

Determinants of Sustainable Waste Management Practices Among Students at STIS Polytechnic of Statistics

Determinasi Tindakan Pengelolaan Sampah Berkelanjutan pada Mahasiswa Politeknik Statistika STIS

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ABSTRACT

Waste management presents a major sustainability challenge for higher education institutions because campuses generate substantial quantities of waste each day. However, campuses also provide strategic environments for developing sustainable behavior among students. This study examined sustainable waste management practices among students at STIS Polytechnic of Statistics and identified the factors associated with these practices. Primary data were collected from 310 active students through an online questionnaire administered using the Computer-Assisted Web Interviewing method. Respondents were selected through stratified random sampling. The data were analyzed using descriptive statistics, binary logistic regression, and factor analysis with principal component extraction and Varimax rotation. The results showed that 63.55% of students practiced sustainable waste management. Binary logistic regression identified campus facility support and exposure to digital and social media as significant predictors of sustainable waste management practices. Exposure to digital and social media exerted the strongest influence. By contrast, environmental knowledge, environmental concern, and personal motivation showed no statistically significant associations with sustainable waste management practices. Factor analysis classified the determinants into internal and external dimensions and identified campus facility support as the dominant external factor. These findings demonstrate that supportive campus facilities and effective digital communication strategies are essential for strengthening sustainable waste management practices among students.

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INTRODUCTION

Municipal solid waste has become an urgent global concern because it threatens environmental quality, public health, and sustainable development. Rapid urbanization, unsustainable consumption patterns, and the widespread use of single-use products have accelerated waste generation beyond the management capacity of many countries. In response, governments have expanded waste-processing infrastructure, strengthened waste management regulations, and promoted the principles of reduce, reuse, and recycle (3R)

alongside circular economy practices (Gusti et al., 2015).

Indonesia faces similar waste management challenges. According to the National Waste Management Information System (SPISN), Indonesia generated approximately 34.2 million metric tons of waste in 2024 (Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia, 2024). This amount is projected to decline slightly to 33.6 million metric tons in 2025. Separately, data from 323 regencies and cities recorded by the Ministry of Environment and Forestry indicate an annual waste generation volume of 35.3 million metric tons (Kementerian Lingkungan



Hidup dan Kehutanan Republik Indonesia, 2024). However, the waste reduction rate remains at only 1.11%, while 61.37% of the generated waste, equivalent to 21.67 million metric tons per year, remains inadequately managed. These figures indicate that Indonesia's waste management system has not yet achieved optimal performance. Because households constitute a major source of municipal waste, effective waste management depends substantially on the daily practices of individual waste generators.

Universities also contribute substantially to waste generation. An international study reported that university campuses generate an average of 0.19–0.21 kg of waste per capita per day. Total daily waste generation can reach several thousand kilograms and exceed 30,000 kg at large institutions. Campus waste primarily consists of organic matter, single-use plastics, beverage containers, and paper associated with academic and administrative activities (Rodríguez-Guerreiro *et al.*, 2024). Universities therefore function as “miniature cities” because their dense populations and intensive daily activities generate substantial quantities of waste.

Universities can also function as strategic agents of environmental change rather than merely as sources of waste (Amaral *et al.*, 2015). As centers of education and research, universities can promote sustainable mindsets and practices by providing appropriate waste management facilities, implementing environmentally responsible policies, and strengthening students' ecological literacy (Mohammadi *et al.*, 2023). Sustainable practices developed on campus may subsequently spread through students' social networks, including their families and communities. Conversely, inadequate waste management can cause environmental pollution and increase the risk of health problems such as diarrhea, respiratory disease, and dengue fever (Ompusunggu *et al.*, 2025).

Despite the strategic role of universities, students do not consistently practice sustainable waste management. Preliminary observations

and a mini-survey indicated that many students had not adopted appropriate waste management practices. Students frequently mixed organic and inorganic waste, underused designated waste bins, and rarely applied the 3R principles. However, most students were already aware of the adverse environmental consequences of inadequate waste management (Qu *et al.*, 2023). This discrepancy indicates a persistent gap between environmental knowledge and waste management behavior (Decoro & Cajucom, 2025).

This study focused on university students because they represent a young and educated population with the potential to promote sustainable behavior both on campus and in the broader community (Budowle *et al.*, 2021). STIS Polytechnic of Statistics provides a relevant institutional setting because its intensive academic and administrative activities generate various types of waste. Its students also receive academic training that emphasizes data analysis and rational decision-making. This distinctive academic context supports an empirical examination of the internal and external factors associated with students' sustainable waste management practices.

