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Smart Waste Management Acceptance and Perceived Urban Environmental Health in Jabodeta

E. Ernyasih[1]*, N. Nelfiyanti[2], Eka Samsul Ma'arif[3], D. Daruki[4], Anwar Mallongi[5], Donita Lutfia Hasanah[6]
[1]Faculty of Public Health, Universitas Muhammadiyah Jakarta, 15445 Jakarta, Indonesia
[2]Department of Industrial Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, 10510 Jakarta, Indonesia
[3]Department of Electrical Engineering, Faculty of Engineering, Universitas Muhammadiyah Jakarta, 10510 Jakarta, Indonesia
[4]Department of Industrial Engineering, Faculty of Engineering, Mercu Buana University, Jakarta, Indonesia
[5]Department of Environmental Health, Faculty of Public Health, Hasanuddin University, Indonesia
[6]Faculty of Public Health, Universitas Muhammadiyah Jakarta, 15445 Jakarta Indonesia

***Corresponding Author**: E-mail: ernyasih@umj.ac.id

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ABSTRACT

Introduction: Urban waste growth in metropolitan areas intensifies sanitation challenges and environmental health risks. Smart waste management offers data-driven waste services; however, its effectiveness depends on public acceptance. Despite increasing implementation of smart waste technologies, limited empirical evidence explains how behavioral and psychosocial determinants shape citizen acceptance in developing urban contexts, particularly in relation to perceived environmental health conditions rather than objectively measured environmental outcomes. This study investigates the determinants of smart waste management acceptance and its association with perceived urban environmental health in Jabodeta, Indonesia, using an extended Technology Acceptance Model that integrates digital literacy, environmental concerns, social norms, and perceived risk.

Methods: A cross-sectional survey of 120 respondents was conducted and analyzed using partial least squares structural equation modeling with bootstrapping. Measurement quality met recommended thresholds, including outer loadings greater than 0.70, average variance extracted ranging from 0.52 to 0.78, strong reliability, and HTMT values below 0.90.

Results: The structural model explained substantial variance in perceived ease of use ($R^2 = 0.81$) and perceived usefulness ($R^2 = 0.69$), moderate-to-strong variance in acceptance ($R^2 = 0.62$), and modest variance in perceived urban environmental health ($R^2 = 0.18$). Digital literacy positively predicted perceived ease of use ($\beta = 0.52$), while perceived risk negatively predicted perceived ease of use ($\beta = -0.37$). Perceived ease of use strongly predicted perceived usefulness ($\beta = 0.74$). Environmental concern ($\beta = 0.26$) and social norms ($\beta = 0.15$) positively predicted perceived usefulness. Perceived usefulness ($\beta = 0.32$) and perceived ease of use ($\beta = 0.19$) positively predicted acceptance, and acceptance was positively associated with perceived urban environmental health ($\beta = 0.43$). Mediation analysis identified statistically significant indirect effects for selected pathways; however, these effects should be interpreted cautiously due to inconsistencies in directional patterns.

Conclusion: The findings suggest that perceived environmental health benefits associated with smart waste management are linked to sustained public acceptance. This acceptance is supported by digital literacy, socially reinforced perceptions of usefulness, and effective risk communication combined with reliable service delivery. These results highlight the importance of behavioral and perceptual factors in shaping citizen engagement with smart environmental technologies, while acknowledging that the study reflects perceived rather than objectively measured environmental outcomes.

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INTRODUCTION

Over the past twenty years, urban growth in Indonesia has been strongly linked to rapid urbanization, population expansion, and increasingly intensive shifts in household consumption behaviors. The interplay of these elements has led to a marked rise in both the volume and diversity of urban solid waste. These developments not only influence the visual quality of urban areas but also impose considerable strain on environmental service systems, such as waste collection, transfer, transportation, sorting, and final disposal. When traditional waste management systems are unable to keep pace with the growing volume and complexity of waste, various issues arise, including the accumulation of waste, declining sanitation standards, greater risks of soil and water pollution (1–3), and increased public health concerns resulting from worsening environmental conditions (4).

To address these issues, many cities around the world have begun implementing smart waste management (SWM) as part of wider smart city initiatives focused on sustainability. SWM employs digital innovations including the Internet of Things (IoT), smart sensors, and real-time data analytics to enhance the efficiency of waste sorting, collection, and transportation processes (5,6). These approaches aim to strengthen operational performance, increase transparency, and improve the responsiveness of waste management services (7,8). From both technical and environmental governance standpoints, SWM holds promise for enhancing sanitation and minimizing environmental risks; however, its effectiveness largely depends on proper implementation and continuous user participation (9–11).

Nonetheless, the effectiveness of SWM implementation is influenced not only by the availability of technology and infrastructure but also by the willingness of citizens who are the main users to accept and actively engage with the system. Studies in technology adoption behavior consistently indicate that public acceptance is a key factor in ensuring the long-term viability of digital innovations in public services (12–14). Without adequate social support, trust, and user engagement, SWM systems may remain underutilized and fail to deliver their intended service improvements (15,16). This challenge is particularly salient in developing countries such as Indonesia, where disparities in digital access, social context, and institutional capacity may shape patterns of technology adoption.

In examining the dynamics of technology acceptance in waste management, this study adopts the Technology Acceptance Model (TAM) as its primary theoretical framework. TAM posits that individuals' decisions to accept and use technology are primarily influenced by perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which individuals believe that a technology enhances performance or outcomes, whereas perceived ease of use reflects the degree to which the technology is perceived as effortless to understand and operate (17,18).

