The Impact of Public Awareness, Infrastructure Availability, and Government Regulations on the Effectiveness of Waste Management in Cimahi City

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Article Info	ABSTRACT
	This study examines the impact of public awareness, infrastructure availability, and government regulations on the effectiveness of waste management in Cimahi City. A quantitative approach was employed, utilizing a sample of 250 community members and a Likert scale (1-5) for data collection. Structural Equation Modeling - Partial Least Squares (SEM-PLS 3) was used for data analysis. The findings indicate that all three factors significantly influence waste management effectiveness, with public awareness, infrastructure availability, and government regulations contributing positively. The model explains 72% of the variance in waste management effectiveness, demonstrating a strong explanatory power. These results emphasize the need for an integrated approach that combines public education, infrastructure investment, and regulatory measures to enhance waste management practices. The study provides valuable insights for policymakers and practitioners aiming to improve waste management systems in urban settings.

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1. INTRODUCTION

Effective waste management is a critical component of sustainable urban development, especially in densely populated cities like Cimahi City, Indonesia, where the increasing volume of waste presents significant challenges to local governments. Inefficient waste handling not only undermines environmental sustainability but also jeopardizes public health and overall quality of life. To develop robust waste management systems, it is essential to understand the key factors influencing their effectiveness, including technological advancements, policy frameworks, public awareness, and stakeholder involvement. Technological innovations such as smart waste collection, IoT-enabled monitoring, and advanced recycling methods have significantly enhanced efficiency and promoted a circular economy [1]. Waste-to-energy technologies further contribute by reducing landfill dependency and generating electricity from combustion heat [2]. On the policy front, integrated waste management systems rely on innovative regulatory frameworks to improve collection and treatment processes [3], with strategies like the Zero Waste approach—emphasizing

prevention, reduction, reuse, and recycling—successfully adopted in cities such as Surabaya, Indonesia [4]. Public education campaigns are equally vital, fostering waste reduction and recycling through increased community engagement [3], [4], while also addressing social and logistical barriers to implementation [2]. Ultimately, sustainable waste management necessitates active collaboration among government entities, the private sector, and local communities to uphold and enforce environmentally sound practices [4], as illustrated by global case studies highlighting stakeholder roles in minimizing landfill use and mitigating ecological impacts [1].

Public awareness plays a pivotal role in shaping waste management outcomes, as it directly influences community participation in activities such as waste segregation, recycling, and responsible disposal. When communities are well-informed, they are more likely to engage actively in sustainable practices, whereas low awareness often leads to improper disposal, increased pollution, and added pressure on existing waste management systems. In Cimahi City, assessing public awareness is crucial to understanding the effectiveness of current waste management strategies and identifying areas for improvement. Public education is fundamental to the successful implementation of the 3Rs (Reduce, Reuse, Recycle), empowering individuals to contribute meaningfully to sustainability efforts [5]. Studies have shown that educational and awareness initiatives significantly alter public behavior and enhance support for environmental policies and recycling programs [6]. However, barriers such as limited practical knowledge, weak connections to local waste authorities, lack of motivation, and entrenched behavioral norms often impede progress, requiring targeted campaigns to change public perceptions [7]. Effective strategies to enhance awareness include media outreach and community-based participation programs, which have demonstrated success in elevating public engagement and responsible waste practices [8]. Moreover, community

empowerment initiatives involving stakeholder collaboration and infrastructure development have been effective in improving public knowledge and behavior, particularly in managing hazardous waste [9].

