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Collaborative waste management through pentahelix stakeholder participation: A qualitative study from South Tangerang City, Indonesia

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Abstract
Urban waste management in rapidly growing cities presents persistent governance challenges due to increasing waste generation, limited disposal capacity, and fragmented coordination among stakeholders. This study aims to examine how collaborative governance operates in urban waste management through a multi-stakeholder (pentahelix) framework and to identify key barriers affecting its implementation. A qualitative descriptive approach was employed, using in-depth interviews, field observations, and document analysis involving representatives from government, private sector, community groups, academia, and media. Data were analyzed thematically using a policy implementation perspective to assess coordination, resources, communication, and institutional capacity. The findings reveal that collaboration among stakeholders remains largely partial and fragmented, functioning mainly at the level of coordination rather than integrated governance. Government actors dominate regulatory and facilitative roles, while private stakeholders contribute technological and operational innovations without strong institutional integration. Community participation is present but faces sustainability constraints, and academic inputs are weakly translated into policy processes. Media engagement tends to be reactive rather than strategic. Key barriers include limited inter-stakeholder communication, unclear role distribution, resource constraints, and the absence of a permanent collaborative mechanism. The study underscores the need for institutionalized multi-stakeholder platforms, clearer governance arrangements, and stronger knowledge integration to improve the effectiveness and sustainability of urban waste management. These findings provide practical insights for policymakers seeking to strengthen collaborative governance models in urban environmental management contexts.

Keywords:
Collaborative Governance, Pentahelix Model, Waste Management, Policy Implementation, South Tangerang, Indonesia

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INTRODUCTION

Waste management has emerged as one of the most pressing environmental challenges worldwide. The World Bank (2018) estimates that global waste generation will reach 3.4 billion tons by 2050, driven by rapid urbanization, population growth, and shifting consumption patterns. Developing countries, particularly in Southeast Asia, face increasing pressure to manage municipal solid waste sustainably while contending with limited infrastructure and institutional capacity (Wilson et al., 2006).

Indonesia is facing an increasingly urgent waste management challenge driven by rapid urbanization, population growth, and rising consumption patterns. Existing waste management systems in many urban areas remain under pressure due to limited disposal capacity and continued dependence on landfill-based approaches. Weak coordination and fragmented governance among key stakeholders further constrain effective waste management performance. These conditions pose serious risks to environmental sustainability and public health. Therefore, strengthening collaborative governance mechanisms has become a critical priority in addressing urban waste management challenges in Indonesia.

Table 1 The data below is the result of data input carried out by 342 districts/cities throughout Indonesia in 2024

Category	Amount (tons/year)	Percentage
Waste Generation	37,311,750.55	-
Waste Reduction	497,733.45	1.33%
Waste Treatment	11,516,746.46	30.87%
Managed Waste	12,014,479.91	32.2%
Unmanaged Waste	25,297,270.65	67.8%
Controlled/Sanitary Landfills	5,943,946.94	-
Open Dumping Landfills	9,729,125.14	-

Source: Indonesia (2024)

In 2024, Indonesia's 342 regencies and cities generated approximately 37.3 million tons of municipal solid waste. Only 1.33% of this was reduced at the source, while 30.87% underwent treatment. Managed waste accounted for 32.2%, leaving 67.8% over 25 million tonsunmanaged. Of the treated waste, 5.94 million tons were deposited in controlled or sanitary landfills, whereas 9.73 million tons ended in open dumps. These figures underscore persistent challenges in waste management, highlighting the urgent need for integrated strategies to enhance collection, treatment, and disposal while addressing environmental and public health impacts.

Urban waste management thus remains among the most persistent challenges in Indonesia's rapidly growing cities (Guerrero et al., 2013) The rising volume of household and industrial waste, coupled with limited landfill capacity and low public awareness, has placed substantial pressure on local governments to develop more sustainable and participatory systems. According to, more than 40 percent of Indonesia's total waste originates from urban households, underscoring the urgent need for an integrated, collaborative approach that engages multiple stakeholders across.

