

Factors Associated with Waste Management Behavior in Coastal Communities: Evidence from Binary Logistic Regression

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Abstract

Many communities continue to struggle with waste management, with improper handling still common, including in Gorontalo. To support effective waste management planning and intervention, it is crucial to identify factors influencing waste management behavior. The purpose of this study was to examine factors associated with waste management behavior using a binary logistic regression model. The study included 347 respondents in the South Leato Coastal Area, Dumbo Raya District, Gorontalo City, Gorontalo Province. It focused on attitude and waste management facilities as independent variables, as well as waste management behavior as a binary outcome. The logistic regression model was statistically significant, with both attitudes and waste management facilities significantly associated with waste management behavior in the South Leato Coastal Area (p -value < 0.05). Individuals with a positive attitude had higher odds of practicing good waste management compared with those with a negative attitude. Likewise, respondents with adequate waste management facilities were more likely to demonstrate good waste management behaviour than those with inadequate facilities. The Hosmer-Lemeshow test indicated that the overall model was statistically significant and showed adequate fit (p -value > 0.05). ROC analysis provided an AUC of 0.711, indicating the model's acceptable discriminative capability.

Keywords: Coastal area, logistic regression, waste management behaviour.

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1. INTRODUCTION

According to BPS-Statistics Indonesia, the total number of coastal villages in Indonesia affected by pollution is 2,131, of which 56.83% the villages experienced water pollution [1]. In Gorontalo province, almost 18% of coastal villages experience water pollution, which ranks second after air pollution. Moreover, Gorontalo produces 142.24 tons of waste per day, most of which is inorganic [2]. Based on preliminary observations in the South Leato Coastal Area, Dumbo Raya District, Gorontalo City, many residents still dispose of waste without separating organic and inorganic waste.

The primary problem, as described by ten people interviewed in this area during the preliminary survey, was suboptimal waste management, including the government's failure to follow up on community complaints, poor public awareness, and little public knowledge about waste management. The results of this interview are consistent with those of Anugerah et al. [3], who concluded that one cause of suboptimal waste management is community behavior that does not adequately support waste management practices. Changing community behavior in coastal areas is therefore necessary to improve waste management.

Addressing waste management is closely linked to both SDG 11 (reducing the environmental impact of cities) and SDG 12 (reducing overall waste generation and improving waste management throughout the lifecycle of products) [4]. Research shows that attitudes toward waste management and the availability of management facilities are related to waste management behavior [5], [6]. More positive environmental attitudes and norms are linked to improved waste sorting and disposal practices [7], [8]. Additionally, the accessibility and convenience of waste management facilities consistently encourage better waste disposal behaviors [7]–[9].

Based on a systematic literature review by Zhang [10], regression analysis is the most commonly used method across 279 previous studies on waste management behavior. However, most of these studies use continuous-scale dependent variables, so the most commonly used analyses are linear regression or SEM [10]. For example, Herdiansyah et al. mapped waste density using spatial analysis in Ambon Bay (continuous dependent variable) [11]. Then, Phelan et al. used linear regression to model factors causing marine pollution from waste across 10 coastal villages in 2 locations, namely Selayar and Wakatobi (continuous dependent variable) [12].

Meanwhile, the application of logistic regression, an analysis suitable for modeling binary dependent variables, such as categories of waste management behavior ("Good" and "Poor"), remains limited, especially in coastal areas. Further, based on Zhang's research, no studies have focused on the Indonesian Coastal Region, especially Gorontalo Province [10]. Thus far, no studies have been conducted on coastal areas using waste management models based on binary logistic regression.

Accordingly, previous studies of waste management behavior have examined variables separately, without accounting for the simultaneous influences of multiple factors, as they primarily relied on descriptive or bivariate analyses [5], [6], [9], [13]. The binary logistic regression approach allows multiple explanatory variables to be analyzed simultaneously and identifies independent predictors when the dependent variable is dichotomous [14], [15].

Therefore, this research applies multivariable logistic regression to identify independent variables (attitudes toward waste management and the availability of management facilities) of waste management behaviour in the Coastal Area of Gorontalo Province, addressing both methodological and geographical gaps in the existing literature. By estimating adjusted odds ratios, this research provides evidence that can

be directly used to support waste-related policies and targeted interventions in coastal areas. Also, descriptive analysis is used to explain the pattern of waste management behaviour and its relationship with the independent variables.