Previous international studies have extensively examined waste management practices among university students. A study conducted in China found that environmental knowledge, personal norms, and components of the Theory of Planned Behavior influenced students' waste management practices (Wu *et al.*, 2022). Research in Vietnam emphasized the importance of institutional policies and campus facilities in promoting waste sorting among students (Bang *et al.*, 2025). By contrast, a study in the Philippines identified a discrepancy between students' high environmental awareness and their persistently inadequate waste management practices (Decoro & Cajucom, 2025). A cross-national study involving Spain, Brazil, and the United Arab Emirates further demonstrated that social and cultural contexts shape students' sustainability behaviors (Chuvieco *et al.*, 2018). Collectively,

these studies have examined various individual and institutional determinants, including knowledge, attitudes, personal norms, facilities, and policy support. However, relatively few studies have explicitly investigated digital and social media exposure as a potential determinant of waste management practices among young adults.

Indonesian research on sustainable waste management has predominantly examined households, communities, academic staff, or the general public. Muniandy et al. (2021) focused on academic staff and did not examine students as primary agents of behavioral change. Ningsih (2025) investigated individuals' interest in becoming waste-bank customers rather than their actual waste management practices. Abd Rauf et al. (2021) and Sapawi et al. (2024) examined domestic and industrial community contexts, which do not adequately represent the higher education environment. Empirical studies that simultaneously examine internal and external determinants of students' waste management practices in Indonesia therefore remain limited. Relevant internal determinants include environmental knowledge, environmental concern, and personal motivation, whereas external determinants include campus facility support and exposure to digital and social media.

This study addresses these research gaps through three main contributions. First, it integrates internal and external determinants into a unified analytical framework for explaining students' sustainable waste management practices. Second, it examines exposure to digital and social media as a potential behavioral determinant that has received limited attention in higher education waste management research. Third, it examines students at an Indonesian government-affiliated higher education institution, which has academic and institutional characteristics that differ from those of conventional universities. These contributions provide a more comprehensive theoretical and empirical understanding of sustainable waste

management practices among students in higher education.

Theoretical Framework for Sustainable Waste Management Practices

Sustainable waste management practices comprise individual or collective actions that reduce waste generation and promote waste sorting, reuse, and recycling. These practices contribute to environmental protection and resource conservation (Rodríguez-Guerreiro et al., 2024). The Theory of Planned Behavior (TPB) provides a theoretical foundation for explaining such practices. According to TPB, attitudes, subjective norms, and perceived behavioral control shape an individual's behavioral intentions and subsequent actions (Ajzen, 1991).

Within the present study, TPB provides a conceptual basis for examining the internal and external determinants of students' waste management practices. Internal determinants include environmental knowledge, environmental concern, and personal motivation. External determinants include campus facility support and exposure to digital and social media. This framework recognizes that individual awareness alone may not produce sustainable behavior. Students also require institutional support and a social environment that facilitates and reinforces sustainable waste management practices.

Factors Influencing Sustainable Waste Management Practices

The determinants of sustainable waste management practices can generally be classified as internal or external. Internal determinants originate within individuals and include their knowledge, attitudes, concerns, values, and motivation. External determinants arise from the institutional, physical, informational, and social environments in which individuals act.

Environmental knowledge refers to an individual's understanding of environmental problems, the consequences of improper waste disposal, and appropriate waste management

methods (Kollmuss & Agyeman, 2002). Students with greater environmental knowledge may be more likely to adopt appropriate waste management practices because they better understand the consequences of their actions. Empirical evidence has associated greater environmental knowledge with more sustainable waste management practices among university students (Wu *et al.*, 2022). Environmental knowledge may also strengthen awareness of and commitment to sustainable waste management standards (Jacob & Dwipayanti, 2022; Rangkuti *et al.*, 2023).

Environmental concern represents an individual's awareness of environmental problems and willingness to support environmental protection. Individuals with greater environmental concern generally evaluate environmentally responsible actions more positively (Schultz *et al.*, 2005). Students with positive environmental attitudes may therefore be more likely to sort and dispose of waste appropriately (Evita *et al.*, 2025). Similar relationships have been observed in other sectors, including the hospitality industry. These findings indicate that environmental concern can provide an important psychological foundation for environmentally responsible behavior (Mensah & Ampofo, 2021).

Personal motivation may strengthen the consistency of pro-environmental practices. Values, beliefs, and personal commitments can encourage students to maintain sustainable waste management practices even when external reinforcement is limited. Environmental knowledge and positive attitudes may further strengthen this motivation (Akhtar *et al.*, 2022; Cho, 2019; Shafiei & Maleksaeidi, 2020). Internal determinants may therefore shape both students' willingness to adopt sustainable practices and their commitment to maintaining them.

External determinants may facilitate or constrain students' ability to translate environmental awareness into action. Campus facility support includes the availability of

sorted waste bins, waste collection systems, waste management programs, and other supporting infrastructure. Previous studies have associated adequate campus facilities with greater student participation in waste management activities (Budihardjo *et al.*, 2021; Timlett & Williams, 2008). Facilities may exert a stronger influence when they are comprehensive, clearly designated, and easily accessible (Bang *et al.*, 2025; Hao *et al.*, 2020). The campus environment can therefore either facilitate or impede students' sustainable waste management practices.