The extension of TAM in this study is theoretically grounded in the assumption that citizens' evaluations of environmental technologies are shaped not only by instrumental judgments of usefulness and ease of use, but also by broader cognitive, normative, and contextual influences. Digital literacy is expected to support perceived ease of use because individuals with stronger digital competence are generally better able to navigate interfaces, interpret digital functions, and engage with app-based or sensor-enabled public services. Environmental concern may strengthen perceived usefulness by increasing the salience of environmental benefits and motivating support for technologies seen as contributing to cleaner urban conditions. Social norms are also likely to reinforce perceived usefulness, as individuals may evaluate SWM more positively when community expectations and shared behavioral standards favor environmentally responsible practices. By contrast, perceived risk may reduce perceived ease of use because concerns about system reliability, privacy, uncertainty, or operational failure can undermine confidence in interacting with digital service platforms. Integrating these constructs therefore provides a theoretically more comprehensive account of SWM acceptance than a conventional TAM specification alone.

In the context of SWM, perceived usefulness refers to the belief that a technology-based waste management system can enhance service efficiency, environmental cleanliness, and overall urban environmental conditions. Perceived ease of use reflects users' perceptions of how easily they can interact with digital waste management platforms, such as reporting applications, sensor-based systems, or app-based collection services. Prior studies have consistently demonstrated that these two constructs are key predictors of technology adoption and usage intentions (19,20).

Beyond cognitive factors, recent studies emphasize the importance of psychosocial determinants, including environmental concern, social norms, and perceived risk, in shaping technology acceptance. Environmental concern functions as an internal motivational driver that encourages individuals to support environmentally sustainable innovations, while social norms influence behavior through perceived expectations and social pressure within communities (21,22). Perceived risk, particularly related to system reliability, privacy, and data security, may reduce users' confidence and willingness to engage with digital systems if not adequately addressed (23,24). Integrating these psychosocial factors into TAM provides a more comprehensive framework for understanding user behavior in the context of environmental technologies such as SWM.

SWM is closely associated with perceived urban environmental health outcomes. Cleaner environments may reduce the risk of environmentally related diseases, improve perceived air and water quality, and enhance community well-being (25–27). However, in behavioral research contexts, environmental health is often captured through citizens' perceptions of environmental conditions rather than objective environmental measurements. An effectively implemented SWM system also aligns with the Sustainable Development Goals, particularly those related to health, sanitation, and sustainable cities (28). Therefore, examining the relationship between SWM acceptance and perceived urban environmental health is important to understand how citizen engagement with digital waste systems is associated with perceived environmental improvements.

Although smart waste management has received growing attention in the literature, three important gaps remain. First, existing studies tend to focus either on the technical performance of smart waste systems or on general technology adoption behavior, while relatively few studies integrate technological, psychosocial, and environmental perception variables within a single explanatory framework. Second, TAM-based studies in environmental public service settings have often emphasized adoption intention or usage behavior, with limited attention to how acceptance relates to downstream perceptions of environmental health conditions. Third, evidence from rapidly urbanizing metropolitan regions in developing countries remains comparatively limited, even though such contexts are marked by uneven digital literacy, diverse social norms, and complex environmental service constraints. By extending TAM with digital literacy, environmental concern, social norms, and perceived risk, and by positioning perceived urban environmental health as a distal perception-based outcome, this study seeks to advance current understanding of how citizens evaluate and engage with smart environmental technologies in developing urban settings. This study addresses these gaps by developing and testing a structural model that incorporates these factors as determinants of technology perception and SWM acceptance, and by examining their association with perceived urban environmental health. Using a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach, this study aims to contribute to the advancement of technology acceptance theory in environmental contexts while providing behaviorally grounded insights for more inclusive and sustainable urban waste management policies.

METHOD

This study employed a structured and systematic methodological approach to ensure the reliability, validity, and transparency of the findings. The key components of the research design, sampling, measurement, and analysis procedures are described below.

This study employed a quantitative approach using a cross-sectional survey design. This design enables the examination of relationships between latent variables within a single observation period, particularly in the context of technology acceptance in public services. However, due to its cross-sectional nature, the study is limited to identifying associations between variables and does not permit causal inference. The study was conducted in the Greater Jakarta area (Jakarta, Bogor, Depok, and Tangerang), which represents a densely populated urban region characterized by complex waste management challenges and ongoing transformation toward smart city-based services.

The study population was urban residents of the Greater Jakarta (JABODETA) aged 18 years and above. Eligibility criteria were defined as follows: (1) residence within the Jabodeta area, (2) age 18 years or older, (3) access to municipal or neighborhood waste management services, (4) ownership or regular use of a digital device such as a smartphone, and (5) prior experience using at least one digital public service within the previous 12 months, such as e-government applications, app-based payment systems, digital complaint platforms, or mobile service interfaces. Respondents were recruited purposively through urban community networks and digitally mediated outreach to identify individuals who were both exposed to urban waste service conditions and familiar with routine digital service use. This recruitment strategy was chosen to ensure conceptual relevance to the study variables; however, it may also have increased the likelihood of selection bias toward more digitally engaged residents.

The sample size was considered acceptable for PLS-SEM because the study was designed as an explanatory and prediction-oriented model test involving reflective constructs and a moderate level of structural complexity. In addition to the commonly cited 10-times rule, the adequacy of the sample was judged in relation to the maximum number of structural paths directed at any endogenous construct and the relatively stable performance of PLS-SEM under non-normal data conditions and modest sample sizes. Nevertheless, the sample should be interpreted as analytically sufficient for estimating the proposed model rather than as statistically representative of the entire Jabodeta population. Because purposive sampling was used, the findings should be generalized cautiously and understood as reflecting patterned associations within the recruited sample rather than population-level estimates.