From a statistical perspective, this research treats waste management behaviour as a dichotomous variable and models the probability of each outcome using binary logistic regression. As cited in [14]–[19], the model estimates the effects of several factors simultaneously using Maximum Likelihood Estimation (MLE). The importance of each factor is assessed using the Wald test, and the overall model is evaluated using the likelihood-ratio (G^2) test. Model fit was assessed using the Hosmer-Lemeshow test. The model's performance was also examined using the Receiver Operating Characteristic (ROC) curve and the Area Under the Curve (AUC) to assess how well it can separate good and poor waste management behaviour [14]–[19]. This full analysis approach for a binary outcome has not been previously applied to studies of waste management behavior in coastal areas of Gorontalo Province.

2. METHOD

This research used primary data collected through interviews, observations, questionnaires, and documentation conducted in the South Leato Coastal Area located in South Leato Village, Dumbo Raya Subdistrict, Gorontalo City, Gorontalo Province. The research focused on the entire community of the South Leato Coastal Area in South Leato Village, with a population of 2,587. To determine the sample size for the research, the Slovin formula was used, resulting in a sample of 347 individuals.

The sampling technique used was purposive sampling. This technique involves the researcher setting specific criteria or assessments, making it well-suited to exploratory research or to studying several subgroups that are difficult to reach, rather than the entire population [20]. The criteria for respondents included in the sample were people aged 17–45 years who had lived in the South Leato Coastal Area for at least 3 months, who were aware of waste management practices in their homes, and who knew how to complete an online questionnaire. People who were unwilling or unable to complete the questionnaire were excluded from the research.

This research includes one dependent variable and two independent variables. The independent variables are attitudes (X_1 , including awareness, perceived benefits, participation, and responsibility) and waste management facilities (X_2). The dependent variable is waste management behavior, which is categorized into binary outcomes: "Good" and "Poor" [5]–[9].

A binary logistic regression model was applied to examine the association between selected independent variables and waste management behaviour. Logistic regression was performed in R software using a generalized linear model with a binomial distribution and a logit link function [21]. Model parameters were estimated using Maximum Likelihood Estimation (MLE) [21]. After specifying and estimating the model, the logistic regression analysis was conducted as follows [16], [22]–[26].

1. Overall model adequacy evaluation

Overall model adequacy was evaluated using Likelihood Ratio tests. The independent variables' contribution to the model was assessed by comparing the null deviance with the residual deviance of the fitted model. The likelihood ratio statistic (G^2), as written in Equation (1), was calculated as the difference between these deviance values and tested using the chi-square distribution.

$$G = -2 \left[\frac{(n_1/n)^{n_1} (n_0/n)^{n_0}}{\prod_{i=1}^n \pi_i^{y_i} (1-\pi_i)^{(1-y_i)}} \right] \quad (1)$$

2. Individual independent variable assessment

Each regression coefficient's statistical significance was assessed using Wald tests based on the z-statistics from the fitted logistic regression model. These tests were used to evaluate whether each independent variable was independently associated with the odds of waste management behaviour. The Wald test formula is given in [Equation \(2\)](#).

$$W_j = \frac{\hat{\beta}_j}{SE(\hat{\beta}_j)} \quad (2)$$

Effect sizes were expressed as odds ratios (ORs), calculated by exponentiating the estimated regression coefficients, as written in [Equation \(3\)](#). 95% confidence intervals (CIs) were calculated based on the adjusted regression coefficients. A p-value of less than 0.05 was considered statistically significant.

$$OR = \exp(\hat{\beta}) \quad (3)$$

Finally, model diagnostics included assessments of model goodness-of-fit and performance [\[16\]–\[19\]](#). Model goodness-of-fit was examined using the Hosmer-Lemeshow test to assess the relationship between observed and predicted probabilities of waste management behaviour. [Equation \(4\)](#) outlined the Hosmer-Lemeshow test formula.

$$\hat{C} = \sum_{k=1}^g \frac{(o_k - n_k \bar{\pi}_k)^2}{n_k \bar{\pi}_k (1 - \bar{\pi}_k)} \quad (4)$$

The ROC curve describes how well a binary classification model distinguishes between two outcome groups across a range of probability thresholds by plotting sensitivity against 1-specificity [\[17\]](#), [\[18\]](#). The 45° diagonal reference line represents random classification, indicating that the model is unable to distinguish between the two outcome groups. Meanwhile, curves higher above this line indicate better separation between the groups [\[19\]](#).

