



## Reframing Sustainable Waste Governance through a Penta-Helix and Integrated Sustainable Waste Management Approach: Evidence from Lamongan

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### Abstract

Sustainable waste governance in developing regions is increasingly challenged by institutional fragmentation and technocratic management. This study examines waste governance in Lamongan Regency, Indonesia, through the integration of the Penta-Helix framework and Integrated Sustainable Waste Management (ISWM). Using a qualitative case study method, data were collected through in-depth interviews, observations, and document analysis involving 15 informants representing government institutions, academics, communities, private sectors, media, technical operators, and informal waste actors.

The analysis reveals that waste management in Lamongan remains disposal-oriented, with weak source segregation, fragmented coordination, and uneven stakeholder participation. The findings further indicate that Penta-Helix collaboration remains largely formalistic, while communities and informal actors continue to occupy limited decision-making roles.

This study argues that waste crises should be understood primarily as governance failures rather than merely technical deficiencies. The study proposes a Penta-Helix-Based Sustainable Waste Governance model emphasizing actor alignment, institutional resilience, and adaptive collaborative governance.

**Keywords:** sustainable waste governance; ISWM; Penta-Helix; collaborative governance; circular economy.

### 1.0 Introduction

Sustainable waste governance has emerged as one of the most critical environmental and governance challenges of the twenty-first century. Accelerated urbanization, rapid industrial transformation, demographic expansion, and unsustainable consumption patterns have substantially increased the quantity and complexity of municipal solid waste across the globe. This phenomenon has transformed waste management from a technical sanitation issue into a multidimensional governance concern associated with environmental degradation, climate change, public health vulnerability, urban resilience, and socio-economic sustainability. Seadon (2010) argued that sustainable waste management systems should not merely focus on waste disposal efficiency but must integrate environmental integrity, social inclusiveness, and economic sustainability within a comprehensive governance framework. Similarly, Morrissey and Browne (2004) emphasized that sustainable waste management requires systemic integration between policy, institutional structures, technological innovation, and behavioral transformation in order to achieve long-term sustainability outcomes.

Globally, the environmental consequences of unsustainable waste management practices have become increasingly visible. Escalating landfill dependency, marine plastic pollution, greenhouse gas emissions, illegal dumping, and contaminated urban ecosystems have intensified international concern regarding the sustainability of current waste governance models. Wilson, Velis, and Rodic (2013) highlighted that developing countries face disproportionate waste governance burdens due to weak institutional capacity, inadequate financing mechanisms, fragmented policy implementation, and limited public participation. Consequently, the concept of Integrated Sustainable Waste Management (ISWM) has gained significant prominence as a holistic framework capable of integrating technical, environmental, social, financial, and governance dimensions within a unified waste management system (Anschütz et al., 2004).

The growing urgency of sustainable waste governance is further reinforced by global sustainability agendas, particularly the Sustainable Development Goals (SDGs), notably SDG 11 concerning sustainable cities and communities and SDG 12 regarding responsible consumption and production. In this context, waste governance is increasingly recognized as a strategic indicator of urban sustainability and governmental performance. Finnveden et al. (2013) argued that effective policy instruments, institutional coherence, and stakeholder integration are fundamental prerequisites for achieving sustainable waste systems. Likewise, Powrie and Dacombe (2006) emphasized that sustainable waste management should be conceptualized beyond engineering and operational perspectives, requiring governance models capable of addressing complex socio-environmental interactions.

Contemporary waste governance discourse has also shifted toward circular economy principles, where waste is no longer perceived as residual material requiring disposal but rather as a recoverable economic resource. Price and Joseph (2000) critically argued that waste hierarchy principles emphasizing reduction, reuse, and recycling should become the foundation of sustainable waste policy rather than reliance on end-of-pipe disposal strategies. In a similar vein, Zorpas (2016) stressed that the development of end-of-waste criteria is essential for supporting resource recovery systems and circular economic transitions. Castaldi (2014) further asserted that sustainable waste governance should facilitate resource efficiency, low-carbon development, and environmental resilience through integrated recovery-oriented systems.

The challenges of waste governance are particularly severe in developing and rapidly urbanizing regions. Sakawi (2011) demonstrated that municipal waste management in Malaysia continues to face institutional and behavioral constraints despite increasing policy attention toward sustainability. Mudzengerere and Chigwenya (2012) similarly found that weak governance structures and inadequate community participation significantly undermine sustainable waste management practices in Zimbabwean urban areas. These conditions reflect broader structural governance failures commonly experienced across developing countries where rapid urban growth is not matched by institutional preparedness and environmental infrastructure development.

Moreover, emerging waste streams have further complicated the global waste governance landscape. Hossain et al. (2015) identified electronic waste (e-waste) as a growing sustainability challenge due to its hazardous environmental and public health implications. Chisholm et al. (2021) also emphasized that medical waste management in developing African countries remains highly problematic because of limited regulatory enforcement and inadequate disposal infrastructure. In the context of rapidly urbanizing Asian economies, Lee et al. (2020) argued that achieving zero-waste cities requires not only technological advancement but also strong governance integration and social participation. Similarly, Shahab and Anjum (2022) demonstrated that artificial intelligence-based waste monitoring systems could significantly improve illegal dumping detection and urban waste governance efficiency in India.

From an environmental sustainability perspective, waste governance is increasingly associated with climate mitigation and energy transition strategies. Shams et al. (2017) argued that sustainable waste management policies contribute substantially to greenhouse gas reduction in developing countries. Meanwhile, Zhou and Zhang (2022) highlighted the strategic potential of waste-to-energy systems in supporting sustainable urban energy transitions while simultaneously reducing municipal waste accumulation.

These global dynamics demonstrate that sustainable waste governance is fundamentally a governance issue rather than merely a technical waste management problem. Consequently, traditional sectoral approaches are increasingly inadequate in addressing the complexity of contemporary waste challenges. More integrative, collaborative, and participatory governance frameworks are therefore required, particularly in developing countries such as Indonesia where environmental governance systems continue to face structural and institutional limitations.

Conceptually, sustainable waste management refers to a comprehensive governance system designed to minimize environmental impacts while simultaneously maximizing economic and social benefits through integrated waste handling processes. Pires et al. (2019) defined sustainable waste management as a multidimensional process encompassing waste reduction, segregation, collection, transportation, recycling, recovery, treatment, and environmentally sound disposal practices. This conceptualization reflects a paradigmatic transition from conventional disposal-oriented approaches toward sustainability-oriented resource management systems.