Exposure to digital and social media may also influence sustainable waste management practices. Digital platforms disseminate environmental information, increase the visibility of waste-related problems, and expose users to social expectations regarding environmentally responsible behavior (Saifullizam *et al.*, 2025; Rahsilaputeri *et al.*, 2022). Greater social media exposure has been associated with higher waste literacy among young people (Silaningrum, 2022). Social media campaigns may also encourage public participation by presenting waste management messages in accessible and engaging formats. For example, cleanliness campaigns delivered through TikTok have been associated with greater public awareness of and participation in waste management activities (Sukmono *et al.*, 2024).

Based on this theoretical and empirical background, the present study had three objectives. First, it determined the proportion of students at STIS Polytechnic of Statistics who practiced sustainable waste management. Second, it examined the factors associated with students' likelihood of adopting sustainable waste management practices. Third, it identified the underlying structure and clustering of the internal and external determinants associated with these practices. The findings provide empirical evidence on sustainability practices within a higher education setting and may inform the development of waste management strategies for campuses and broader urban communities.

This study hypothesized that environmental knowledge, environmental concern, personal motivation, campus facility support, and exposure to digital and social media would each be positively associated with students' sustainable waste management practices. Environmental knowledge and concern were expected to strengthen students' awareness of the consequences of inadequate waste management. Personal motivation was expected to support the consistent implementation of sustainable practices. Campus facility support was expected to facilitate appropriate waste management behavior, while digital and social media exposure was expected to reinforce students' awareness and engagement.

RESEARCH METHOD

This study used a quantitative design that combined descriptive and explanatory components. The descriptive component systematically characterized the distribution of students' sustainable waste management practices and the factors associated with these practices without manipulating the study variables (Nazir, 2014). The explanatory component tested the hypothesized relationships between these factors and students' sustainable waste management practices (Sugiyono, 2017). The explanatory variables comprised environmental knowledge, environmental concern, campus facility support, exposure to digital and social media, and personal motivation. The study collected data through a structured questionnaire and analyzed them using descriptive and inferential statistical methods.

Participants

The study population comprised all 1,618 active students enrolled at STIS Polytechnic of Statistics during the 2025/2026 academic year. The population included students from Levels I–IV. These students constituted the target population because they regularly participated in campus activities and used facilities related to waste management.

The study selected 310 students based on a 5% margin of error. The sampling procedure applied stratified random sampling without replacement and unequal allocation. Stratification divided the population into relatively homogeneous groups based on educational level and improved the representation of each group in the sample (Mukherjee, 2023). Sampling without replacement ensured that each student could be selected only once (Aubry, 2024). Unequal allocation allowed the sample size assigned to each stratum to be adjusted to improve estimation efficiency and precision compared with proportional allocation (Iqbal et al., 2024; Triveni et al., 2024). This procedure ensured adequate representation across educational levels.

Measures

The study used a structured questionnaire to assess students' sustainable waste management practices and the factors associated with these practices. The questionnaire comprised an introductory section, a respondent profile section, and six measurement sections:

1. Study information and confidentiality statement;
2. Respondent characteristics;
3. Sustainable waste management practices;
4. Environmental knowledge;
5. Environmental concern;
6. Campus facility support;
7. Exposure to digital and social media; and
8. Personal motivation.

The study selected these variables based on empirical evidence that sustainable waste management constitutes a form of pro-environmental behavior shaped by internal and external factors (Mohammadi et al., 2023). Environmental knowledge (X_1) represents an individual's understanding of environmental issues and appropriate waste management practices (Wu et al., 2022). Environmental concern (X_2) represents an individual's awareness of environmental problems and willingness to undertake environmentally

responsible actions (Mensah & Ampofo, 2021). Campus facility support (X_3) represents the availability of infrastructure that facilitates appropriate waste management practices (Budihardjo *et al.*, 2021). Exposure to digital and social media (X_4) represents access to environmental information and messages disseminated through digital platforms (Rahsilaputeri *et al.*, 2022). Personal motivation (X_5) represents the internal drive that supports consistent engagement in pro-environmental practices (Akhtar *et al.*, 2022).

Each variable was measured using five items, resulting in 30 measurement items. All items used a four-point Likert scale, which is commonly applied in social research to assess attitudes, perceptions, and self-reported behaviors (Koo & Yang, 2025). The response categories were coded as follows: 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

The study calculated a composite score for each variable by averaging the corresponding item scores. The mean provided a standardized representation of each construct because all items used the same measurement scale. The study categorized sustainable waste management practices using cutoff values of 2.50 and 3.25 (Bishop & Herron, 2015).

