources with strong future potential that can be relied upon to collaborate in improving the quality of the surrounding environment.

Acknowledgement

This research was conducted with financial support from Universitas Pembangunan Nasional "Veteran" Jawa Timur through the Internal Funding Program 2025, Novice Lecturer Research Scheme.

Special gratitude goes to all research members and other contributors to this research work, whose help was also relevant.

Ethics Statement

The need for ethical review and approval was waived for this study because the survey did not involve any intervention or collection of sensitive personal information. Participation was entirely optional and anonymous, with informed consent secured from all respondents prior to the poll. This study was executed in alignment with the ethical rules of Universitas Pembangunan Nasional "Veteran" Jawa Timur and complied with the principles of the Declaration of Helsinki.

CRediT Author Statement

Nurvita Cundaningsih: Idea Development, Research Design, Manuscript Draft Preparation, Data Curation. **Rizka Novembrianto**: Program Development, Resources, Supervision. **Kabul Fadilah**: Result Verification, Manuscript Review and Revision.

References

Cavanaugh, J.E., and Neath, A.A. 2019. The Akaike information criterion: Background, derivation, properties, application, interpretation, and refinements. Wiley Interdisciplinary Reviews: Computational Statistics 11, e1460.

Cecilia, S., Murayama, T., Nishikizawa, S., and Suwanteep, K. 2024. Preferences and valuation of small-scale wastewater treatment system maintenance using discrete choice method: Case of community-managed system in Jakarta, Indonesia. Journal of Environmental Management 371, 123115.

Ćetković, J., Knežević, M., Lakić, S., Žarković, M., Vujadinović, R., Živković, A., and Cvijović, J. 2022. Financial and economic investment evaluation of wastewater treatment plant. Water (Basel) 14, 122.

Chotima, U.H., and Aji, J.M.M. 2021. Analysis of willingness to pay for 'Ketakasi'ground coffee in Jember Regency. In: IOP Conference Series: Earth and Environmental Science. IOP Publishing, p. 012060.

De, I., Hasan, R., and Iqbal, M. 2022. Natural treatment systems and importance of social cost benefit analysis in developing countries: A critical review. Sustainability 14, 3913.

Do, H.H., and Frör, O. 2022. River ecosystem resilience: applying the contingent valuation method in Vietnam. Sustainability 14, 12029.

Fernandez, G.C.J. 1992. Residual analysis and data transformations: important tools in statistical analysis. HortScience 27, 297–300.

Firdaus, M., Hatanaka, K. and Saville, R. 2021. Mangrove forest restoration by fisheries communities in lampung bay: a study based on perceptions, willingness to pay, and management strategy. Forest and Society, 5(2), 224-244.

Hanley, N., Barbier, E.B., and Barbier, E. 2009. Pricing nature: cost-benefit analysis and environmental policy. Edward Elgar Publishing.

Hasbiah, A.W., Rochaeni, A., and Sutopo, A.F. 2018. Analisis kesediaan membayar (willingness to pay) dan kesediaan untuk menerima kompensasi (willingness to accept) dari keberadaan tempat penampungan sementara ciwastra dengan Contingent Valuation Method. Infomatek 20, 107–116.

Ho, N.B., Vo, D. Van, and Rowley, C. 2024. Contingent valuation versus choice experiment: estimating the willingness to pay for organic oranges in Vietnam. Journal of Trade Science 12, 268–283.

Hutagalung, I.R., and Rachman, I. 2023. Analysis of consumer preferences on online delivery plastic packaging consumption behavior: An Indonesian survey. Jurnal Presipitasi: Media Komunikasi dan Pengembangan Teknik Lingkungan 20, 85–92.

Irawan, D.R., Syarifuddin, H., and Fahri, S. 2021. Household solid waste management strategy in danau teluk sub-district, Jambi City. Jurnal Presipitasi Media Komunikasi dan Pengembangan Teknik Lingkungan 18, 282–298.

Irawan, E. 2019. Contingent valuation of Lake Rawapening as a source raw drinking Water. Jurnal Ilmu Lingkungan 17, 492–499.

Izah, S.C., Sylva, L., and Hait, M. 2023. Cronbach's alpha: a cornerstone in ensuring reliability and validity in environmental health assessment. ES Energy & Environment 23, 1057.

Jiao, J. 2024. Residents' willingness to participate in domestic sewage treatment in rural China: Application of a multi-stakeholder perspective. Universite de Liege (Belgium).

Karisyawati, N.D., Suryantini, A., and Utami, A.W. 2019. Estimation of consumers' willingness to pay for cavendish banana using contingent valuation method in special Province Yogyakarta. Agro Ekonomi 30, 167–181.

Li, C., Yang, X., Wei, H., Hu, Z., and Zhang, Z. 2025. Research on the influencing factors of college students' willingness-to-pay for carbon offsets in the context of climate change. Sustainability (Switzerland) 17.

Mariel, P., and Arata, L. 2022. Incorporating attitudes into the evaluation of preferences regarding agri-environmental practices. Journal of Agricultural Economics 73, 430–451.

Marzban, C. 2004. The ROC curve and the area under it as performance measures. Weather Forecast 19, 1106–1114.

Mcgranahan, G., Leitman, J., and Surjadi, C. 1998. Policy and practice green grass and brown roots: understanding environmental problems in deprived neighbourhoods. Journal of Environmental Planning and Management 41, 505–518.

Miłaszewski, R. 2021. Application of the contingent valuation method in water resources protection. Central European Economic Journal 8, 212–218.

Paudel, U., Adhikari, S.R., and Pant, K.P. 2023. Willingness to pay for environmental quality improvement programs and its determinants: empirical analysis in western nepal. Sustainability (Switzerland) 15.

Qian, Cheng, Yu, Kangkang, Gao, and Jian. 2019. Understanding environmental attitude and willingness to pay with an objective measure of attitude strength. Environment and Behavior 53, 119–150.

Qiao, D., Liu, H., Zhang, D., Xu, T., and Gan, Y. 2022. Chasing the unbiased willingness to pay: Using an integrated contingent valuation survey in estimating the non-market value of rubber plantation ecological restoration programs in China. Frontiers in Ecology and Evolution Volume 10-2022.

Senaviratna, N., and Cooray, T. 2019. Diagnosing multicollinearity of logistic regression model. Asian Journal of Probability and Statistics 5, 1–9.

Shrestha, N. 2021. Factor analysis as a tool for survey analysis. American journal of Applied Mathematics and statistics 9, 4–11.

Sugiyono, S., 2016. Metode Penelitian Kuantitatif, Kualitatif, dan R&D Cetakan ke-23. Bandung: CV Alfabeta.

Tan, Y., Ying, X., Ge, J., Gao, W., Zhao, X., and Wang, S. 2025. Study on the key factors of public participation in low carbon city construction and willingness to pay. Scientific Reports 15, 6741.

Venkatachalam, L. 2004. The contingent valuation method: a review. Environmental impact assessment review 24, 89–124.

Wang, W., Jin, J., He, R., Gong, H., and Tian, Y. 2018. Farmers' willingness to pay for health risk reductions of pesticide use in China: A contingent valuation study. International journal of environmental research and public health 15, 625.

Whittington, D. 2002. Improving the performance of contingent valuation studies in developing countries. Environmental and resource economics (Dordr) 22, 323–367.

Wulandari, S.S., Soeprobowati, T.R., and Kismartini, K. 2024. Strategi Pengelolaan Limbah Domestik Berbasis Masyarakat pada IPAL Komunal Guyub Rukun di Kota Salatiga. Jurnal Ilmu Lingkungan 22, 1466–1476.