The research instrument was a structured questionnaire developed based on an extensive literature review and adapted from validated measurement scales used in prior studies on technology acceptance and environmental behavior. All indicators were measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The constructs measured included digital literacy, environmental concern, social norms, perceived risk, perceived ease of use, perceived usefulness (TAM), acceptance of SWM, and perceived urban environmental health. The latter construct was operationalized using subjective indicators reflecting respondents' perceptions of environmental cleanliness, waste-related health risks, and environmental quality (e.g., perceived air and water conditions), rather than objective environmental measurements. Each construct was measured using multiple items adapted to the local urban context, and the questionnaire was refined through preliminary review to ensure clarity and contextual relevance. Data collection was conducted through a survey, with informed consent obtained at the beginning of the questionnaire. Participant anonymity and data confidentiality were strictly maintained. Responses that did not meet eligibility criteria or exhibited low-quality patterns (e.g., incomplete or inconsistent responses) were excluded prior to analysis.

The questionnaire consisted of multi-item reflective measures for digital literacy, environmental concern, social norms, perceived risk, perceived ease of use, perceived usefulness, smart waste management acceptance, and perceived urban environmental health. Item wording was adapted from prior technology acceptance and environmental behavior studies and then refined to fit the context of digital waste management services. The adaptation process focused on conceptual equivalence, local contextual relevance, and item clarity. Before the main survey, the instrument underwent preliminary review to assess wording clarity, face validity, and contextual appropriateness for urban respondents familiar with digital public services. The final instrument used a 5-point Likert scale ranging from strongly disagree to strongly agree for all construct indicators.

Table 1. Operational Definition of Constructs and Measurement Domains

Construct	Conceptual Definition	Measurement Domain	Example Indicator Focus
Digital Literacy	Individual capacity to understand and use digital tools and interfaces	Ability to use apps, navigate digital platforms, interpret digital functions	Confidence in using app-based public services
Environmental Concern	Degree of concern about environmental problems and sustainability	Awareness of waste problems, concern for urban cleanliness, ecological responsibility	Concern about waste impacts on the urban environment
Social Norms	Perceived expectations and social influence from others regarding environmentally responsible behavior	Community expectations, peer influence, perceived approval	Perception that important others support smart waste practices
Perceived Risk	Perceived uncertainty or concern regarding the use of SWM technology	Privacy concern, service reliability, uncertainty, operational failure	Concern that the system may not function reliably

Perceived Ease of Use	Perceived degree of effort required to use SWM technology	Ease of learning, clarity of use, simplicity of interaction	SWM applications are easy to understand and use
Perceived Usefulness	Belief that SWM technology improves service performance or environmental management	Efficiency, convenience, service effectiveness, environmental benefit	SWM helps improve waste service quality
SWM Acceptance	Readiness or willingness to accept and engage with smart waste management systems	Favorable attitude, intention to engage, support for implementation	Willingness to use and support SWM services
Perceived Urban Environmental Health	Citizens' perceptions of environmental cleanliness and waste-related health conditions	Perceived sanitation, perceived waste-related health risks, perceived environmental quality	Perception that waste conditions are cleaner and healthier

Data analysis was performed using SmartPLS with the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. Evaluation of the measurement model included assessments of reliability and construct validity, including outer loadings (≥ 0.70), composite reliability and Cronbach's alpha (≥ 0.70), and average variance extracted (AVE ≥ 0.50). Discriminant validity was assessed using the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio. After confirming the adequacy of the measurement model, the structural model was evaluated using path coefficients, R^2 values, f^2 effect sizes, Q^2 predictive relevance, and collinearity diagnostics (VIF). The significance of structural relationships was tested using bootstrapping with 5,000 subsamples to obtain t-statistics, p-values, and confidence intervals. Mediation analysis was conducted to assess the role of SWM acceptance as an intermediary variable linking individual and psychosocial factors with perceived urban environmental health outcomes. All interpretations of structural relationships were limited to associative patterns consistent with the cross-sectional design. This research obtained ethical approval from the Faculty of Public Health (FKM Universitas Muhammadiyah Jakarta) with approval number 10.235.C/KEPK-FKMUMJ/V/2025.

RESULTS

Respondent Characteristics

Respondent characteristics describe the profile of the study sample in the Greater Jakarta metropolitan area, comprising a total of 120 respondents. Overall, the sample was concentrated among working-age adults, women, and respondents with higher educational attainment. In terms of age, the majority of respondents were categorized as productive adults (114 respondents; 95%), whereas older adults accounted for 6 respondents (5%). This composition indicates that the findings primarily reflect the perceptions and experiences of the working-age population, while the representation of older adults remains limited.

In terms of gender, female respondents accounted for 92 participants (76.6%), while male respondents accounted for 28 participants (23.4%). The predominance of female respondents should be considered when interpreting the findings, as some measured constructs may be shaped by gendered social roles and preferences. Accordingly, the structural relationships reported in this study should be interpreted within the context of this sample composition rather than as fully representative of the broader urban population.

Based on educational attainment, most respondents had a college-level education (81 respondents; 67.5%). Respondents with a high school education or equivalent numbered 34 (28.4%), while those with a junior high school education or equivalent numbered 5 (4.1%) as shown in table 2. The dominance of respondents with higher education suggests a relatively strong literacy profile within the sample, which may have supported questionnaire comprehension and response quality. However, this pattern also warrants caution in generalizing the findings to the wider Jabodeta population, particularly to groups with lower levels of formal education that were less represented in the sample.

Table 2. Description of Respondent Characteristics in JABODETA

Variables	Number (n)	Percentage (%)
Age		
Productive Adults	114	95
Elderly	6	5
Gender		
Man	28	23.4
Woman	92	76.6
Education		
Junior high school/equivalent	5	4.1
High school/equivalent	34	28.4
College	81	67.5

Evaluation of Measurement Model

Evaluation of the measurement model was conducted to determine whether the indicators used were valid and reliable representations of the study's latent constructs. The structural model tested using the PLS-SEM approach is presented in Figure 1.