The study evaluated the measurement instrument through validity and reliability testing. Item validity was assessed using item–total correlations. All items produced correlation coefficients greater than the critical value of 0.361. The observed coefficients ranged from 0.498 to 0.919, indicating that all items adequately represented their respective constructs (Gültürk, 2024).

Internal consistency was assessed using Cronbach's alpha. All reliability coefficients exceeded the minimum acceptable threshold of 0.70. The reported coefficients ranged from 0.872 to 0.890, indicating satisfactory internal consistency across the measurement items (Taber, 2018). The instrument therefore met the predetermined validity and reliability criteria.

Procedure

The study proceeded through several stages. The first stage involved developing questionnaire items based on the theoretical indicators for each variable. The researchers then selected respondents using the predetermined sampling procedure and distributed the questionnaire online. Data collection took place from November 14 to 26, 2025.

After data collection, the researchers reviewed, coded, and processed the responses. Data processing included checking response completeness, calculating composite scores, and categorizing the dependent variable. The researchers then conducted descriptive and inferential analyses to address the study objectives.

Data Analysis

The study employed descriptive and inferential statistical analyses. Descriptive analysis summarized the distributions of respondent characteristics and study variables. Pie charts and stacked bar charts presented selected data distributions.

Inferential analysis comprised binary logistic regression and principal component analysis. Binary logistic regression examined the associations between the explanatory variables and the dichotomous outcome variable. Model evaluation included an overall goodness-of-fit test, Wald tests, odds ratios, 95% confidence intervals, and a classification table.

Principal component analysis identified the underlying component structure of the variables associated with sustainable waste management practices. The analysis applied Varimax rotation to improve component interpretability. The Kaiser–Meyer–Olkin measure and Bartlett's test of sphericity assessed the suitability of the data for principal component analysis. The analysis determined the number of retained components based on eigenvalues greater than 1.00, the scree plot, and theoretical interpretability. A biplot visualized the relationships among the variables

and the extracted components (Abdi & Williams, 2010; Gabriel, 1971)

Table 1. Results of the Validity and Reliability Tests

Variable		Validity	Reliability
Environmental Knowledge	P1	0.621	0.882
	P2	0.670	0.880
	P3	0.611	0.882
	P4	0.719	0.881
	P5	0.764	0.879
Environmental Awareness	P1	0.577	0.879
	P2	0.498	0.882
	P3	0.808	0.872
	P4	0.572	0.881
	P5	0.788	0.874
Campus Facilities Support	P1	0.607	0.885
	P2	0.894	0.874
	P3	0.802	0.880
	P4	0.821	0.878
	P5	0.804	0.877
Digital and Social Media Exposure	P1	0.720	0.875
	P2	0.822	0.874
	P3	0.753	0.875
	P4	0.765	0.876
	P5	0.822	0.874
Personal Motivation	P1	0.907	0.876
	P2	0.863	0.878
	P3	0.846	0.872
	P4	0.919	0.873
	P5	0.853	0.874
Sustainable Behavior	P1	0.688	0.879
	P2	0.557	0.886
	P3	0.780	0.884
	P4	0.719	0.890

RESULTS

Sustainable Waste Management Practices among Students

Descriptive analysis determined the proportion of students at STIS Polytechnic of Statistics who practiced sustainable waste management. The analysis also summarized environmental knowledge, environmental concern, personal motivation, campus facility support, and exposure to digital and social media.

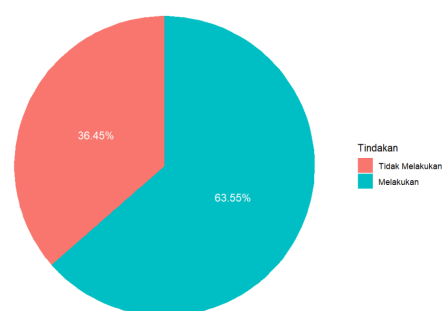


Figure 1. Proportion of students practicing sustainable waste management at STIS Polytechnic of Statistics

Figure 1 shows that 197 of the 310 respondents (63.55%) practiced sustainable waste management, whereas 113 respondents (36.45%) did not. Most respondents therefore demonstrated sustainable waste management practices. However, more than one-third of the respondents remained in the unsustainable category, indicating substantial scope for improvement in campus waste management practices. The analysis subsequently examined the distribution of sustainable waste management practices across academic levels.