The AUC summarizes the ROC curve into a single numerical value. It represents the probability that a randomly selected individual with a positive outcome will have a higher predicted probability than a randomly selected individual with a negative outcome [\[17\]](#), [\[19\]](#). An AUC value of 0.5 corresponds to the diagonal line of 45° and suggests no discrimination between the two groups, whereas a value of 1.0 indicates a perfect separation between the two groups. The AUC does not depend on a specific classification threshold, so it is particularly useful for evaluating binary models with unbalanced outcome distributions [\[17\]–\[19\]](#).

3. RESULTS AND DISCUSSION

3.1. Results

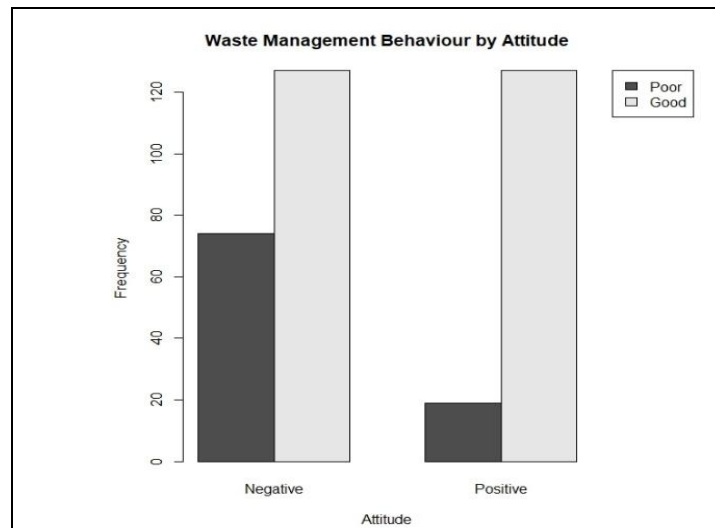
3.1.1. Descriptive Analysis

A description of respondents is provided in [Table 1](#). Most respondents showed good waste management behaviour (73.199%), while just over a quarter (26.801%) had poor behaviour.

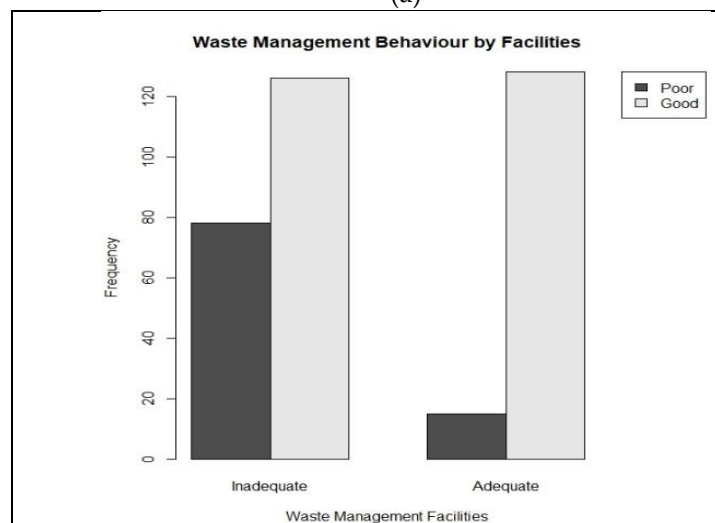
Table 1. Descriptive Characteristics of Respondents

Variable	Category	Frequency	Percentage
Waste management behaviour	Poor	93	26.801
	Good	254	73.199
Attitude	Negative	201	57.925
	Positive	146	42.075
Waste management facilities	Inadequate	204	58.790
	Adequate	143	41.210

Furthermore, more than half of the respondents (57.925%) had a negative attitude toward waste management, whereas 42.075% had a positive attitude. As for the availability of facilities, nearly 60% of respondents reported inadequate waste management facilities, while slightly more than two-fifths (41.210%) reported adequate facilities. **Figure 1** presents stacked bar charts showing waste management behaviour by attitude and waste management facilities. **Figure 1(a)** shows that good waste management behaviour was more frequent among respondents with a positive attitude than among those with a negative attitude. In contrast, the proportion of poor behaviour was higher in the group with a negative attitude.