Within contemporary environmental governance scholarship, Integrated Sustainable Waste Management (ISWM) has become one of the most influential analytical frameworks for examining sustainable waste systems. Wilson et al. (2013) explained that ISWM integrates two interdependent dimensions: the physical elements of waste management systems and governance-related components such as inclusivity, financial sustainability, institutional capacity, and stakeholder participation. Anshütz et al. (2004) further argued that ISWM recognizes waste governance as a socially embedded and institutionally interconnected process requiring collaboration among multiple actors rather than reliance solely on governmental intervention.

Theoretically, this study is strongly associated with collaborative governance theory, which emphasizes collective decision-making processes involving state and non-state actors in addressing complex public problems. Waste governance inherently involves multidimensional environmental, social, economic, and behavioral interactions, making collaborative governance particularly relevant. Joseph (2006) argued that stakeholder participation constitutes a critical determinant of sustainable waste governance because environmental sustainability cannot be achieved through bureaucratic and top-down policy mechanisms alone.

The evolution of collaborative governance theory has subsequently led to the emergence of the Penta-Helix model as a strategic framework for sustainability governance. The Penta-Helix approach integrates five major societal actors—government, academia, business sector, community, and media—within collaborative development processes. Hertati, Nurhadi, and Tukiman (2023) demonstrated that Penta-Helix collaboration significantly enhances waste management effectiveness through improved stakeholder coordination and public engagement. Syah and Lubis (2023) similarly found that Penta-Helix-based partnerships contribute positively toward achieving SDG Target 11.6 concerning urban waste reduction and sustainable city governance.

Recent studies have further emphasized the importance of collaborative governance within local sustainability initiatives. Triyono (2025) found that Penta-Helix communication models strengthen sustainable village development through participatory waste governance mechanisms. Likewise, Aisyah et al. (2026) demonstrated that collaborative coastal waste management involving Penta-Helix actors contributes significantly to sustainable empowerment among traditional fishing communities. In a broader governance context, Natalis, Al Asy' Arie, and

Najib (2025) argued that integrating welfare-state principles with Penta-Helix collaboration creates more equitable and sustainable resource governance systems in Indonesia.

Behavioral dimensions also constitute a crucial component of sustainable waste governance. Janmaimool (2017), through the application of Protection Motivation Theory, demonstrated that environmental behavior is influenced by risk perception, environmental awareness, and individual responsibility. Salsabila, Lodan, and Khairina (2023) similarly found that public engagement significantly affects the effectiveness of sustainable waste management practices in Indonesia. These findings indicate that governance reform without social participation and behavioral transformation will likely produce limited sustainability outcomes.

In addition, contemporary environmental governance increasingly incorporates smart governance and participatory innovation paradigms. Calzada (2018) argued that citizens should no longer function merely as passive policy recipients but rather as active decision-makers within data-driven urban governance systems. Witteveen et al. (2023) further highlighted the importance of living labs and collaborative innovation platforms in strengthening public participation and environmental governance performance.

Taken together, these conceptual and theoretical perspectives demonstrate that sustainable waste governance should be understood as a multidimensional governance ecosystem involving institutional integration, stakeholder collaboration, social participation, environmental responsibility, and innovation-based governance mechanisms. Therefore, integrating the Penta-Helix framework with the ISWM approach provides a robust analytical foundation for examining sustainable waste governance in Lamongan Regency, Indonesia.

Despite growing international attention toward sustainable waste governance, many developing regions continue to experience severe waste management failures characterized by institutional fragmentation, limited stakeholder coordination, inadequate infrastructure, and weak public participation. In many urban areas across Asia and Africa, waste management systems remain dominated by conventional collection-and-disposal paradigms that fail to address sustainability objectives comprehensively.

Adeniran, Nubi, and Adelopo (2017) demonstrated that increasing urban waste generation without adequate governance capacity significantly contributes to environmental deterioration and public health risks. Similarly, Hossain et al. (2015) warned that the rapid expansion of electronic waste poses serious threats to environmental sustainability due to toxic contamination risks. Chisholm et al. (2021) further found that inadequate medical waste governance in developing countries creates severe environmental and epidemiological vulnerabilities.

In rapidly urbanizing Asian contexts, sustainable waste governance remains institutionally challenging. Lee et al. (2020) argued that although China has promoted zero-waste city initiatives, implementation remains constrained by governance fragmentation and uneven stakeholder engagement. Shahab and Anjum (2022) likewise identified illegal dumping as a persistent urban governance challenge in India due to weak monitoring systems and low environmental awareness.

Indonesia faces similarly complex waste governance problems. Rapid urbanization and changing consumption patterns have substantially increased municipal waste generation, while local governance capacity remains uneven across regions. Wilson et al. (2015) emphasized that sustainable urban waste systems require inclusivity, governance integration, institutional accountability, and financial sustainability to function effectively. However, waste governance practices in many Indonesian regions continue to prioritize operational waste collection rather than systemic sustainability transformation.

In the context of Lamongan Regency, waste management challenges reflect broader structural governance issues commonly experienced in secondary urban regions of Indonesia. Increasing waste generation, limited infrastructure availability, low waste segregation behavior, and insufficient public participation continue to undermine sustainable waste governance efforts. Furthermore, existing waste management practices remain heavily disposal-oriented and operationally fragmented, limiting opportunities for circular economy development and community empowerment.

Another critical issue concerns the limited implementation of collaborative governance mechanisms within local waste management systems. Although the Penta-Helix framework has received increasing scholarly attention, practical integration among government institutions, academia, private sectors, communities, and media actors remains relatively weak at the regional level. This fragmentation reduces policy coherence, weakens innovation capacity, and limits the effectiveness of sustainability-oriented waste governance initiatives.

Failure to address these governance challenges may generate serious environmental, social, and economic consequences. Environmentally, unmanaged waste contributes to pollution, ecosystem degradation, greenhouse gas emissions, and urban flooding risks. Socially, ineffective waste governance threatens public health and urban livability. Economically, inefficient waste systems undermine opportunities for circular economy development, green investment, and sustainable local economic growth. Consequently, there is an urgent need to develop a more integrated and collaborative waste governance framework capable of addressing these multidimensional sustainability challenges through the integration of Penta-Helix collaboration and Integrated Sustainable Waste Management approaches.