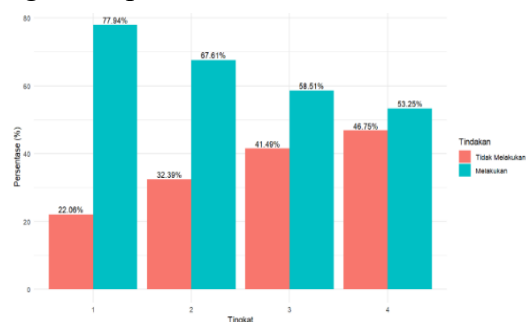


Figure 2. Distribution of sustainable waste management practices by academic level

Figure 2 shows that the proportion of students practicing sustainable waste management differed across academic levels. Level I had the highest proportion at 77.94%, followed by Level II at 67.61% and Level III at 58.51%. Level IV had the lowest proportion at 53.25%. The proportion of students practicing sustainable waste management was therefore progressively lower at higher academic levels. This trend may be attributed to stronger motivational and disciplinary characteristics typically observed in the early phases of academic study.

Descriptive Statistics for the Study Variables

Table 2 presents the means and standard deviations of the study variables.

Table 2. Descriptive Statistics for the Study Variables

Variable	Mean	Standard Deviation
Environmental Knowledge	3.69	0.36
Environmental Awareness	3.68	0.39
Campus Facilities Support	2.77	0.69
Digital and Social Media Exposure	3.02	0.65
Personal Motivation	3.60	0.47

The results facilitate comparison across variables without applying specific thresholds to determine whether a value is high, low, or homogeneous. Environmental knowledge had the highest mean score ($M = 3.69$, $SD = 0.36$). Environmental concern had a similar mean score ($M = 3.68$, $SD = 0.39$). The small standard deviations indicate relatively limited variation in students' responses to both variables.

Personal motivation had a mean score of 3.60 and a standard deviation of 0.47. This variable had the third-highest mean and showed slightly greater response variability than environmental knowledge and environmental concern.

Exposure to digital and social media had a mean score of 3.02 and a standard deviation of 0.65. Campus facility support had the lowest mean score ($M = 2.77$, $SD = 0.69$). Campus facility supports also had the largest standard deviation, indicating greater variation in students' perceptions of campus waste management facilities.

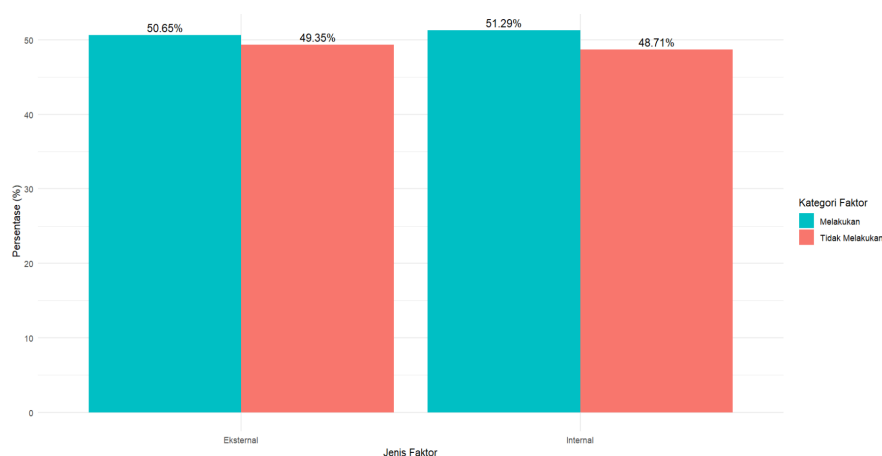


Figure 3. Distribution of sustainable waste management practices according to internal and external factors

Distribution of Internal and External Factors

Figure 3 shows nearly balanced distributions for both internal and external factors. Internal factors comprised environmental knowledge, environmental concern, and personal motivation. Based on these factors, 51.29% of students practiced sustainable waste management, whereas 48.71% did not. External factors comprised campus facility support and exposure to digital and social media. Based on these factors, 50.65% of students practiced sustainable waste management, whereas 49.53% did not. These proportions indicate only small differences between students who practiced sustainable waste management and those who did not within each factor category.

The nearly balanced distributions suggest that neither internal nor external factors alone adequately differentiated the two behavioral groups. Sustainable waste management practices may therefore reflect the combined contribution of individual characteristics and environmental support.

Table 3. Generalized Variance Inflation Factors for the Explanatory Variables

Variabel	GVIF
Environmental Knowledge	1.9036
Environmental Awareness	2.0056
Campus Facilities Support	1.0922
Digital and Social Media Exposure	1.4037
Personal Motivation	2.2593

Table 4. Binary Logistic Regression Parameter Estimates

Variable	Estimate	Std. Error	Sig.	Odds Ratio
Intercept	-4.2631	1.4155	0.0026	0.0141
Environmental Knowledge	-0.1207	0.4907	0.8058	0.8863
Environmental Awareness	0.0987	0.4623	0.8310	1.1037
Campus Facilities Support	0.4773	0.2098	0.0229	1.6117
Digital and Social Media Exposure	1.1510	0.2600	0.0000	3.1614
Personal Motivation	0.0607	0.4096	0.8821	1.0626

Binary Logistic Regression

Multicollinearity Assessment

The generalized variance inflation factor values were below 3 for all explanatory variables, and most values were close to 1. These results indicate no evidence of problematic multicollinearity among the explanatory variables. All variables were therefore retained in the binary logistic regression model.