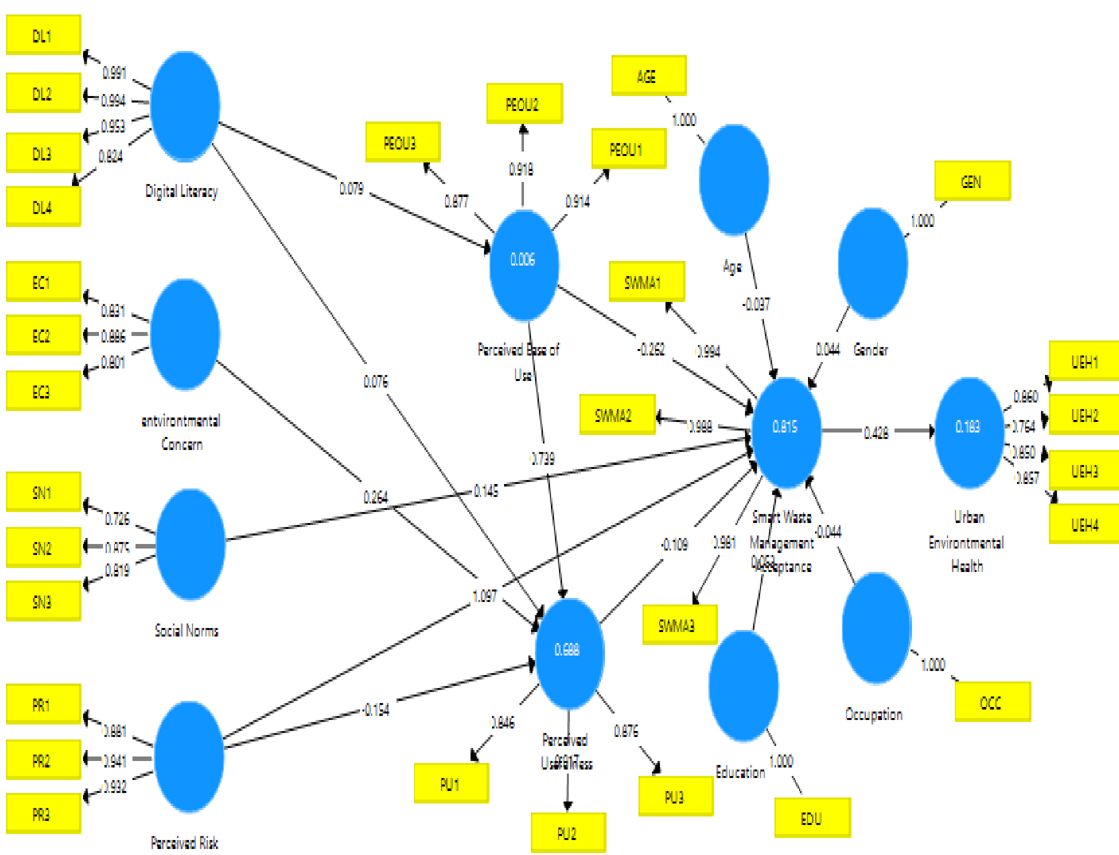

Figure 1 Structural model of smart waste management acceptance and perceived urban environmental health (PLS Algorithm)

Convergent validity was assessed using outer loading and average variance extracted (AVE) values. The results showed that all indicators had outer loading values above 0.70, indicating that each indicator adequately represented its intended construct. The AVE values for all constructs ranged from 0.52 to 0.78, exceeding the recommended threshold of 0.50. These findings indicate that the constructs captured a sufficient proportion of variance from their respective indicators and therefore met the criteria for convergent validity, as shown in Table 3.

Table 3. AVE Values and Outer Loadings of Constructs

Construct	Outer Loading Range	AVE	Interpretation
Digital Literacy	0.78 – 0.91	0.68	Valid
Environmental Concern	0.73 – 0.88	0.64	Valid
Social Norms	0.70 – 0.84	0.59	Valid
Perceived Risk	0.80 – 0.90	0.72	Valid
Perceived Ease of Use	0.76 – 0.89	0.67	Valid
Perceived Usefulness	0.74 – 0.88	0.66	Valid
Smart Waste Management Acceptance	0.79 – 0.91	0.69	Valid
Perceived Urban Environmental Health	0.75 – 0.88	0.65	Valid

The findings confirm that more than 50% of indicator variance was explained by the measured constructs, thereby supporting convergent validity. Construct reliability was evaluated using Composite Reliability (CR) and Cronbach's Alpha (α). All constructs demonstrated CR values above 0.80 and Cronbach's Alpha values above 0.70, indicating good internal consistency and satisfactory measurement stability. These results support the conclusion that the indicators consistently measured the intended behavioral and perceptual constructs, as presented in Table 4.

Table 4. Composite Reliability and Cronbach's Alpha Values

Construct	Composite Reliability	Cronbach's Alpha	Interpretation
Digital Literacy	0.93	0.88	Reliable
Environmental Concern	0.90	0.84	Reliable
Social Norms	0.86	0.78	Reliable
Perceived Risk	0.91	0.86	Reliable
Perceived Ease of Use	0.92	0.87	Reliable
Perceived Usefulness	0.91	0.86	Reliable
Smart Waste Management Acceptance	0.93	0.88	Reliable
Urban Environmental Health	0.89	0.82	Reliable

Discriminant validity was assessed using the Fornell–Larcker Criterion and the Heterotrait–Monotrait Ratio (HTMT). The results showed that the square root of the AVE for each construct exceeded its correlations with other constructs, and all HTMT values were below 0.90. This condition indicates that each construct demonstrated adequate discriminatory capacity and did not conceptually overlap with other constructs in the model. Taken together, the results suggest that the measurement model was valid and reliable overall.