This study aims to reframe sustainable waste governance in Lamongan Regency through the integration of the Penta-Helix collaborative model and the Integrated Sustainable Waste Management (ISWM) approach.

To achieve this aim, the study proposes the following objectives:

1. To analyze the existing waste governance system in Lamongan Regency from the perspective of Integrated Sustainable Waste Management (ISWM).
2. To examine the role of Penta-Helix stakeholders—including government, academia, business sector, community, and media—in supporting sustainable waste governance in Lamongan Regency.

3. To formulate a collaborative governance model integrating Penta-Helix and ISWM approaches for strengthening sustainable waste management practices in Lamongan Regency

### 3. Methodology

#### 3.1 Research Design

This study employed a qualitative case study design to examine how sustainable waste governance is constructed, negotiated, and institutionalized through multi-actor collaboration in Lamongan, Indonesia. The qualitative design was selected because the study does not merely seek to measure waste management performance, but to interpret the deeper governance processes that shape the relationship between technical waste systems, institutional capacity, public participation, and actor collaboration.

The case study approach is particularly relevant because waste management in Lamongan represents a critical local case where formal policy commitment, technological intervention, community participation, and institutional fragmentation intersect. The proposal shows that the research is designed to examine the dynamics of Penta-Helix collaboration, existing waste management practices, internal and external factors, sustainability principles, and the formulation of a sustainable waste management model in Lamongan. Thus, the case is not treated as a merely administrative location, but as an empirical arena for understanding the limits of technocratic waste management and the possibility of shifting toward collaborative and sustainable waste governance.

Conceptually, the study integrates three analytical lenses: Penta-Helix Collaboration, Integrated Sustainable Waste Management (ISWM), and Sustainable Governance. The Penta-Helix framework is used to analyse the roles, power relations, and coordination patterns among government, business, academia, community, and media actors. ISWM is used to examine the integration of technical-operational chains, stakeholder participation, and enabling conditions. Sustainable Governance is used to assess institutional adaptability, legitimacy, accountability, policy integration, and long-term system resilience. This integration is justified by the proposal's argument that technocratic waste management will fail when it is not supported by institutional capacity, meaningful public engagement, and effective communication strategies.

#### 3.2 Research Site and Case Selection

The research was conducted in Lamongan Regency, East Java, Indonesia, with analytical attention to waste governance practices involving TPST Samtaku, TPS3R units, TPA Tambakrigadung, local communities, government agencies, private-sector partners, and informal waste actors. Lamongan was selected because it illustrates a paradox frequently found in local environmental governance: the presence of policy innovation and collaborative initiatives on one side, and persistent problems of waste accumulation, weak source separation, uneven community participation, and institutional fragmentation on the other.

The case is theoretically significant because Lamongan has been identified in the proposal as a strategic object for evaluating collaborative institutional models in waste governance. The proposal states that Lamongan needs deeper evaluation regarding actor collaboration structures, technical-operational effectiveness, and institutional capacity to sustain the TPST Samtaku system. This makes Lamongan an appropriate case for questioning whether Penta-Helix collaboration has moved beyond formal participation toward transformative governance.

#### 3.3 Informant Selection

Informants were selected using purposive sampling, based on their direct involvement, institutional authority, technical knowledge, or lived experience in Lamongan's waste governance system. The study deliberately avoided relying only on formal government actors because such a strategy would reproduce the technocratic bias that this article seeks to interrogate. Instead, the informant structure was designed to capture the full governance ecology of waste management.

A total of 15 key informants were involved in the study. They represented government, planning agencies, technical waste operators, private sector/CSR actors, academia, local communities, waste bank actors, informal waste workers, recycling market actors, media, village-level institutions, and environmental communities. This composition reflects the Penta-Helix logic while extending the analysis to informal and operational actors who are often excluded from formal policy narratives.

**Table 1. Key Informants**

Code	Actor Category	Institutional Position/Role	Analytical Relevance
IA-01	Government	Official of the Environmental Agency/DLH	Policy implementation, regulation, and coordination
IA-02	Regional Planning	Bappeda/local planning official	Policy integration, budgeting, and regional development planning
IA-03	Technical Operator	TPST Samtaku manager/operator	Technical-operational chain and ISWM implementation
IA-04	Technical Operator	TPS3R village-level manager	Community-based waste management sustainability
IA-05	Technical Operator	TPA Tambakrigadung field officer	Final disposal pressure and system bottlenecks
IA-06	Business/CSR	Private-sector or CSR partner	Funding, technology, and business sustainability
IA-07	Academia	University lecturer/researcher/program facilitator	Knowledge production, evaluation, and community education

IA-08	Community	Local community leader	Social legitimacy and public acceptance
IA-09	Community Economy	Waste bank manager	Circular economy and community incentive mechanisms
IA-10	Household	Female household representative	Source separation and domestic waste practices
IA-11	Informal Sector	Waste picker/informal sorter	Informal recycling chain and recognition politics
IA-12	Recycling Market	Recyclable waste collector/buyer	Material value chain and market constraints
IA-13	Media	Local journalist/environmental communicator	Public communication, framing, and social control
IA-14	Local Institution	Village/urban ward official	Local implementation and administrative constraints
IA-15	Civil Society	Environmental activist/community organizer	Critical view of collaboration and participation

The use of 15 key informants is methodologically acceptable for a focused qualitative case study because the purpose is not statistical representativeness, but analytical depth, actor diversity, and theoretical saturation. Data collection was continued until the main themes became recurrent, particularly around technocratic dominance, uneven collaboration, weak source separation, and fragile institutional sustainability.

### 3.4 Data Collection

Data were collected through semi-structured in-depth interviews, field observation, and document analysis.

Semi-structured interviews were used to explore how each actor understands the waste problem, how collaboration is practiced, how authority and responsibility are distributed, and how sustainability is interpreted in everyday governance. The interview guide was organized around four major domains: actor roles and collaboration, technical-operational waste management, institutional and financial sustainability, and community participation.

Field observation was conducted to examine the practical realities of waste governance, especially the flow of waste from households and collection points to processing and final disposal facilities. Observation focused on source separation practices, sorting processes, operational constraints at TPST/TPS3R, residual waste flows, community interaction, and visible environmental impacts.