Parameter Estimates

The binary logistic regression analysis identified campus facility support and exposure to digital and social media as statistically

significant predictors of sustainable waste management practices. Environmental knowledge, environmental concern, and personal motivation were not statistically significant predictors.

The estimated binary logistic regression equation was as follows:

$$\ln\left(\frac{p_i}{1-p_i}\right) = -4,2631 - 0,1207\text{Pengetahuan}_i + 0,0987\text{Sikap}_i + 0,4773\text{Fasilitas}_i + 1,1510\text{Media}_i + 0,0607\text{Motivasi}_i$$

Campus facility support had an odds ratio of 1.612. Holding the other variables

constant, a one-unit increase in perceived campus facility support was associated with 1.612 times the odds of practicing sustainable waste management. This result indicates a positive association between campus facility support and sustainable waste management practices.

Exposure to digital and social media had an odds ratio of 3.162. Holding the other variables constant, a one-unit increase in digital and social media exposure was associated with 3.162 times the odds of practicing sustainable waste management. Digital and social media exposure therefore had the largest odds ratio among the explanatory variables.

Model Fit

The Hosmer–Lemeshow test produced a *p*-value of 0.8102. This value exceeded the significance level of 0.05. The test therefore provided no evidence of a significant discrepancy between the observed and model-predicted outcomes. The logistic regression model consequently showed an acceptable fit to the observed data.

Odds Ratio

Figure 4 presents the odds ratios and 95% confidence intervals for the explanatory variables. Campus facility supports and exposure to digital and social media had odds ratios greater than 1, and their confidence intervals did not include 1. These results confirm statistically significant positive associations with sustainable waste management practices.

Campus facility support had an odds ratio of approximately 1.612. Exposure to digital and social media had a larger odds ratio of approximately 3.161, identifying it as the strongest predictor in the model.

Environmental knowledge, environmental concern, and personal motivation were not statistically significant. The confidence intervals for these variables included the reference value of 1. The analysis therefore did not provide sufficient evidence that these variables were independently associated with sustainable waste management practices after adjustment for the other predictors.

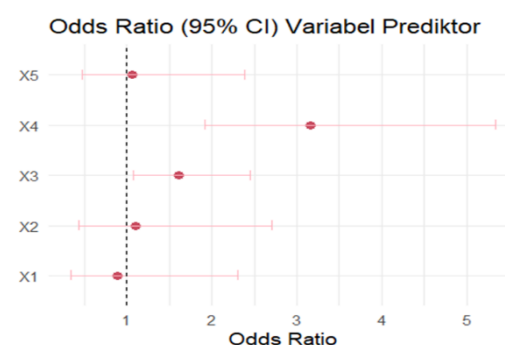


Figure 4. Odds ratios and 95% confidence intervals for the binary logistic regression model

Classification Performance

The binary logistic regression model achieved an overall classification accuracy of 68.39%. The model correctly classified 163 students who practiced sustainable waste management as positive cases. It also correctly classified 49 students who did not practice sustainable waste management as negative cases.

The model incorrectly classified 34 students who practiced sustainable waste management as negative cases. It also incorrectly classified 64 students who did not practice sustainable waste management as positive cases. These findings indicate that the model classified sustainable practices more accurately than unsustainable practices.

Although prediction errors persist, an accuracy rate exceeding 65% is generally

considered adequate for behavioral research, as human behavior is shaped by complex social and psychological factors.

Principal Component Analysis

Principal component analysis examined the empirical structure of the explanatory variables. The analysis assessed whether the variables clustered according to the proposed internal and external dimensions.

Suitability of the Data

The Kaiser–Meyer–Olkin measure was 0.814, indicating adequate shared variance among the variables for principal component analysis. Bartlett’s test of sphericity was statistically significant, $\chi^2 = 572.109$, $p < 0.001$. The significant result indicates that the correlation matrix differed from an identity matrix. The data were therefore suitable for principal component analysis.

Components Extraction

The first component had an eigenvalue of 2.930 and explained 58.60% of the total variance. The second component had an eigenvalue of 0.843 and explained an additional 16.86%. Together, the first two components explained 75.46% of the total variance.

The Kaiser criterion, which retains components with eigenvalues greater than 1, supported a one-component solution. However, the analysis retained two components based on the theoretical distinction between internal and external determinants and the interpretability of the two-component solution. This decision

should be interpreted cautiously because the second component had an eigenvalue below 1.