(a)



(b)

Figure 1. Waste Management Behaviour by (a) Attitude and (b) Waste Management Facilities

Figure 1(b) indicates that respondents with adequate facilities had a higher proportion of good waste management behaviour than those with inadequate facilities. Conversely, poor behaviour was more common among respondents with inadequate facilities.

3.1.2. Logistic Regression

The results of the binary logistic regression analysis are presented in **Table 2**. The binary logistic regression model for waste management behaviour is given in **Equation (5)**.

$$\pi(x) = \frac{\exp(0.302 + 0.851x_{1(1)} + 1.317x_{2(1)})}{1 + \exp(0.302 + 0.851x_{1(1)} + 1.317x_{2(1)})} \quad (5)$$

By transforming $\pi(x)$ into logit form, this approach keeps the model's linearity while improving its interpretability [16]. The model transformation is shown in **Equation (6)**.

$$\log it(\pi(x)) = 1.353 + 2.341x_{1(1)} + 3.730x_{2(1)} \quad (6)$$

The overall model was first evaluated using the likelihood ratio (G^2) test, written in **Equation (1)**. The G^2 test showed that the model with independent variables fit the data better than the model without independent variables (p-value = 0.000). This result indicates that at least one independent variable was significantly associated with waste management behaviour (p-value < 0.05).

Table 2. Logistic Regression Results

Variable	β	Std. Error	p-value	Adjusted OR	95% CI
Coefficient	0.302	0.157	0.054	1.353	0.997-1.845
Attitude (<i>Negative vs Positive</i>)	0.851	0.312	0.006	2.341	1.285-4.389
Waste management facilities (<i>Inadequate vs Adequate</i>)	1.317	0.331	0.001	3.730	1.911– 7.340

According to **Table 2**, the Wald test results, calculated using **Equation (2)**, indicate that attitude was significantly associated with waste management behaviour. Using **Equation (3)** (result displays in **Table 2**), participants with a positive attitude had higher odds of taking part in waste management behavior than those with a negative attitude (adjusted OR = 2.341; 95% CI = 1.285-4.389; p-value = 0.006).

The presence of waste management facilities was also significantly related to waste management behaviour. Participants with adequate facilities had greater odds of engaging in waste management behaviour than those with inadequate facilities (adjusted OR = 3.730; 95% CI = 1.911– 7.340; p-value = 0.001).

3.1.3. Model Diagnostics

The Hosmer-Lemeshow test in **Equation (4)** was used to examine the model goodness-of-fit [16]. The test showed no statistically significant difference between the observed and predicted values ($\chi^2 = 1.581$; p-value = 0.209). This result indicates that the logistic regression model had an adequate fit to the data (p-value > 0.05).

ROC curves were used to assess the model's ability to differentiate respondents with good and poor waste management practices [17]–[19]. The ROC curve (**Figure 2**)

lies above the diagonal reference line, indicating that the model performs better than random classification.