Structural Model Evaluation

Structural model evaluation was conducted to assess the predictive power of exogenous constructs on endogenous constructs and to test the significance of the relationship specified in the model. The coefficient of determination (R^2) was used to estimate the proportion of variance in each endogenous construct explained by its predictors. Based on the PLS Algorithm results, the R^2 value ranged from weak to strong. The highest R^2 value was observed for Perceived Ease of Use (0.81), indicating that the exogenous variables strongly explained variation in this construct. Perceived Usefulness also showed a strong R^2 value (0.69). For Smart Waste Management Acceptance, the R^2 value of 0.62 indicates moderate-to-strong explanatory power. In contrast, Perceived Urban Environmental Health had an R^2 value of 0.18, suggesting that this construct was explained only to a limited extent by the variables included in the model and that additional factors outside the model may also be relevant, as shown in Table 5.

Table 5. Coefficient of determination (R^2) for endogenous constructs

Endogenous Variables	R^2	Interpretation
Perceived Ease of Use	0.81	Strong
Perceived Usefulness	0.69	Strong
Smart Waste Management Acceptance	0.62	Moderate–Strong
Perceived Urban Environmental Health	0.18	Weak–Moderate

The relationships between constructs were tested using the path coefficient (β) analysis with bootstrapping indicated several statistically significant and substantively relevant associations, as presented in Table 6. First, Digital Literacy had a positive and significant association with Perceived Ease of Use ($\beta = 0.52$; $t = 8.12$; $p < 0.001$), indicating that respondents with stronger digital literacy tended to perceive SWM technology as easier to use.

Second, Environmental Concern had a positive and significant association with Perceived Usefulness ($\beta = 0.26$; $t = 2.92$; $p = 0.004$), suggesting that stronger environmental concern was associated with greater perceived usefulness of SWM technology. Social Norms also had a positive and significant association with Perceived Usefulness ($\beta = 0.15$; $t = 1.98$; $p = 0.048$), indicating that perceived social support and normative influence contributed to favorable usefulness perceptions.

Third, Perceived Risk had a negative and significant association with Perceived Ease of Use ($\beta = -0.37$; $t = 5.98$; $p < 0.001$), suggesting that concerns related to reliability, security, or uncertainty may reduce users' comfort in interacting with the system.

Fourth, within the TAM structure, Perceived Ease of Use showed a strong positive association with Perceived Usefulness ($\beta = 0.74$; $t = 4.39$; $p < 0.001$), indicating that ease of use functioned as an important antecedent of usefulness perceptions.

Fifth, both Perceived Usefulness ($\beta = 0.32$; $t = 3.23$; $p = 0.001$) and Perceived Ease of Use ($\beta = 0.19$; $t = 2.02$; $p = 0.043$) were positively associated with Smart Waste Management Acceptance.

Finally, Smart Waste Management Acceptance had a positive and significant association with Perceived Urban Environmental Health ($\beta = 0.43$; $t = 5.35$; $p < 0.001$), indicating that higher acceptance of SWM corresponded to more favorable perceptions of environmental cleanliness, waste-related health risks, and environmental quality.

Table 6. Path Coefficients Test Results

Relationship between variables	β	t-value	p-value	Interpretation
Digital Literacy → PEOU	0.52	8.12	<0.001	Significant
Environmental Concern → PU	0.26	2.92	0.004	Significant
Social Norms → PU	0.15	1.98	0.048	Significant
Perceived Risk → PEOU	-0.37	5.98	<0.001	Significant Negative
PEOU → PU	0.74	4.39	<0.001	Significant
PU → SWM Acceptance	0.32	3.23	0.001	Significant
PEOU → SWM Acceptance	0.19	2.02	0.043	Significant
SWM Acceptance → Perceived Urban Environmental Health	0.43	5.35	<0.001	Significant

Indirect effect analysis was conducted to assess the mediating role of Smart Waste Management Acceptance in linking technology perception and psychosocial factors with Perceived Urban Environmental Health.

Table 7. Indirect Effects (Mediation) of Bootstrapping Results

Mediation Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics	P Values	Interpretation
Perceived Ease of Use → SWM Acceptance → Perceived Urban Environmental Health	-0.146	-0.151	0.053	2,739	0.006	**Statistically Significant**
Perceived Risk → SWM Acceptance → Perceived Urban Environmental Health	0.476	0.495	0.091	5,228	0.000	**Statistically Significant**
Environmental Concern → SWM Acceptance → Perceived Urban Environmental Health	-0.012	-0.013	0.012	1,037	0.300	Not significant
Perceived Usefulness → SWM Acceptance → Perceived Urban Environmental Health	-0.046	-0.047	0.040	1,157	0.247	Not significant
Social Norms → SWM Acceptance → Perceived Urban Environmental Health	0.062	0.063	0.035	1,770	0.077	Marginal
Digital Literacy → SWM Acceptance → Perceived Urban Environmental Health	-0.015	-0.018	0.021	0.720	0.472	Not significant

DISCUSSION

SWM Acceptance as a Predictor of Perceived Urban Environmental Health

SWM acceptance was found to be positively and significantly associated with perceived urban environmental health, as reflected in the path coefficient SWM Acceptance → Perceived Urban Environmental Health ($\beta = 0.43$; $t = 5.35$; $p < 0.001$). Given the cross-sectional design and reliance on perceptual measures, this relationship should be interpreted as an association rather than a causal effect. Conceptually, this finding suggests that higher levels of public readiness to accept and engage with technology-based waste management systems are linked to more favorable perceptions of environmental conditions at the citizen level. In the context of public waste management, acceptance represents not only attitudes toward digital systems but also behavioral engagement that may facilitate more efficient, transparent, and responsive service processes. Thus, consistent with the literature on public technology adoption (29,30), user acceptance can be understood as a key enabling factor that supports the perceived effectiveness of digital public service innovations. From an environmental health perspective, acceptance of SWM is understood to relate to users' perceptions of improved sanitation, lower exposure to waste-related hazards, and enhanced environmental quality, rather than to directly measured environmental outcomes (31).