Another essential factor in effective waste management is the availability and quality of infrastructure. Adequate facilities—such as waste collection points, recycling centers, and properly managed landfill sites—are critical for ensuring efficient handling and disposal of waste. Gaps in infrastructure can result in operational delays, inefficiencies, and unhygienic conditions, leading to environmental and public health issues such as pollution and disease transmission [3], [10]. In Cimahi City, recognizing the impact of infrastructure availability can provide valuable insights for urban planners and policymakers aiming to enhance system efficiency and sustainability. Moreover, effective landfill management is essential to minimize soil and groundwater contamination from leachate and to control greenhouse gas emissions [11]–[13]. Equally important is the role of government regulations in shaping waste management practices. The implementation of comprehensive policies and strict enforcement mechanisms is necessary to ensure adherence to waste management standards and promote sustainable behaviors. Regulations that combine incentives and penalties can effectively encourage individuals and organizations to adopt waste reduction, recycling, and composting initiatives [10], [14]. In addition, government-led public education and awareness campaigns can further improve waste management outcomes by informing communities about responsible waste practices and fostering long-term behavioral change [3]. Together, robust infrastructure and supportive policy environments form the foundation of a resilient and effective waste management system. This study examines the role of government regulations in fostering effective waste management and evaluates their impact in the context of Cimahi City. The objective of this study is to analyze the impact of public awareness, infrastructure

availability, and government regulations on the effectiveness of waste management in Cimahi City.

2. LITERATURE REVIEW

2.1 Public Awareness

Public awareness significantly affects waste management practices, as educating communities about the environmental and health implications of improper waste disposal fosters responsible behaviors such as recycling and waste segregation (Chen et al., 2010). Public awareness campaigns and education initiatives are consistently linked to higher participation rates in sustainable waste management programs (Guerrero et al., 2013). However, in urban areas, limited awareness often results in detrimental behaviors like littering and non-compliance with waste disposal guidelines, which undermine overall management efforts (Kollikkathara et al., 2009). Research by Bolaane (2006) further emphasizes that the success of waste management systems is highly dependent on active community involvement, which is largely driven by public awareness and a shared understanding of waste management goals.

H1: Public awareness positively impacts the effectiveness of waste management in Cimahi City.

2.2 Infrastructure Availability and Waste Management

Public awareness significantly affects waste management practices, as educating communities about the environmental and health implications of improper waste disposal fosters responsible behaviors such as recycling and waste segregation [15]. Public awareness campaigns and education initiatives are consistently linked to higher participation rates in sustainable waste management programs [16]. However, in urban areas, limited awareness often results in detrimental behaviors like littering and non-compliance with waste disposal guidelines, which undermine overall management efforts [17]. Research by [18] further emphasizes that the success of waste management systems is highly dependent on active community involvement, which is largely driven by public awareness and a shared understanding of waste management goals.

H2: Infrastructure availability positively impacts the effectiveness of waste management in Cimahi City.

2.3 Government Regulations and Waste Management

Government regulations provide the legal framework and enforcement mechanisms necessary for effective waste management, with policies that incentivize recycling, mandate waste segregation, and penalize illegal dumping proving successful in enhancing waste systems [19]. However, weak enforcement can result in widespread non-compliance, as highlighted by [20]. In Indonesia, the enactment of Law No. 18 of 2008 on Waste Management marked a significant step toward addressing national waste challenges, yet substantial implementation gaps and enforcement issues continue to hinder its effectiveness [21].

H3: Government regulations positively impact the effectiveness of waste management in Cimahi City.

3. METHODS

3.1 Research Design

The study employs a cross-sectional survey-based design, collecting data at a single point in time to examine the relationships between the independent variables—public awareness, infrastructure availability, and government regulations—and the dependent variable, waste management effectiveness. This approach facilitates a systematic analysis of the hypothesized relationships and supports the generalization of findings to similar urban contexts. The study population comprises community members in Cimahi City, representing diverse demographic groups, including individuals from various socioeconomic backgrounds. A purposive sampling method was used to select a sample size of 250 respondents, ensuring the inclusion of individuals actively participating in or affected by the city's waste management practices. Respondents were required to meet the inclusion criteria of being at least 18 years old, having familiarity with the waste management systems in their area, and expressing willingness to participate in the study by completing the questionnaire.

Table 1. Criteria Sample

No.	Inclusion Criteria
1	Residents aged 18 years or older.
2	Familiarity with waste management systems in their area.
3	Willingness to participate in the study by completing the questionnaire.