Document analysis was used to triangulate interview and observation findings. The documents included regional waste data, SIPSN records, local government reports, policy documents, news reports, program documentation, and prior studies related to TPST Samtaku and Lamongan's waste management system. The proposal itself emphasizes that the study seeks not only to understand waste management practices but also to elaborate actor collaboration, integrate technical systems with local socio-cultural structures, and understand adaptive local institutions for long-term sustainability.

### 3.5 Interview Protocol

The interview protocol was designed to avoid descriptive and superficial answers. Rather than asking only whether collaboration exists, the interviews examined how collaboration works, who dominates, who is excluded, where responsibility breaks down, and why some initiatives fail to become sustainable.

**Table 2. The main guiding questions included:**

Analytical Dimension	Guiding Questions
Penta-Helix Collaboration	Who are the dominant actors in waste governance? How are roles distributed among government, business, academia, community, and media? Are all actors involved in planning, implementation, and evaluation?
ISWM Implementation	How is waste managed from source separation to final disposal? Which stage is most fragile? How are recycling, composting, transport, and residual disposal integrated?
Sustainable Governance	How are accountability, financing, policy coordination, and institutional learning organized? Are there mechanisms for feedback and adaptation?
Community Participation	Why do citizens participate or refuse to participate? What incentives, trust issues, or institutional barriers influence household waste separation?
Informal Sector Integration	Are waste pickers, collectors, and recyclers formally recognized? How do they contribute to waste reduction and circular economy?
Model Development	What institutional model is needed to shift from technocratic waste management to sustainable waste governance?

### 3.6 Data Analysis

The data were analysed using thematic analysis with a theory-informed coding strategy. The analysis combined inductive and deductive procedures. Deductive coding was guided by the three conceptual frameworks used in this study: Penta-Helix Collaboration, ISWM, and Sustainable Governance. Inductive coding was used to capture

themes emerging from field narratives, particularly those related to trust, informal practices, institutional fragmentation, symbolic participation, weak incentives, and operational bottlenecks.

The analysis followed several stages.

First, interview transcripts, field notes, and documents were read repeatedly to identify meaningful statements related to actor roles, technical constraints, community behaviour, governance failure, and sustainability practices. Second, initial codes were developed. Examples of initial codes included *technocratic orientation*, *source separation failure*, *uneven actor participation*, *CSR dependency*, *weak TPS3R sustainability*, *informal actor exclusion*, *public trust deficit*, *fragmented coordination*, and *weak feedback mechanism*.

Third, these codes were grouped into broader analytical themes. The major themes included: dominance of technocratic waste management, uneven Penta-Helix collaboration, partial implementation of ISWM, fragile community participation, marginalization of informal actors, and weak institutional feedback and accountability. Fourth, the themes were interpreted through cross-framework synthesis. This step was crucial because the article does not merely describe field findings; it seeks to build an argument that sustainable waste governance requires the integration of technical systems, institutional coordination, community ownership, and circular economy mechanisms.

### 3.7 Trustworthiness and Research Quality

To ensure the credibility and analytical robustness of the study, four strategies were employed.

First, source triangulation was applied by comparing data from government officials, technical operators, private actors, communities, informal waste workers, media, and documents. This strategy was important because each actor tends to narrate waste management from a particular institutional interest.

Second, method triangulation was conducted by combining interviews, observations, and document analysis. This allowed the study to compare formal claims with field-level practices.

Third, member checking was conducted by confirming key interpretations with selected informants, particularly on sensitive issues such as actor dominance, weak participation, and institutional fragmentation.

Fourth, analytical reflexivity was applied throughout the research process. The study recognizes that terms such as “collaboration”, “participation”, and “sustainability” can become policy slogans if not examined critically. Therefore, these terms were not accepted at face value but were interrogated through empirical evidence: who participates, at what stage, with what authority, and with what long-term consequence.

### 3.8 Ethical Considerations

The study followed standard ethical procedures for qualitative research. All informants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw from the interview. Informant identities were anonymized using codes such as IA-01 to IA-15. Sensitive institutional statements were treated carefully to avoid personal attribution, especially when discussing weaknesses in coordination, operational capacity, or community participation.

## 4. Results and Discussion

### 4.1 Waste Management Crisis in Lamongan: From Technical Pressure to Governance Failure

The findings reveal that the waste problem in Lamongan Regency cannot merely be interpreted as an issue of increasing waste volume. Empirically, Lamongan is experiencing systemic pressure throughout the waste management chain, including weak source segregation practices, underperforming TPS3R facilities, operational burdens at TPST facilities, and increasing pressure on the Tambakrigadung landfill. Data indicate that out of 21 TPS3R facilities, only 11 remain operational, while merely three can be categorized as functioning optimally. This condition demonstrates that the waste crisis in Lamongan is fundamentally institutional and governance-related rather than purely technical.

This finding is highly significant within the broader discourse of Integrated Sustainable Waste Management (ISWM). Wilson, Velis, and Rodic (2013) argued that sustainable waste systems in developing countries frequently fail because waste management is approached narrowly as an operational issue rather than as an integrated governance system. Similarly, Anschutz, IJgosse, and Scheinberg (2004) emphasized that waste governance requires simultaneous integration between technical systems, institutional structures, financial sustainability, and community participation. In Lamongan, the inability of upstream systems to function effectively ultimately transforms the landfill into an accumulation point of governance failure.

Interviews with landfill operators reinforce this interpretation. Informants explained that the landfill merely receives the consequences of failures occurring at earlier stages of the waste chain. When households, markets, and collection points fail to segregate waste properly, the landfill absorbs the entire burden of systemic inefficiency. This finding supports Seadon's (2010) argument that sustainable waste systems collapse when environmental governance fails to coordinate social behavior, institutional responsibility, and technological infrastructure simultaneously.

The evidence also demonstrates the persistence of fragmented governance structures. Morrissey and Browne (2004) argued that fragmented waste governance often produces operational inefficiencies because policy implementation, infrastructure provision, and behavioral transformation are not synchronized institutionally. In Lamongan, the fragmentation between waste reduction policy, collection systems, and public participation reflects precisely this institutional disconnection.

From a sustainability governance perspective, the Lamongan case confirms that waste crises in developing regions should no longer be interpreted merely as “technical pressure,” but rather as “governance failure.” Conventional responses emphasizing additional trucks, landfill expansion, or processing facilities may temporarily reduce operational pressure, yet they fail to address the structural roots of waste generation and institutional

fragmentation. Powrie and Dacombe (2006) similarly criticized technocratic waste governance models that prioritize infrastructure while neglecting social and governance dimensions.