South Tangerang City, located in Banten Province, represents a typical case of urban waste-management challenges within Indonesia's metropolitan areas. The city's growing population and high economic activity have led to daily waste generation exceeding 1.000 tons (Triyoga, 2024), while only a portion is processed through *Tempat Pengolahan Sampah Reduce-Reuse-Recycle (TPS3R)* facilities or other community-based initiatives (Nusi Ichsan et al., 2024). Despite ongoing local initiatives, waste reduction and recycling programs in Indonesia continue

to encounter significant challenges, including inadequate stakeholder coordination, limited infrastructure, and low levels of community engagement (Wikurendra et al., 2024).

To address this gap, the present study analyzes the implementation of the Pentahelix collaboration model in waste management in South Tangerang City using a qualitative approach. It explores how each stakeholder government, academia, business sector, community, and media contributes to the formulation and implementation of local waste policies, and how their interactions influence the effectiveness of waste-reduction initiatives. Guided by Van Meter and Van Horn's (1975) implementation theory, this research identifies the supporting and inhibiting factors affecting Pentahelix-based waste policy implementation, particularly regarding communication, resources, stakeholder disposition, and the socio-political environment.

LITERATURE REVIEW

Waste Management and Collaborative Governance

Waste management has evolved from a purely technical and infrastructural concern into a broader issue of governance and societal participation. Effective waste governance requires not only the provision of infrastructure and technology but also the engagement of multiple actors across different levels of government and society (Wilson et al., 2006).

The concept of collaborative governance offers a theoretical lens for understanding cross-sector partnerships in public service delivery. Ansell and Gash (2008) define collaborative governance as a process where public agencies engage non-state stakeholders in collective decision-making processes that are formal, consensus-oriented, and deliberative. In the context of environmental management, collaborative governance emphasizes shared responsibility, trust-building, and mutual learning among diverse actors (Emerson et al., 2012).

The Pentahelix Model in Sustainable Development

The Pentahelix model builds upon the earlier Triple Helix framework proposed by Etzkowitz and Leydesdorff (2000), which describes innovation as a product of interaction among academia, government, and industry. Later, Carayannis and Campbell (2012) expanded this model into a Quadruple and Quintuple Helix, incorporating the community and the natural environment as additional drivers of innovation and sustainability. In the Indonesian context, the Pentahelix framework has been expanded to include media as the fifth actor, highlighting its critical role in shaping public awareness, disseminating information, and promoting accountability (Rini et al., 2021).

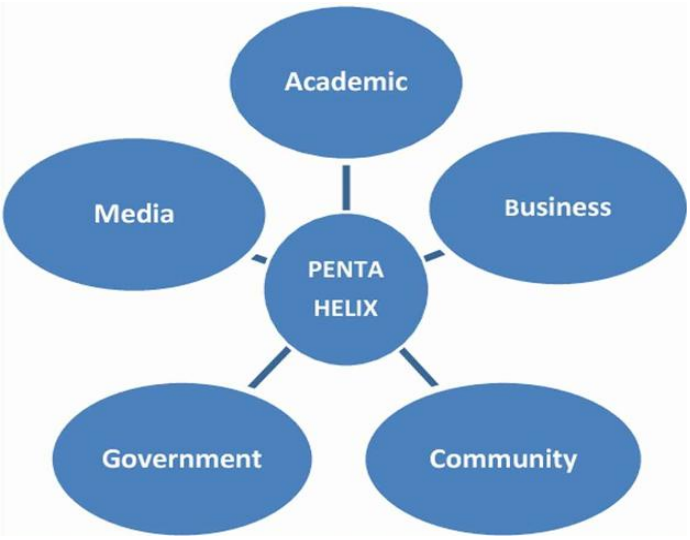

Figure 1. Pentahelix Model
Source: Subagyo (2021)

Table 2. Roles of Stakeholders within the Pentahelix Framework

Helix (Stakeholder)	Primary Role	Specific Functions
Government	Policy direction and regulation	Formulates policies, enforces regulations, allocates resources, and coordinates cross-sectoral programs for sustainable waste management.
Academia	Knowledge and innovation provider	Conducts research, develops appropriate technologies, and provides evidence-based recommendations for policy and practice.
Business Sector	Resource mobilizer and market actor	Supplies financial support, invests in waste-to-energy and recycling initiatives, and promotes circular-economy models.
Community (Civil Society)	Grassroots implementer and change agent	Engages in waste sorting, recycling, and awareness campaigns; builds local ownership and behavioral change.
Media	Communication and advocacy platform	Disseminates information, raises awareness, encourages transparency, and builds public engagement through campaigns and reporting.