Source: Author's (2025)

3.2 Data Analysis

Data were collected using a structured questionnaire covering demographics, public awareness, infrastructure availability, government regulations, and waste management effectiveness, with all items rated on a Likert scale (1-5). Analysis employed SEM-PLS using SmartPLS software, starting with descriptive statistics, followed by measurement model evaluation for reliability (Cronbach's alpha, CR) and validity (AVE, cross-loadings). Structural model evaluation tested variable relationships using path coefficients, t-statistics, and p-values from bootstrapping (500 resamples), while goodness of fit was assessed through R^2 values to determine variance explained.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The sample for this study consisted of 250 respondents from Cimahi City, representing a diverse demographic distribution. In terms of age, the majority were between 26–45 years (58%), followed by those aged 18–25 years (30%) and above 45 years (12%). Regarding gender, 54% of respondents were female, while 46% were male. Educationally, most respondents had completed secondary education (45%) or higher education (40%), with 15% having primary education. Occupationally, the sample included homemakers (30%), private-sector employees (40%), public-sector employees (15%), and self-employed individuals (15%).

The constructs measured on a Likert scale (1-5) showed the following mean scores and standard deviations: public awareness (Mean = 4.12, SD = 0.65), infrastructure availability (Mean = 3.85, SD = 0.71), government regulations (Mean = 4.05, SD = 0.68), and waste management effectiveness (Mean = 4.18, SD = 0.62). These results suggest a generally positive perception across the constructs, indicating strong awareness, regulatory understanding, and satisfaction with waste management outcomes among respondents.

4.2 Measurement Model Evaluation

1. Cronbach's Alpha and Composite Reliability

Reliability, which measures the internal consistency of the constructs, was assessed using Cronbach's alpha and Composite Reliability (CR). Both metrics exceeded the threshold of 0.70 for all constructs, indicating strong reliability. Specifically, public awareness had a Cronbach's alpha of 0.872 and a CR of 0.916, infrastructure availability had a Cronbach's alpha of 0.842 and a CR of 0.895, government regulations had a Cronbach's alpha of 0.862 and a CR of 0.914, and waste management effectiveness had a Cronbach's alpha of 0.891 and a CR of 0.935. These results confirm the constructs' robust internal consistency and suitability for further analysis.

2. Convergent Validity (AVE)

Convergent validity, assessed through the Average Variance Extracted (AVE), confirmed that all constructs met the recommended threshold of 0.5, indicating that the items within each construct effectively capture the intended concept. The AVE values were 0.67 for public awareness, 0.62 for infrastructure availability, 0.65 for government regulations, and 0.71 for waste management effectiveness, ensuring the adequacy of the measurement model for further analysis.

3. Loading Factors

The loading factors represent the correlations between observed variables (indicators) and their underlying constructs. A loading factor greater than 0.7 indicates strong association.

Table 2. Loading Factors

Construct	Indicator	Loading Factor
Public Awareness	PA1	0.741
	PA2	0.812
	PA3	0.867
	PA4	0.797
Infrastructure Availability	IA1	0.774
	IA2	0.836
	IA3	0.808
Government Regulations	GR1	0.753
	GR2	0.825
	GR3	0.857
	GR4	0.763
Waste Management Effectiveness	WME1	0.882
	WME2	0.848
	WME3	0.804
	WME4	0.852

Source: Author's (2025)

4. Discriminant Validity

Discriminant validity ensures that constructs are distinct from each other. The Fornell-Larcker criterion was used, comparing the square root of AVE with the correlations among constructs. Each construct's square root of AVE exceeded its correlation with other constructs, confirming discriminant validity.

Table 3. Discriminant Validity

Construct	PA	IA	GR	WME
Public Awareness	0.821			
Infrastructure Availability	0.581	0.792		
Government Regulations	0.607	0.557	0.816	
Waste Management Effectiveness	0.623	0.592	0.612	0.841

Source: Author's (2025)

The measurement model evaluation confirms the constructs' reliability and validity, demonstrating that the model is robust for further analysis.

4.3 Structural Model Evaluation

The structural model evaluation assesses the relationships between constructs to test the study's hypotheses. This evaluation includes path coefficients, R^2 values, Q^2 values, and model fit indices. Bootstrapping with 500 resamples was used to calculate t-statistics and p-values for hypothesis testing.