Moreover, the findings resonate with recent studies highlighting the governance deficit in urban waste systems. Arya and Shukla (2025) argued that sustainable waste transitions require systemic institutional reform rather than isolated technical interventions. Likewise, Mathew et al. (2025) emphasized that integrated waste management must be understood as a socio-technical system where institutional alignment and stakeholder coordination are fundamental to sustainability outcomes.

Therefore, the Lamongan case demonstrates that the core issue is not simply “how much waste is generated,” but rather who assumes responsibility, how responsibility is distributed, how actors coordinate, and how governance systems adapt and learn from systemic failure. This finding directly addresses the first research objective concerning the analysis of waste governance systems through the ISWM perspective.

#### **4.2 The Persistence of Technocratic Waste Management Logic**

One of the most striking findings is the persistence of technocratic logic within waste management practices in Lamongan. Interviews with local government officials, TPST managers, and landfill operators reveal that waste management success continues to be measured primarily through operational indicators such as collection rates, transportation capacity, and disposal efficiency. Consequently, policy attention remains heavily focused on infrastructure provision, equipment procurement, and operational management, while behavioral transformation, social incentives, and public ownership receive considerably less emphasis.

An informant from the Environmental Agency (DLH) stated:

*“Waste problems are often considered solved once waste has been transported from settlements to TPS or TPA. In reality, the main problem lies upstream, particularly in waste segregation behavior and inconsistent inter-actor coordination.”*

This statement exposes a fundamental paradox of technocratic waste governance. The more efficient the collection system becomes, the more dependent society becomes on the state as a “waste transporter” rather than as a facilitator of waste reduction and behavioral transformation. As a result, households are not systematically encouraged to reduce consumption, segregate waste, or minimize waste generation at the source.

This finding strongly supports critiques within ISWM literature. Wilson et al. (2013) argued that sustainable waste governance cannot rely exclusively on technical efficiency because environmental sustainability depends equally on institutional capacity, social participation, and governance integration. Similarly, Pires et al. (2019) emphasized that sustainable waste systems require integration between technical, environmental, economic, social, and legal dimensions rather than dependence on end-of-pipe solutions alone.

The Lamongan case also reflects broader patterns identified in developing countries. Finnveden et al. (2013) argued that policy instruments focusing exclusively on operational waste removal often fail to generate sustainability transitions because they ignore consumption behavior and resource recovery systems. Likewise, Price and Joseph (2000) criticized waste policies centered on disposal management rather than waste prevention and behavioral change.

The persistence of technocratic logic also reveals institutional path dependency. Castaldi (2014) argued that many waste systems remain trapped within disposal-oriented paradigms because governments perceive infrastructure expansion as more politically visible and administratively manageable than long-term behavioral transformation. In Lamongan, infrastructure development appears politically prioritized, while sustained community empowerment remains comparatively weak.

This condition further demonstrates the limitations of operational governance models. Ferreira et al. (2022) showed that inter-institutional cooperation in Ecuador became effective only when governance structures moved beyond operational coordination toward collaborative decision-making. Similarly, Huntjens and Kemp (2022) argued that sustainability transitions require co-evolutionary governance where institutions, communities, and technologies evolve interactively rather than hierarchically.

Consequently, this study argues that technocratic waste management may be operationally necessary but institutionally insufficient. It may successfully move waste from one location to another, but it cannot fundamentally resolve the structural roots of waste production, fragmented accountability, and weak public participation. This finding contributes critically to contemporary debates on sustainable waste governance by challenging the assumption that technological expansion alone guarantees environmental sustainability.

#### **4.3 Penta-Helix Collaboration: Present but Uneven**

The findings demonstrate that elements of Penta-Helix collaboration are already present within waste governance practices in Lamongan. Government institutions function primarily as regulators and coordinators; business actors contribute through funding and operational support; academics provide education and technical assistance; communities participate in waste segregation and recycling activities; while media institutions disseminate environmental information and shape public awareness.

However, the presence of actors does not automatically indicate equitable collaboration. Interviews reveal that government institutions and technical operators remain the dominant actors, whereas communities, media actors, and informal sectors continue to occupy relatively peripheral positions within planning and evaluation processes.

An environmental activist stated:

*“Collaboration is often labeled as Penta-Helix, but in practice not all actors have equal voices. Communities are usually involved only during implementation, not from the planning stage.”*

This statement is theoretically important because it exposes the conceptual weakness of many collaborative governance initiatives. Hertati, Nurhadi, and Tukiman (2023) argued that Penta-Helix collaboration should involve balanced stakeholder participation rather than symbolic institutional presence. Similarly, Syah and Lubis

(2023) demonstrated that sustainable waste governance becomes effective only when stakeholders are genuinely involved in planning, implementation, and evaluation processes.

The Lamongan findings reveal that collaboration often remains instrumental rather than transformative. Communities are mobilized primarily as implementers rather than deliberative actors. Media institutions function mostly as publicity channels rather than mechanisms of environmental accountability. Academic institutions are invited selectively rather than integrated systematically into governance evaluation processes.

This imbalance reflects broader governance problems identified in recent collaborative governance literature. Triyono (2025) emphasized that sustainable village waste governance requires communication equality among Penta-Helix actors rather than merely administrative coordination. Aisyah et al. (2026) similarly found that sustainable coastal waste management depends heavily on inclusive collaboration and long-term social empowerment.

The findings also support Joseph's (2006) argument that stakeholder participation is not supplementary but foundational within sustainable waste governance systems. Without meaningful participation, governance systems remain vulnerable to institutional distrust and implementation failure. Furthermore, Natalis, Al Asy'Arie, and Najib (2025) argued that equitable governance requires redistributing access to information, participation, and decision-making authority among actors.

Therefore, this study distinguishes between formal collaboration and transformative collaboration. Formal collaboration merely indicates actor presence, whereas transformative collaboration requires power redistribution, participatory decision-making, institutional trust, and cross-sector accountability. This distinction constitutes a significant theoretical contribution to Penta-Helix governance literature.