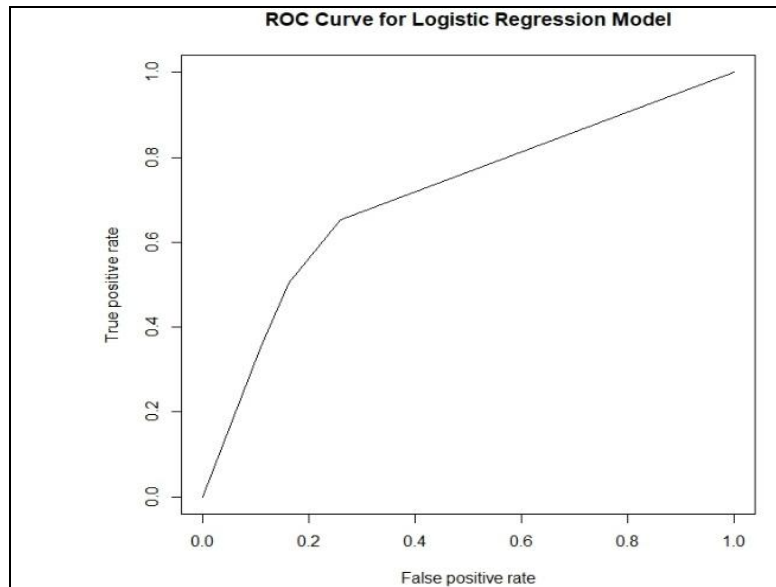


Figure 2. ROC Curve of the Logistic Regression Model for Waste Management Behaviour

AUC is a numerical value that summarizes the ROC curve [17]–[19]. An AUC value between 0.7 and 0.8 is considered fair, values between 0.8 and 0.9 are considered substantial, and values above 0.9 are considered excellent. By contrast, an AUC value between 0.6 and 0.7 indicates poor performance, and one between 0.5 and 0.6 indicates performance no better than random classification [17], [19].

The model's AUC was 0.711, indicating fair to acceptable ability to distinguish between respondents with good and poor waste management behavior. Thus, the model ranks individuals with good behavior higher than those with poor behavior in most cases, although the distinction is not perfect.

3.2. Discussion

South Leato Coastal Area, Dumbo Raya District, Gorontalo City residents still dispose of waste without separating organic and inorganic materials. As a result, waste is visible along the coastline, posing a threat to the environment's cleanliness. This situation, as illustrated in Figure 3, reflects the ongoing challenges in managing household and community waste in the South Leato Coastal Area.

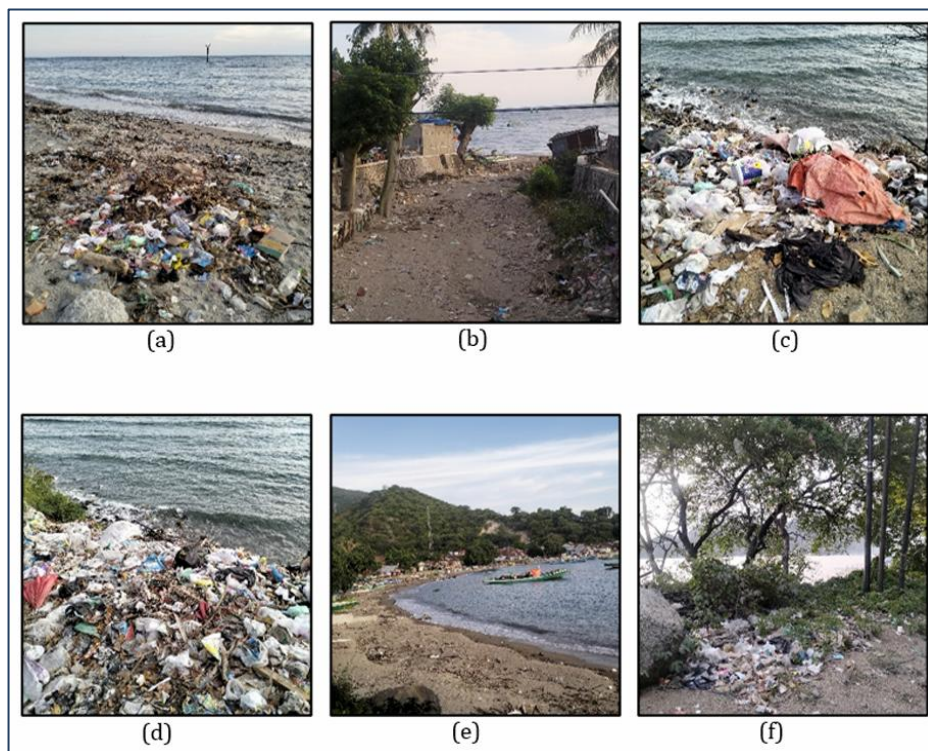


Figure 3. Waste around the South Leato Coastal Area

This research examined factors associated with waste management behaviour using a binary logistic regression model. The results showed that attitude and waste management facilities were significantly associated with waste management behaviour. The overall model was statistically significant and demonstrated adequate fit. This suggests that the selected factors have a significant impact on waste management behaviour in the South Leato Coastal Area, Gorontalo Province. Both the graphical distribution and the binary logistic regression model indicate that attitude and waste management facilities significantly impact waste management behavior, as evidenced by the descriptive patterns in the stacked bar charts (Figure 1).