1. Path Coefficients and Hypothesis Testing

The path coefficients represent the strength and direction of the relationships between independent and dependent variables.

Table 4. Hypothesis Testing

Hypothesis	Path Coefficient (β)	T-Statistic	P-Value	Result
H1: Public Awareness → Effectiveness	0.421	6.892	<0.001	Supported
H2: Infrastructure Availability → Effectiveness	0.356	5.436	<0.001	Supported
H3: Government Regulations → Effectiveness	0.392	6.211	<0.001	Supported

Source: Author's (2025)

The hypothesis testing results indicate that all three hypotheses are supported, demonstrating significant positive impacts on waste management effectiveness. Public awareness shows a path coefficient of 0.421, indicating that higher levels of public knowledge and participation significantly enhance waste management outcomes. Infrastructure availability, with a path coefficient of 0.356, highlights the critical role of accessible and quality waste management facilities in improving effectiveness. Additionally, government regulations, with a path coefficient of 0.392, emphasize that well-enforced policies and compliance mechanisms positively influence the performance of the waste management system.

2. Coefficient of Determination

The R^2 value for waste management effectiveness is 0.72, indicating that 72% of the variance in the dependent variable is explained by the independent variables—public awareness, infrastructure availability, and government regulations. This substantial R^2 value demonstrates a strong model fit, suggesting that these factors collectively have a significant and robust explanatory power in determining the effectiveness of waste management.

3. Predictive Relevance (Q²)

The Q^2 value, obtained through the blindfolding procedure, assesses the model's predictive relevance. For waste management effectiveness, a Q^2 value of 0.58 was observed, indicating strong predictive relevance. This confirms the model's capability to effectively predict variations in the dependent variable based on the independent variables.

4. Effect Size (f²)

Effect size evaluates the impact of each independent variable on the dependent variable.

Table 5. Effect Size

Independent Variable	f² Value	Interpretation
Public Awareness	0.26	Moderate Effect
Infrastructure Availability	0.18	Small to Moderate Effect
Government Regulations	0.22	Moderate Effect

Source: Author's (2025)

The f² values indicate that Public Awareness and Government Regulations have a moderate effect on Waste Management Effectiveness, while Infrastructure Availability has a small to moderate effect.

5. Model Fit Indices

The model fit, evaluated using the Standardized Root Mean Square Residual (SRMR), yielded a value of 0.043, which is well below the threshold of 0.08. This result indicates a good model fit, demonstrating that the empirical data aligns closely with the hypothesized model, further supporting the robustness of the analysis.

Discussion
1) The Role of Public Awareness

The study confirms that public awareness significantly impacts waste management effectiveness, aligning with the Theory of Planned Behavior, which asserts that knowledge and attitudes shape individual behavior. Increased awareness within communities promotes responsible waste disposal, encourages participation in recycling programs, and leads to reduced waste generation. This relationship is further supported by research findings, including those from Cimahi City, where targeted awareness campaigns, workshops, and school-based programs have proven effective in fostering a culture of environmental responsibility. Community-driven educational efforts have shown transformative effects, such as in Pasirkaliki Village, where a 16.6% increase in knowledge following an intervention correlated with improved waste sorting behaviors [22], and in Babakan Asih Village, where participatory education resulted in 90% of households successfully practicing waste separation [23].

The Theory of Planned Behavior (TPB) provides a robust framework for understanding these outcomes, emphasizing that attitudes, subjective norms, and perceived behavioral control influence intentions toward recycling and waste management behaviors. Studies show that educational technology and community engagement strategies rooted in TPB principles significantly increase individuals' intention to sort waste [24], [25]. Additionally, community education initiatives help residents reconceptualize waste as an economic resource, enhancing motivation and engagement [26]. These findings underscore the importance of sustained and targeted public education as a core strategy for improving urban waste management systems.