Table 6. Principal Component Analysis Results

Components	Eigen Value	Proportions of Variance	Cumulative
1	2.930	58.600	58.600
2	0.843	16.860	75.460
3	0.530	10.860	86.330
4	0.382	7.640	93.960
5	0.302	6.040	100.000

Unrotated Component Matrix

The unrotated component matrix showed that most variables loaded strongly on the first component, with loadings ranging from approximately 0.75 to 0.86. The first component therefore represented the dominant dimension in the data.

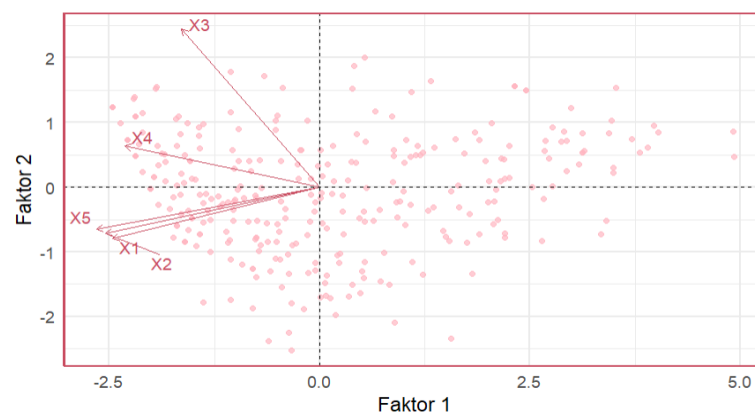
Several variables also showed substantial loadings on the second component. The unrotated solution consequently did not provide a sufficiently distinct component structure. Varimax rotation was applied to improve component separation and interpretability.

Table 7. Unrotated Principal Component Matrix

Variable	Component 1	Component 2
1	0.802	-0.258
2	0.829	-0.233
3	0.534	0.797
4	0.753	0.207
5	0.864	-0.210
6	0.802	-0.258
7	0.829	-0.233
8	0.534	0.797
9	0.753	0.207
10	0.864	-0.210

Table 8. Rotated PCA Results (Varimax)

Variable	Component 1	Component 2	Dominant
Environmental Knowledge	0.833	0.130	Factor 1
Environmental Awareness	0.845	0.164	Factor 1
Campus Facilities Support	0.119	0.952	Factor 2
Digital and Social Media Exposure	0.580	0.523	Factor 1
Personal Motivation	0.866	0.200	Factor 1

**Figure 5. Biplot of the principal component analysis**

Rotated Component Structure

Varimax rotation produced a clearer component structure. Environmental knowledge, environmental concern, and personal motivation loaded primarily on the first component. These variables represented the internal dimension of sustainable waste management practices.

Campus facility support loaded strongly on the second component, with a loading of 0.952. This variable therefore represented the external institutional dimension. The component assignment of exposure to digital and social media must be reported according to its largest rotated loading in Table 8.

The rotated solution indicates that students' sustainable waste management practices reflect distinct individual and environmental dimensions. However, the

interpretation of digital and social media exposure must remain consistent across the rotated matrix and the biplot.

Biplot Interpretation

Figure 5 illustrates the relationships between the study variables and the two retained components. Environmental knowledge, environmental concern, and personal motivation were oriented toward the first component. Their similar directions indicate positive relationships among these internal variables.

Campus facility support was oriented toward the second component and had the longest vector. This pattern indicates that campus facility support contributed strongly to the external dimension. Exposure to digital and social media should be assigned to the

component toward which its vector is most closely aligned.

Most respondent observations were concentrated near the center of the biplot. This concentration indicates that many respondents had scores close to the sample averages across the study variables. Observations positioned farther from the center reflected stronger associations with the variables oriented in the same direction.

The biplot corroborates the findings of the previous Varimax principal component analysis, demonstrating that the factor structure among students at the STIS Polytechnic of Statistics is distinctly divided into two groups: internal factors (environmental knowledge, environmental concern, personal motivation) and external factors (campus facility support, exposure to digital and social media).

DISCUSSION

This study identified campus facility support and exposure to digital and social media as significant predictors of students' sustainable waste management practices. By contrast, environmental knowledge, environmental concern, and personal motivation showed no statistically significant associations with these practices. These findings indicate that contextual and environmental conditions may shape students' waste management practices more strongly than individual characteristics alone.

The significant association between campus facility support and sustainable waste management practices is consistent with previous findings. Budihardjo et al. (2021), Hao et al. (2020), and Bang et al. (2025) reported that segregated waste bins, waste management programs, and supporting infrastructure can strengthen students' participation in sustainable waste management. This finding also aligns with the Theory of Planned Behavior, particularly the concept of perceived behavioral

control (Ajzen, 1991). This concept proposes that individuals are more likely to perform a behavior when adequate resources and supportive conditions make the behavior easier to undertake. Students may therefore possess strong environmental awareness but remain less likely to practice sustainable waste management when campus facilities are inadequate or inaccessible.