The analysis showed that attitude was significantly associated with waste management behaviour in the South Leato Coastal Area. Individuals with a positive attitude were more likely to have good waste management behaviour than those with a negative attitude. This finding is consistent with previous studies, which support the idea that attitude influences daily practices related to waste handling, suggesting that a positive attitude may reflect greater awareness, concern for the environment, and a willingness to follow proper waste management practices [7], [8], [27]–[30].

Waste management facilities were also found to be significantly linked to waste management behaviour in the South Leato Coastal Area. Individuals with adequate facilities were more likely to demonstrate good waste management behaviour than those with inadequate facilities. This finding aligns with previous studies indicating that accessible, convenient facilities greatly support proper waste practices, such as household sorting and effective waste management [7]–[9], [27]–[30].

Moreover, the research suggests that both individual and structural factors influence waste management behavior, indicating that to improve waste management practices, it is necessary to address both attitudes and infrastructure in the South Leato Coastal Area. Prior research ([27]–[30]) shows that attitudes and available facilities significantly influence plastic waste management behavior. Waste sorting should involve the entire community, not just garbage collectors, and improving waste

management facilities is extremely important. Even with positive attitudes, insufficient facilities can interfere with effective waste management. Proper facilities are necessary for waste separation, storage, and disposal, which aligns with the previous research [27]–[30].

The model's diagnostic evaluation further supports these conclusions. The ROC analysis yielded an AUC of 0.711, indicating that the model had an acceptable ability to discriminate between respondents with good and poor waste management behaviour. Based on this analysis, the model not only fits the data well but also differentiates behavioral outcomes by attitude and waste management facilities.

This research found that improving waste management facilities and encouraging positive attitudes towards proper waste disposal are important, as these two components complement one another in shaping individual and community behaviors. In areas facing significant challenges in waste handling, such as those with inadequate infrastructure and limited environmental awareness, a combined approach is important to support sustainable improvement.

This research has some limitations. In this research, data were collected at a single time point, so the results describe relationships between variables but do not indicate which factor occurs first. Due to this, the findings should be viewed as associations rather than cause-and-effect relationships. Moreover, this research focused on a limited number of key variables found relevant to waste management behavior. Although these variables showed meaningful associations, other related factors were not explored in this research. Future studies may examine a broader range of factors or employ different approaches to understand better how waste management behavior evolves. Despite these limitations, this research provides useful evidence on factors associated with waste management behavior. Using logistic regression, independent factors can be identified and precise effect estimates provided to assist in planning and decision-making for waste management in the South Leato Coastal Area.

4. CONCLUSION

This research examined factors associated with waste management behaviour in the South Leato Coastal Area, Gorontalo Province, using a binary logistic regression analysis. According to the results, attitude and waste management facilities were significantly related to waste management behavior. Individuals with positive attitudes and adequate facilities were more likely to practice proper waste management. Logistic regression revealed an adequate fit and acceptable discriminative ability, suggesting that the selected variables were appropriate for explaining variations in waste management behavior in the South Leato Coastal Area. Based on these results, both individual and environmental factors influence waste management practices in coastal communities. The findings demonstrate that to improve waste management in the South Leato Coastal Area, it is important to combine strategies that promote positive attitudes with adequate facilities. These combined efforts are likely to support more sustainable waste management behaviour and contribute to improved coastal environmental quality.

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Author Contributions Statement

Amanda Adityaningrum: Conducted the binary logistic regression analysis, performed model validation using the Hosmer–Lemeshow goodness-of-fit test, and interpreted the results using odds ratios and 95% confidence intervals. Muhammad Rezky Friesta Payu: Developed the research instrument and conducted validity and reliability testing of the questionnaire. Bela Silfana: Performed data entry and data processing.

All authors collected the research data through surveys and interviews, discussed the results, and contributed to the final manuscript.

Conflict of Interest Statement

Authors state no conflict of interest.

Data Availability

This research's data are available from the corresponding author upon reasonable request.

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