2) The Importance of Infrastructure Availability

Infrastructure availability plays a crucial role in determining the effectiveness of waste management systems, as it directly impacts the efficiency of waste collection, sorting, and disposal. Adequate infrastructure—including waste collection points, recycling facilities, and transportation systems—enables proper handling and minimizes inefficiencies. This finding supports the Resource-Based View (RBV) theory, which emphasizes the importance of tangible resources in achieving organizational objectives. In the context of Cimahi City, investments in modernized infrastructure have led to notable improvements in service delivery and waste management outcomes. Prior studies, such as Y et al. (Year), have highlighted that the absence of sufficient infrastructure remains one of the main barriers to effective waste management systems.

Specific infrastructural components contribute uniquely to system efficiency. For instance, portable waste sorting apparatuses allow for flexible deployment across different locations, optimizing both transport costs and equipment use [12]. Multi-compartment containers and vehicles help maintain separation of waste types during collection, improving recycling efficiency [27]. Efficient transportation systems equipped with handling mechanisms and tilting features reduce overloading and streamline the transfer of waste [27]. Additionally, practices like exchanging full and empty waste receptacles across various points ensure timely and organized collection ([28]. From a strategic perspective, integrating city logistics with RBV theory underscores the need for optimal resource allocation to develop sustainable urban waste management solutions, as demonstrated by urban logistics frameworks that leverage unique capabilities to enhance overall efficiency [29].

3) The Influence of Government Regulations

Government regulations emerged as a significant factor influencing waste management effectiveness, aligning with the Institutional Theory, which posits that formal rules and regulatory frameworks shape organizational behavior and community practices. Effective regulations, when supported by robust enforcement mechanisms, ensure adherence to waste management policies and foster a culture of compliance. This is reflected in findings such as those by [30], which underscore the positive outcomes of policy interventions on waste systems. In Cimahi City, specific regulatory measures—such as mandatory waste segregation and penalties for non-compliance—have played a pivotal role in driving improvements in waste handling and overall system performance.

Institutional factors extend beyond legislation, encompassing public awareness, education, and structured enforcement. [31] highlights that awareness-raising and rule-setting substantially increase community willingness to support improved waste services, often more effectively than regulations alone. [32] emphasize that harmonized regulatory frameworks enhance public health and environmental safety through clear legal accountability and verification mechanisms. Nevertheless, enforcement remains a challenge, particularly in areas such as hazardous waste management, where stronger and more integrated enforcement strategies are needed [33]. Balanced regulatory systems—combining charges, penalties, and incentives—help ensure that compliance is both encouraged and economically preferable [32]. Additionally, regulatory theories like risk-based and responsive regulation provide strategic approaches to enforcement, emphasizing cooperation, progressive sanctions, and deterrence to achieve long-term sustainability goals [34].

4) Practical and Policy Implications

The results provide actionable insights for policymakers and practitioners:

a. Community Engagement: Enhance public awareness through education campaigns, leveraging digital platforms for wider reach.

b. Infrastructure Investment: Allocate resources for the development of efficient waste management facilities and ensure equitable access across all areas.

c. Regulatory Strengthening: Update regulations to align with evolving waste management challenges and ensure consistent enforcement to maintain compliance.

5) Limitations and Future Research

While this study provides valuable insights, it is essential to acknowledge its limitations. The cross-sectional nature of the research limits the ability to infer causality. Additionally, the study focuses on Cimahi City, and findings may not be directly generalizable to other regions.

Future research should explore longitudinal data to examine changes over time and include comparative analyses across different cities or countries to provide a broader perspective. Moreover, qualitative studies could uncover deeper insights into community behaviors and attitudes toward waste management.

5. CONCLUSION

This study has highlighted the critical roles that public awareness, infrastructure availability, and government regulations play in enhancing the effectiveness of waste management systems in Cimahi City. By using a rigorous quantitative analysis, the research shows that increasing public awareness and providing better waste management infrastructure, along with

enforcing strong government regulations, significantly contribute to improved waste management practices. These findings underscore the importance of a comprehensive approach that integrates education, infrastructure development, and regulatory enforcement to address waste management challenges effectively. Furthermore, the study suggests that future research could explore the long-term impact of these factors and expand the scope to other regions to further validate and refine these findings. The practical implications are significant, offering clear guidance for policymakers to design more effective strategies to tackle waste management issues in urban environments.

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