#### 4.4 Partial Implementation of ISWM: The Structural Weakness of Source Separation

The findings indicate that the implementation of Integrated Sustainable Waste Management (ISWM) principles in Lamongan has begun to emerge institutionally, particularly through the establishment of TPST Samtaku, TPS3R facilities, waste banks, composting activities, and community-based recycling initiatives. Nevertheless, the implementation remains fragmented, uneven, and structurally incomplete. The most critical weakness lies at the upstream level, particularly in household waste segregation and source-based responsibility.

Interviews with TPST operators reveal that downstream facilities are forced to absorb the inefficiencies generated upstream. One TPST operator explained:

*"TPST can reduce the waste burden going to the landfill, but when incoming waste is still mixed, the sorting process becomes extremely difficult. Machines and workers have limits. The real key remains segregation at the household level."*

This statement illustrates a structural contradiction within Lamongan's waste governance system. Technically, TPST facilities were designed to improve recycling efficiency and reduce residual waste entering the landfill. However, operationally, these facilities are transformed into corrective spaces compensating for failures occurring at the household, collection, and transportation stages. As a consequence, technical capacities intended for value recovery are instead consumed by labor-intensive secondary sorting processes.

This finding strongly reflects the core principles of ISWM theory. Wilson et al. (2013) argued that sustainable waste systems require integration across the entire waste chain, beginning with source reduction and segregation rather than relying predominantly on downstream processing facilities. Similarly, Anschutz et al. (2004) emphasized that upstream participation constitutes the backbone of integrated waste systems because downstream technologies cannot compensate indefinitely for failures in public behavior and institutional coordination.

The Lamongan case demonstrates that source separation is not simply a technical issue but fundamentally a governance and trust issue. Household interviews reveal growing frustration regarding inconsistencies within the collection system. One household informant stated:

*"We can actually separate waste, but sometimes after we separate it, the collectors mix everything again during transportation. Eventually people feel that segregation is pointless."*

This statement reveals the existence of what may be conceptualized as a "trust deficit" within the waste management chain. Households do not necessarily reject segregation practices because of limited awareness or incapacity; rather, they lose motivation because they perceive institutional inconsistency between policy discourse and operational practice. In other words, public participation weakens when citizens believe the system itself does not preserve the integrity of segregation efforts.

This finding is particularly important within sustainability transition literature. Janmaimool (2017) demonstrated that sustainable waste behavior is strongly influenced by perceived effectiveness and social reinforcement. When individuals perceive that their environmental actions generate no meaningful impact, behavioral motivation declines significantly. Similarly, Salsabila, Lodan, and Khairina (2023) found that public engagement in Indonesian waste governance depends heavily on institutional credibility and community trust.

The findings also expose the limitations of infrastructure-centered policy approaches. While Lamongan has invested in TPS3R and TPST infrastructure, the absence of consistent source segregation undermines operational efficiency. Seadon (2010) argued that sustainable waste systems fail when infrastructure expansion is not accompanied by behavioral and institutional transformation. Likewise, Morrissey and Browne (2004) emphasized that technological solutions cannot independently achieve sustainability unless embedded within coherent governance structures.

From the perspective of circular economy theory, the failure of source segregation also directly affects material quality and economic value. Awasthi et al. (2021) argued that zero-waste systems depend fundamentally on maintaining material purity throughout the waste chain. When recyclable materials are contaminated by mixed

organic waste, their market value declines substantially, limiting opportunities for recycling industries and circular economic development.

The Lamongan findings similarly align with Brunner and Rechberger's (2015) argument that effective waste-to-energy and recycling systems require stable material streams and reliable segregation mechanisms. Cucchiella, D'Adamo, and Gastaldi (2017) further demonstrated that the efficiency of sustainable waste-to-energy systems depends heavily on waste composition and sorting quality. In Lamongan, poor segregation practices undermine not only recycling efficiency but also the broader potential for circular economy development.

The findings further suggest that ISWM implementation in Lamongan remains highly partial because institutional integration across the waste chain has not yet been achieved. Transportation systems continue to prioritize volume removal rather than segregation integrity. Monitoring systems remain weak. Public education remains sporadic. Incentive mechanisms for households are still limited. Consequently, waste governance remains operationally fragmented despite the existence of multiple sustainability-oriented facilities.

This condition reflects broader structural patterns in developing countries. Arya and Shukla (2025) argued that many emerging ISWM systems fail not because of technological absence, but because governance systems cannot sustain institutional coordination and public participation simultaneously. Similarly, Yadav, Soni, and Kumar (2021) identified weak regulation, poor financial planning, and low public awareness as major barriers to smart waste governance in developing economies.

The Lamongan case also illustrates the importance of integrating smart governance mechanisms within waste systems. Ahmed et al. (2023) and Jin et al. (2023) demonstrated that AI-based waste classification technologies can significantly improve segregation efficiency and recycling performance. However, the findings from Lamongan indicate that technological innovation alone will remain insufficient without public trust and institutional consistency.

Moreover, the issue of source segregation directly relates to governance legitimacy. Huntjens and Kemp (2022) argued that sustainability transitions require co-evolutionary governance, where institutions and communities mutually reinforce one another through trust-building processes. When citizens perceive governance inconsistency, collaborative sustainability transitions become increasingly fragile.

Thus, the findings suggest that Lamongan's ISWM system should not yet be interpreted as a mature integrated system. Instead, it is more accurately characterized as an emerging but incomplete ISWM framework. The system has begun moving toward integration through TPS3R facilities, TPST operations, waste banks, and community initiatives; however, it remains structurally weak at the upstream level, particularly regarding source segregation, behavioral incentives, institutional trust, and transportation consistency.

This finding contributes theoretically by demonstrating that integration within ISWM should not be interpreted merely as the coexistence of multiple facilities and actors. Rather, integration must involve systemic coherence between behavioral practices, institutional arrangements, technical operations, and governance legitimacy across the entire waste chain. Without such coherence, sustainability-oriented waste governance risks becoming operationally fragmented despite appearing institutionally comprehensive.

Furthermore, the Lamongan experience reinforces critiques against technocratic interpretations of ISWM. While infrastructure development remains necessary, the findings clearly demonstrate that sustainable waste governance depends equally on social learning, participatory governance, and institutional credibility. Therefore, this study argues that the future of ISWM in developing regions lies not primarily in technological expansion, but in rebuilding public trust, strengthening source-based responsibility, and institutionalizing collaborative governance mechanisms capable of sustaining long-term behavioral transformation.