Exposure to digital and social media emerged as the strongest predictor of sustainable waste management practices. This finding is consistent with Rahsilaputeri et al. (2022), who emphasized the role of media in shaping pro-environmental behavior among younger populations. Silaningrum (2022) and Sukmono et al. (2024) similarly reported that social media can strengthen environmental literacy, awareness, and public participation in waste management. Digital media may exert a strong influence on university students because this population interacts extensively with digital platforms. Environmental information, campaigns, and social norms communicated through these platforms may consequently shape students' perceptions and encourage their translation into actual practices.

Environmental knowledge, environmental concern, and personal motivation showed no statistically significant associations with sustainable waste management practices. This finding differs from previous studies that identified environmental knowledge, attitudes, and motivation as important determinants of pro-environmental behavior (Wu et al., 2022; Mensah & Ampofo, 2021; Akhtar et al., 2022). The knowledge-action gap may explain this discrepancy. This gap occurs when individuals possess adequate knowledge and favorable attitudes but fail to translate them into consistent behavior (Kollmuss & Agyeman, 2002; Decoro & Cajucom, 2025). The descriptive findings support this interpretation. Students reported relatively high environmental knowledge, environmental concern, and personal motivation, yet a substantial proportion did not practice sustainable waste

management. Individual awareness may therefore be insufficient when the surrounding environment does not adequately support the intended behavior.

The principal component analysis provided additional insight into the relationships among the explanatory variables. The two retained components accounted for more than 75% of the total variance. After Varimax rotation, environmental knowledge, environmental concern, personal motivation, and exposure to digital and social media loaded primarily on the first component. Campus facility support formed a distinct second component. Although digital and social media exposure was conceptually classified as an external factor, its empirical association with the first component suggests that media content may operate through internal psychological processes. Students must interpret and internalize digital information before it can shape their attitudes, motivation, or behavior.

Overall, the findings indicate that sustainable waste management practices emerge from the interaction between individual characteristics and environmental conditions. Among students at STIS Polytechnic of Statistics, campus facility support and exposure to digital and social media showed stronger statistical associations with sustainable practices than environmental knowledge, environmental concern, and personal motivation. These findings underscore the importance of strengthening campus waste management infrastructure, implementing consistent sustainability programs, and using digital media strategically for environmental education and behavioral campaigns. An integrated approach that combines accessible facilities with sustained digital communication may promote more consistent sustainable waste management practices among students.

CONCLUSIONS

Among the 310 students surveyed at STIS Polytechnic of Statistics, 63.55% practiced sustainable waste management, whereas 36.45% did not. The proportion of students practicing sustainable waste management was highest at Level I and progressively lower at Levels II–IV. Because this study used a cross-sectional design, this pattern indicates differences among academic levels rather than a decline in individual behavior over time.

Binary logistic regression identified campus facility support and exposure to digital and social media as significant predictors of sustainable waste management practices. Exposure to digital and social media had the strongest association with these practices. By contrast, environmental knowledge, environmental concern, and personal motivation showed no statistically significant associations after adjustment for the other variables. These findings indicate that environmental knowledge and positive intentions may not consistently translate into sustainable practices without accessible facilities and continued informational reinforcement.

Principal component analysis further clarified the relationships among the explanatory variables. Environmental knowledge, environmental concern, personal motivation, and exposure to digital and social media loaded primarily on the first component. Campus facility support formed a distinct second component. Although digital and social media exposure was conceptually classified as an external determinant, its empirical association with the first component suggests that media content may influence behavior through individual processes of interpretation and internalization.

Overall, students' sustainable waste management practices reflect the interaction between individual characteristics and contextual support. Campus interventions should therefore prioritize accessible segregated waste bins, convenient disposal points, consistent waste management programs, and institutional policies that facilitate

environmentally responsible practices. Campuses should complement these measures with sustained digital communication that provides environmental information, education, and behavioral campaigns through platforms commonly used by students. Integrating supportive infrastructure with targeted digital communication may produce more consistent sustainable waste management practices than interventions that rely primarily on environmental knowledge or personal motivation.

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AI USAGE STATEMENT

Generative artificial intelligence (ChatGPT) was used during manuscript preparation to assist in identifying unclear passages and improving the readability and clarity of the text. All AI-assisted outputs were subsequently reviewed, edited, and revised by the authors. Generative AI was not used to conduct the research, perform data analysis, or draw conclusions. The authors take full responsibility for the final content of the manuscript.

AUTHORSHIP CONTRIBUTION

Adrian Januartha: Conceptualization, methodology, data curation, investigation, formal analysis, writing-original draft, and visualization.

Benedicta Aurelia Syafhura Angelina: Conceptualization, data curation, investigation, and writing -original draft.

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All authors reviewed and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this research, its authorship, or publication.

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