These results are in line with previous research indicating that the adoption of digital technologies in waste management systems is linked to greater service efficiency and more effective environmental governance in urban areas (32). They are also consistent with the broader body of literature on technology adoption, which emphasizes the importance of user acceptance in shaping the performance of digital public service systems. Nevertheless, it should be acknowledged that this study reflects respondents' subjective assessments of environmental conditions rather than objective environmental or epidemiological measurements. As such, although higher acceptance of SWM may support more efficient waste collection, processing, and monitoring, the relationships identified here should be interpreted as indicative of perceived improvements in sanitation and environmental quality, rather than confirmed environmental changes (33).

Psychosocial Determinants: Environmental Concern and Social Norms

Environmental concern showed a positive and statistically significant relationship with perceived usefulness ($\beta = 0.26$; $t = 2.92$; $p = 0.004$), suggesting that individuals who hold stronger ecological values are more inclined to view SWM technologies as advantageous. This result is consistent with theoretical perspectives proposing that pro-environmental values act as internal motivational forces that increase the perceived relevance and utility of environmental innovations (34,35).

In a similar vein, social norms were also found to be significantly related to perceived usefulness ($\beta = 0.15$; $t = 1.98$; $p = 0.048$), indicating that perceived social expectations and shared behavioral tendencies play a role in shaping how individuals assess the benefits of SWM systems. From a theoretical standpoint, this finding reflects social influence processes described in behavioral models, where expectations from peers and communities affect individual attitudes toward adopting technology. Overall, these results highlight the importance of incorporating psychosocial factors into TAM-based frameworks when analyzing the acceptance of environmental technologies (36).

Acceptance of SWM as a Mediation Mechanism

The results of the mediation analysis need to be considered carefully. While some indirect effects were statistically significant, several displayed directional trends that do not fully align with the model's theoretical assumptions. This may indicate the presence of suppression effects or limitations inherent to the model. Consequently, these mediation findings are included for completeness but should not be regarded as strong explanatory evidence in this study. Further research with larger sample sizes and alternative model configurations is necessary to confirm these relationships.

The extended TAM framework used in this study integrates psychosocial and environmental factors, positioning perceived environmental health outcomes as distal, perception-based results of the technology adoption process. From a policy standpoint, public acceptance of technological innovations should be understood not only as an outcome but also as a key mechanism that influences how environmental services are perceived and experienced by the community (33). SWM innovations therefore function as both behavioral and environmental governance interventions, rather than purely technical solutions. The construct of perceived urban environmental health in this study reflects perceived environmental conditions, including cleanliness, perceived health risks, and environmental quality, which are closely aligned with health promotion perspectives emphasizing lived environmental experiences (37,38).

Moreover, SWM is consistent with the health, sanitation, and sustainability objectives outlined in the Sustainable Development Goals, functioning as a cross-sectoral approach within urban health promotion efforts. Health promotion serves an essential role in connecting key stakeholders such as environmental service providers, public health agencies, communities, and technology developers to support effective participation in SWM systems (39). In this context, promoting technology adoption is not sufficient on its own; it must be accompanied by institutional reliability, service quality, and trust-building mechanisms to ensure that adoption translates into improved citizen experiences. Accordingly, the scope of health promotion goes beyond simply promoting the use of technology; it also involves reinforcing the conditions that enable technology acceptance to translate into positive perceived environmental outcomes (40,41).

CONCLUSION

This study indicates that acceptance of SWM is an important factor linked to perceived urban environmental health in Greater Jakarta (Jabodeta). Higher levels of acceptance are associated with more positive public perceptions of environmental conditions, implying that improved views of sanitation and reduced environmental health risks tend to coincide with stronger engagement and acceptance of the technology. However, due to the cross-sectional nature of the study and its reliance on perception-based measures, these relationships should be interpreted as associative rather than causal. The mechanisms underlying acceptance are largely driven by perceived usefulness and perceived ease of use, while digital literacy provides a fundamental basis for interacting effectively with digital systems. In addition, environmental concern and social norms strengthen perceived usefulness, highlighting the need for public interventions to address community values, social influence, and behavioral context alongside technological aspects.

Perceived risk plays a complex role, acting both as a cognitive barrier and as a possible motivator for engagement, particularly when framed around environmental and health risks related to waste.

Furthermore, this study expands the Technology Acceptance Model by incorporating psychosocial variables such as digital literacy, environmental concern, social norms, and perceived risk, and by positioning perceived environmental health as a downstream outcome of the technology adoption process rather than focusing solely on behavioral intention. The findings suggest that acceptance may act as an intermediary mechanism connecting technology perceptions with perceived environmental outcomes; however, these mediation effects should be approached with caution due to inconsistencies in indirect effect patterns and the inherent limitations of cross-sectional data. From a practical standpoint, efforts to promote SWM adoption should prioritize improving digital literacy, enhancing risk communication, encouraging community-based participation, and maintaining service reliability. These strategies may increase public acceptance and engagement, which are in turn associated with more favorable perceptions of environmental conditions, although further studies using objective environmental indicators are needed to confirm these relationships.

AUTHOR CONTRIBUTION STATEMENT

E. Ernyasih led the conceptualization, research design, implementation coordination, and finalization of the manuscript. N. Nelfiyanti developed the analytical framework and quantitative methodology design. Eka Samsul Ma'arif and Aulia Fahreza Ismanto supported the operationalization of the technology construct and the interpretation of the empirical model. Donita Lutfia Hasanah prepared the instruments, coordinated data collection, and managed the data. D. Daruki refined the methodology, interpreted the findings, and substantially revised the manuscript. Anwar Mallongi strengthened the health perspective.

CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest. They have no financial or personal relationships with any parties that could potentially affect their objectivity. The authors also confirm that there are no known conflicts of interest relevant to this publication.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

In preparing this manuscript, the authors made limited use of ChatGPT (OpenAI) to refine language usage, restructure sentences, and improve clarity and readability. This tool did not include scientific content creation, idea development, data analysis, or interpretation of research results. All key aspects of the research, including design, analysis, and conclusion drawing, were conducted entirely independently by the authors to maintain academic integrity and meet ethical standards for scientific publication. Scholarly work. The integrity and accuracy of the article remain the full responsibility of the authors

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BIBLIOGRAPHY

1. Zhang Y, Luo X, Han X, Lu Y, Wei J, Yu C. Optimization of Urban Waste Transportation Route Based on Genetic Algorithm. Secur Commun Networks. 2022;2022(1). https://doi.org/10.1155/2022/8337653
2. Acevedo-De-los-Rios A, Chumpitaz-Requena FR, Rondinel-Oviedo DR, Cardenas-Mamani U, Redondo JM. Exploring the urban systemic scenarios of improving socioecological conditions in an informal settlement of a developing country with a system dynamics model. Environ Sci Policy. 2025;169(September 2024). https://doi.org/10.1016/j.envsci.2025.104079
3. Nurjanana N, Darma DC, Suparjo S, Kustiawan A, Wasono W. Two-Way Causality Between Economic Growth and Environmental Quality: Scale in the New Capital of Indonesia. Sustain. 2025;17(4):1–22. https://doi.org/10.3390/su17041656
4. Anokye K, Mohammed AS, Agyemang P, Agya BA, Amuah EEY, Sodoke S. A systematic review of the impacts of open burning and open dumping of waste in Ghana: A way forward for sustainable waste management. Clean Waste Syst. 2024;8(June). https://doi.org/10.1016/j.clwas.2024.100152
5. Sanjay, V., Khamparia, A., Gupta, D., Kumar, A., Yang, T., Rathore RS. IoT-Driven Waste Management in Smart Cities: Real-Time Monitoring and Optimization. Proc Fourth Int Conf Comput Commun Networks ICCCN 2024 Springer Singapore. 2025;1293(Lecture Notes in Networks and Systems). https://doi.org/10.1007/978-981-96-3247-3_31
6. Felt Z. Urban Waste Management : Smart Cities and the Future of Waste Handling. Opinion. 2024;09(04). https://doi.org/10.37421/2475-7675.2024.9.360
7. Hussain DI, Elomri DA, Kerbache DL, Omri DA El. Smart city solutions: Comparative analysis of waste management models in IoT-enabled environments using multiagent simulation. Sustain Cities Soc. 2024;103(October 2023):105247. https://doi.org/10.1016/j.scs.2024.105247
8. Prata J, Simoes CL, Simoes R. Improvements to Municipal Solid Waste Collection Systems Using Real-Time Monitoring. Sustain. 2025;17(4). https://doi.org/10.3390/su17041405
9. Manik SLC, Berawi MA, Gunawan, Sari M. Smart Waste Management System for Smart & Sustainable City of Indonesia's New State Capital: A Literature Review. E3S Web Conf. 2024;517. https://doi.org/10.1051/e3sconf/202451705021
10. Abdel Aziz T. a Framework for Waste Management Plan in Cities (Case Study Great Cairo Region). J Al-Azhar Univ Eng Sect. 2024;19(71):582–601. https://doi.org/10.21608/auej.2024.252937.1505
11. Atofarati EO, Adogbeji VO, Enweremadu CC. Sustainable smart waste management solutions for rapidly urbanizing African Cities. Util Policy. 2025;95(May):101961. https://doi.org/10.1016/j.jup.2025.101961
12. Nagi AS, Panda A, Keshari A, Mazumder A, Yamini B. Urban Waste Management : A Study on Public Participation and Policy Implementation Along with Data Driven Approaches. Int J Sci Res Eng Dev. 2025;8(2).
13. Kubanza NS. Analysing the challenges of solid waste management in low-income communities in South Africa: a case study of Alexandra, Johannesburg. South African Geogr J. 2025;107(2):169–89. https://doi.org/10.1080/03736245.2024.2356563
14. Massoud M, Lameh G, Bardus M. Determinants of Waste Management Practices and Willingness to Pay for Improving Waste Services in a Low-Middle Income Country. Environ Manage. 2021;68. https://doi.org/10.1007/s00267-021-01469-7
15. Yuniana Cahyaningrum, Asif M, Ihsan A, Rezki Z. Sustainability and Ethics in Information Systems. J Inf Syst Technol Res. 2025;4(1):13–21.
16. Kirchner-Krath J, Morschheuser B, Sicevic N, Xi N, von Korflesch HFO, Hamari J. Challenges in the adoption of sustainability information systems: A study on green IS in organizations. Int J Inf Manage. 2024;77(November 2023). https://doi.org/10.1016/j.ijinfomgt.2024.102754
17. Lee AT, Ramasamy RK, Subbarao A. Understanding Psychosocial Barriers to Healthcare Technology Adoption: A Review of TAM Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology and UTAUT Frameworks. Healthc. 2025;13(3). https://doi.org/10.3390/healthcare13030375