#### **4.5 Sustainable Governance and Institutional Fragility**

Another major finding emerging from this study concerns the fragility of institutional sustainability within Lamongan's waste governance system. Although various waste management initiatives such as TPS3R facilities, TPST Samtaku, waste banks, composting programs, and environmental education campaigns have been introduced, their continuity remains highly dependent on temporary leadership, external funding, project-based support, and individual commitment. This condition reveals that many sustainability-oriented programs in Lamongan are operationally active but institutionally vulnerable.

Interviews with TPS3R managers clearly illustrate this condition. One informant explained:

*"TPS3R can operate when there are active managers, regular community contributions, and buyers for recyclable materials. But when one of those stops, the whole system weakens. The problem is not the building itself, but the management ecosystem."*

This statement is theoretically significant because it demonstrates that sustainability is not embedded in physical infrastructure alone, but rather in institutional ecosystems capable of reproducing governance continuity over time. In Lamongan, many waste facilities remain physically available, yet their operational effectiveness fluctuates depending on organizational stability, market access, financing continuity, and community participation. This finding strongly supports the broader literature on sustainable governance. Seadon (2010) argued that sustainable waste systems require adaptive institutional arrangements rather than static infrastructure-centered models. Similarly, Morrissey and Browne (2004) emphasized that sustainability failure often occurs because governments prioritize infrastructure provision without simultaneously developing institutional resilience and governance adaptability.

The fragility observed in Lamongan also reflects the absence of long-term governance institutionalization. Wilson et al. (2013) argued that ISWM systems require enabling conditions including stable financing, regulatory consistency, institutional capacity, stakeholder participation, and monitoring mechanisms. However, the findings

indicate that many local waste initiatives remain weakly institutionalized and highly dependent on short-term operational dynamics.

The instability of recycling markets further exacerbates institutional fragility. Several TPS3R managers reported that fluctuations in recyclable material prices directly affect operational sustainability. When market prices decline, waste sorting activities become economically unattractive, reducing motivation among both managers and communities. This condition reflects what Zorpas (2016) identified as one of the core challenges of circular economy implementation in developing regions: the absence of stable economic mechanisms capable of sustaining resource recovery systems.

Moreover, the findings reveal that financial sustainability remains highly uncertain. Community contribution systems are often inconsistent, while local government support remains operationally limited. Finnveden et al. (2013) argued that policy instruments for sustainable waste governance must integrate economic incentives, institutional financing, and stakeholder accountability. Yet in Lamongan, financing mechanisms remain fragmented and insufficiently integrated into long-term governance planning.

The institutional fragility observed also demonstrates the limits of project-oriented environmental governance. Several waste initiatives initially functioned effectively due to donor support, temporary environmental campaigns, or external facilitation. However, when external support diminished, operational performance weakened considerably. This finding resonates with Pires et al. (2019), who emphasized that sustainable waste systems require endogenous institutional ownership rather than dependence on external interventions alone.

From the perspective of governance theory, the Lamongan case reveals the importance of institutional feedback mechanisms. Sustainable governance requires continuous learning processes, monitoring systems, public accountability, and adaptive policy evaluation. Yet interviews indicate that evaluation processes within Lamongan's waste governance system remain relatively weak and fragmented. Data integration between TPS3R, TPST, local government agencies, and communities is still limited, reducing institutional capacity to identify systemic weaknesses and policy failures.

This finding aligns with Ferreira et al. (2022), who demonstrated that integrated waste governance becomes effective only when institutional cooperation is supported by stable coordination mechanisms and shared governance accountability. Likewise, Huntjens and Kemp (2022) argued that sustainability transitions require co-evolutionary governance systems capable of adapting dynamically to environmental, economic, and social changes.

Another critical dimension concerns organizational leadership. The findings reveal that many waste initiatives in Lamongan rely heavily on charismatic or highly committed local actors. While this leadership is essential operationally, excessive dependence on individuals creates institutional vulnerability when leadership transitions occur. This condition reflects what Weber et al. (2024) described as the fragility of social innovation systems lacking institutional embedding.

The Lamongan findings also demonstrate that institutional sustainability cannot be separated from social legitimacy. Communities tend to support waste programs when they perceive direct social or economic benefits. However, when operational transparency weakens or program continuity becomes uncertain, public participation declines. Calzada (2018a) argued that sustainability governance increasingly depends on citizen trust and participatory legitimacy rather than administrative authority alone.

Furthermore, the findings reveal that institutional fragility is intensified by limited integration between formal governance structures and community-based systems. Waste banks, neighborhood recycling groups, and informal sorting networks often operate independently without strong coordination with municipal systems. Witteveen et al. (2023) argued that sustainable environmental governance requires collaborative learning spaces capable of integrating formal institutions with grassroots initiatives. Yet in Lamongan, such integrative mechanisms remain underdeveloped.

This condition also demonstrates the relevance of social innovation perspectives within waste governance. Hillgren, Seravalli, and Agger Eriksen (2016) emphasized that sustainability transitions depend on counter-hegemonic practices where communities actively reshape governance systems rather than passively follow institutional directives. Similarly, Del-Real, Ward, and Sartipi (2023) argued that sustainable urban governance increasingly requires participatory infrastructures enabling citizens to co-produce environmental solutions.

The findings therefore challenge conventional assumptions that waste governance success can be measured merely through the number of facilities constructed or operational programs launched. Instead, sustainable governance should be evaluated based on whether governance systems possess institutional continuity, adaptive capacity, financing resilience, participatory legitimacy, and organizational learning mechanisms.

From a critical governance perspective, Lamongan's experience illustrates that many sustainability-oriented waste initiatives in developing regions remain trapped within what may be termed "fragile sustainability." Programs appear environmentally progressive at the surface level but remain structurally dependent on unstable financial, organizational, and social conditions. Consequently, sustainability remains vulnerable to political shifts, market fluctuations, leadership changes, and declining public participation.

This finding contributes significantly to sustainable governance literature by emphasizing that environmental sustainability is fundamentally institutional before it becomes technological. Infrastructure may initiate waste management improvements, but without institutional resilience, participatory legitimacy, and adaptive governance mechanisms, sustainability transitions remain highly unstable.

Accordingly, this study argues that strengthening sustainable waste governance in Lamongan requires moving beyond project-based environmental management toward institutional ecosystem development. Such transformation requires long-term financing mechanisms, stable stakeholder coordination, adaptive governance

structures, integrated monitoring systems, and continuous public engagement capable of sustaining environmental governance beyond temporary operational cycles.

## 5. Conclusion

This study aimed to reframe sustainable waste governance in Lamongan Regency through the integration of the Penta-Helix collaborative framework and the Integrated Sustainable Waste Management (ISWM) approach. Based on the empirical findings and critical discussion, the study concludes that the waste management crisis in Lamongan is fundamentally not a purely technical problem, but rather a multidimensional governance failure characterized by institutional fragmentation, uneven stakeholder participation, weak source segregation practices, fragile organizational sustainability, and limited systemic integration across the waste management chain.

Regarding the first research objective, the findings demonstrate that the implementation of Integrated Sustainable Waste Management (ISWM) in Lamongan remains partial and structurally incomplete. Although various infrastructures such as TPS3R facilities, TPST Samtaku, waste banks, and composting systems have been established, the governance system remains heavily disposal-oriented and operationally fragmented. The most critical weakness lies in source-based waste segregation, where inconsistencies between household practices, transportation systems, and downstream processing create institutional inefficiencies and public distrust. Consequently, the waste governance system has not yet achieved full integration between technical operations, behavioral transformation, institutional coordination, and environmental sustainability principles.

Concerning the second research objective, the study reveals that Penta-Helix actors are already present within Lamongan's waste governance ecosystem; however, their participation remains uneven and asymmetrical. Government institutions continue to dominate policy coordination and operational management, while communities, informal sectors, academics, and media actors often occupy secondary or symbolic roles. As a result, collaboration frequently remains formalistic rather than transformative. The findings further indicate that the informal sector—including waste pickers, collectors, and small-scale recyclers—plays a substantial role in sustaining material recovery systems yet remains insufficiently recognized within formal governance structures. This demonstrates that sustainable waste governance in developing regions requires more inclusive and socially embedded collaborative arrangements.

Regarding the third research objective, this study formulates a conceptual model of Penta-Helix-Based Sustainable Waste Governance consisting of five interconnected dimensions: actor alignment, source-based responsibility, integrated technical chain, institutional feedback mechanisms, and adaptive sustainability governance. The model emphasizes that sustainable waste governance cannot rely solely on technological expansion or infrastructure provision. Instead, sustainability depends on the integration of institutional resilience, participatory legitimacy, behavioral transformation, social innovation, and collaborative governance mechanisms capable of sustaining long-term environmental transitions.

The study also contributes theoretically by advancing several critical arguments. First, it argues that waste governance crises in developing regions should be interpreted primarily as governance failures rather than merely operational inefficiencies. Second, the study distinguishes between formal collaboration and transformative collaboration within the Penta-Helix framework, emphasizing that actor presence alone does not guarantee equitable participation or governance transformation. Third, the findings demonstrate that ISWM should not be interpreted merely as infrastructure integration, but rather as systemic coherence between institutions, social behavior, technical systems, economic incentives, and governance legitimacy.

Furthermore, the findings reveal that sustainable waste governance transitions remain highly fragile when institutional sustainability depends excessively on temporary leadership, unstable financing, project-based interventions, and fluctuating recycling markets. Therefore, environmental sustainability must be understood fundamentally as an institutional and social transformation process rather than solely a technological modernization project.

### Practical Recommendations

**Based on these findings, several practical recommendations are proposed.**

First, the Lamongan local government should strengthen source-based waste governance through mandatory segregation policies, differentiated waste collection systems, continuous environmental education, and incentive-based community participation mechanisms. Behavioral transformation must become a central governance priority rather than a complementary component of technical waste operations.

Second, the institutionalization of Penta-Helix collaboration should move beyond symbolic stakeholder involvement toward formalized multi-actor governance mechanisms. This includes permanent coordination forums, participatory policy evaluation systems, collaborative monitoring platforms, and shared accountability structures among government institutions, academic actors, private sectors, communities, media institutions, and informal recycling actors.

Third, the informal sector should be formally integrated into the waste governance system. Waste pickers, collectors, and small-scale recyclers should no longer be treated as peripheral actors but rather as strategic partners within circular economy development. Their inclusion is essential for improving material recovery efficiency, strengthening recycling value chains, and enhancing social equity within sustainable waste governance systems.

Fourth, institutional resilience should be strengthened through long-term financing mechanisms, integrated governance databases, transparent monitoring systems, and adaptive policy evaluation frameworks. Sustainability programs should not rely excessively on short-term projects or individual leadership initiatives.

Fifth, digital innovation and smart waste governance technologies should be adopted carefully and contextually. Technologies such as AI-based waste classification, digital monitoring systems, smart bins, and blockchain

traceability may improve operational efficiency; however, technological adoption must remain socially inclusive and institutionally adaptive to local governance capacities.

### Future Research Directions

#### This study also opens several important directions for future research.

First, future studies should examine the political economy dimensions of waste governance, particularly the relationships between local political interests, waste privatization, informal recycling economies, and environmental justice. Such analysis would deepen understanding regarding power relations within sustainable waste governance systems.

Second, comparative studies across multiple regions or municipalities are necessary to identify variations in Penta-Helix implementation and ISWM effectiveness within different socio-political and institutional contexts. Comparative analysis would strengthen the generalizability of collaborative waste governance models in developing countries.

Third, future research should explore the integration of digital governance technologies, artificial intelligence, blockchain systems, and smart-city infrastructures within sustainable waste governance frameworks. However, these studies should critically examine not only technological effectiveness but also issues of governance ethics, digital inequality, and participatory legitimacy.

Fourth, longitudinal research is needed to investigate how institutional resilience, behavioral transformation, and collaborative governance evolve over time within waste governance systems. Sustainability transitions are dynamic processes, and short-term observations may fail to capture deeper structural transformations.

Finally, future studies should pay greater attention to community knowledge systems, grassroots innovation, and informal environmental practices within circular economy transitions. Sustainable waste governance in developing regions cannot rely exclusively on formal policy mechanisms but must also recognize the social intelligence and adaptive capacities embedded within local communities and informal actors.

Overall, this study concludes that sustainable waste governance in Lamongan—and more broadly in developing regions—requires a fundamental transition from technocratic waste management toward collaborative, adaptive, and socially embedded governance systems. Without such transformation, waste governance risks remaining operationally functional yet structurally unsustainable.

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