18. Badda A. Technology Acceptance Model (TAM): Literature Review Modèle d ' Acceptation de la Technologie (TAM) : Revue de littérature Technology Acceptance Model (TAM): Literature Review. Int J Accounting, Financ Audit Manag Econ. 2025;6(11):459–92.
19. Lakhouit A. Revolutionizing urban solid waste management with AI and IoT: A review of smart solutions for waste collection, sorting, and recycling. Results Eng. 2025;25(January). https://doi.org/10.1016/j.rineng.2024.103828
20. Truc LT. Empowering tomorrow: Unleashing the power of e-wallets with adoption readiness, personal innovativeness, and perceived risk to client's intention. J Open Innov Technol Mark Complex. 2024;10(3). https://doi.org/10.1016/j.joitmc.2024.100322
21. Sultana N, Rahman MM, Khanam R. Interconnections Between Environmental Awareness and Green Technology Adoption: Empirical Evidence from Informal Business Enterprises. Sustain. 2025;17(21):1–17. https://doi.org/10.3390/su17219595
22. Tomar A, Srivastava S, Serrano JF, Tomar A. Drivers of pro-environmental behaviour: A mediated analysis of perceived risk, functionality, and post-purchase dissonance. Sustain Futur. 2025;10(December 2024). https://doi.org/10.1016/j.sftr.2025.100406
23. Di Fiore G, Specht K, Rover OJ, Zanasi C. Stakeholders' social acceptance of a new organic waste management policy in the city of Florianópolis (Brazil). J Clean Prod. 2022;379(October). https://doi.org/10.1016/j.jclepro.2022.134756
24. Fadugba GO, Yusoff MS, Rogundade S, Adam NH, Wang LK, Wang MS. Sustainable Solid Waste Management. In: Wang, L.K., Wang, MH.S., Hung, YT. (eds) Solid Waste Engineering and Management. Handbook of Environmental Engineering. Vol 24. Springer; 2022. https://doi.org/10.1007/978-3-030-89336-1_1
25. Kannan D, Khademolqorani S, Janatyan N, Alavi S. Smart waste management 4.0: The transition from a systematic review to an integrated framework. Waste Manag. 2024;174(July 2023):1–14. https://doi.org/10.1016/j.wasman.2023.12.019
26. Kitole FA, Ojo TO, Emenike CU, Khumalo NZ, Elhindi KM, Kassem HS. The Impact of Poor Waste Management on Public Health Initiatives in Shanty Towns in Tanzania. Sustain. 2024;16(24):1–26. https://doi.org/10.3390/su162410873
27. Fayomi GU, Mini SE, Chisom CM, Fayomi OSI, Udoye NE, Agboola O, et al. Smart Waste Management for Smart City: Impact on Industrialization. IOP Conf Ser Earth Environ Sci. 2021;655(1). https://doi.org/10.1088/1755-1315/655/1/012040
28. Fayomi GU, Bracci E. Waste Management, Waste Indicators and the Relationship with Sustainable Development Goals (SDGs): A Systematic Literature Review. Sustain. 2024;16(19). https://doi.org/10.3390/su16198274
29. Pradana HA, Salamat MA Bin. Analysis of Public Acceptance of E-Government Services Using The TAM Model (Technology Acceptence Model(. Major Sci J. 2025;3(4).
30. Wirani Y, Eitiveni I, Sucahyo YG. Framework of Smart and Integrated Household Waste Management System: A Systematic Literature Review Using PRISMA. Sustainability. 2024;16(12):4898. https://doi.org/10.3390/su16124898
31. Gebrekidan TK, Weldemariam NG, Hidru HD, Gebremedhin GG, Weldemariam AK. Impact of improper municipal solid waste management on fostering One Health approach in Ethiopia — challenges and opportunities: A systematic review. Sci One Heal. 2024;3(October):100081. https://doi.org/10.1016/j.onehlt.2024.100081
32. Onur N, Alan H, Demirel H, Köker AR. Digitalization and Digital Applications in Waste Recycling: An Integrative Review. Sustainability (Switzerland). 2024. https://doi.org/10.3390/su16177379
33. Ferronato N, Torretta V. Waste mismanagement in developing countries: A review of global issues. Int J Environ Res Public Health. 2019;16(6). https://doi.org/10.3390/ijerph16061060
34. Mishra S, Jena L, Tripathy HK, Gaber T. Prioritized and predictive intelligence of things enabled waste management model in smart and sustainable environment. PLoS One. 2022;17(8 August):1–22. https://doi.org/10.1371/journal.pone.0272733

35. Baran M, Sypniewska B. Determinants of pro-environmental innovative behaviour: A comparison of three generations. J Innov Knowl. 2024; https://doi.org/10.1016/j.jik.2024.100613
36. Li S, Xia Y, Xiao R, Jiang H. Residents' Behavioral Intention of Environmental Governance and Its Influencing Factors: Based on a Multidimensional Willingness Measure Perspective. Int J Environ Res Public Health. 2022;19(22). https://doi.org/10.3390/ijerph192214734
37. Wilson BM, Delmas MA, Rajagopal D. Behavioral interventions for waste reduction: a systematic review of experimental studies. Front Psychol. 2025;16(June):1–14. https://doi.org/10.3389/fpsyg.2025.1561467
38. Ferdinan, Utomo SW, Soesilo TEB, Herdiansyah H. Changes community behavior in management of household waste in Bekasi City, Indonesia. IOP Conf Ser Earth Environ Sci. 2021;716(1). https://doi.org/10.1088/1755-1315/716/1/012072
39. Abubakar IR, Maniruzzaman KM, Dano UL, AlShihri FS, AlShammari MS, Ahmed SMS, et al. Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. Int J Environ Res Public Health. 2022;19(19). https://doi.org/10.3390/ijerph191912717
40. Manapurath R, Raran Veetil D, Kamath MS. Use of modern technologies for promoting health at the population level in India. Lancet Reg Heal - Southeast Asia. 2024;23(March 2023):1–5. https://doi.org/10.1016/j.lansea.2024.100349
41. Faizan M, Han C, Lee SW. Policy-Driven Digital Health Interventions for Health Promotion and Disease Prevention: A Systematic Review of Clinical and Environmental Outcomes. Healthc. 2025;13(18):1–36. https://doi.org/10.3390/healthcare13182319