Recent studies indicate that collaborative governance frameworks enhance inclusive governance by bridging formal institutions and informal community networks. Nevertheless, the effectiveness of such models is contingent upon strong coordination, mutual trust, and equitable resource sharing among stakeholders, which continue to pose challenges in many urban and local contexts (Ahmad & Esposito, 2025; Song et al., 2025)

Pentahelix in Waste Management Contexts

The application of the Pentahelix approach in waste management remains limited compared to other policy sectors. Several studies in Indonesia highlight partial adoption of the model. For instance, community participation in "Bank Sampah" programs, revealing that strong community engagement can enhance waste segregation and recycling rates but requires continuous government facilitation and business incentives. Likewise, Ahmad and Esposito (2025) observed that local governments frequently serve as the primary drivers of collaborative initiatives, whereas academic institutions and media are often underleveraged in facilitating knowledge sharing and influencing public behavior.

Internationally, multi-actor collaboration in waste management has demonstrated promising outcomes. In Japan and South Korea, for example, public-private-community partnerships have been key to achieving high recycling rates through co-production of services and shared monitoring mechanisms (Lee & Paik, 2011; Sakai, 1996). These findings indicate that waste management effectiveness depends not only on institutional design but also on the interaction quality among stakeholders, which shapes trust, legitimacy, and compliance.

Policy Implementation and the Van Meter–Van Horn Framework

To understand how the Pentahelix model operates in practice, this study draws on Van Meter and Van Horn's (1975) policy implementation theory, which identifies six key variables influencing implementation performance:

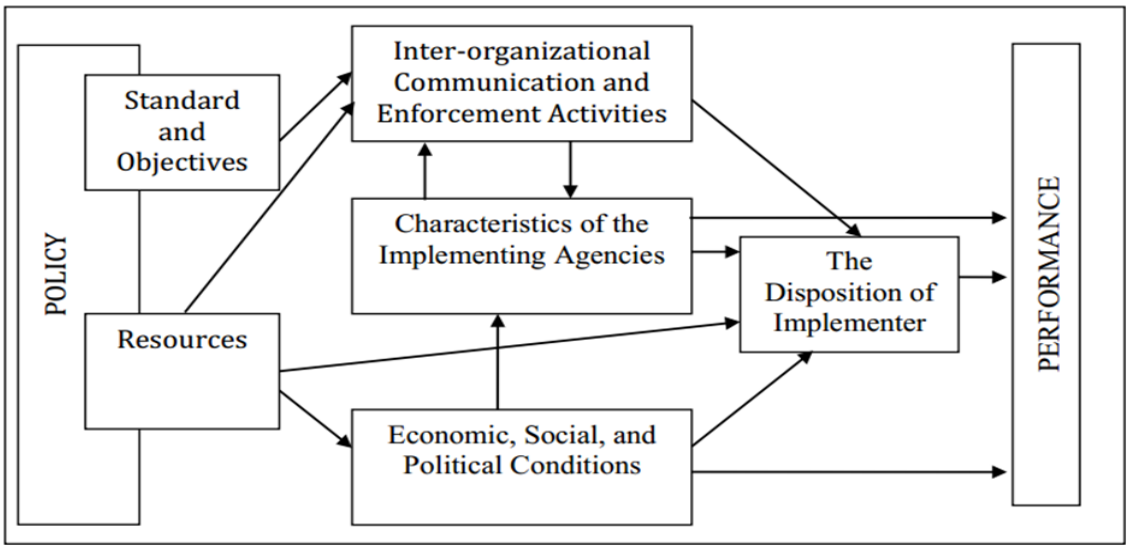

Figure 2. Van Meter and Van Horn's Model of Implementation

This framework provides a systematic approach to analyzing how collaboration among Pentahelix actors influences policy outcomes. It helps explain not only the presence of partnerships but also why and how they succeed or fail in achieving intended objectives. By integrating this model with the Pentahelix approach, this study aims to reveal the multidimensional nature of collaboration in urban waste governance, where success is shaped by communication patterns, leadership, institutional alignment, and shared commitment among diverse actors.

Research Gap and Conceptual Framework

Despite growing recognition of collaborative approaches in public administration, empirical evidence on Pentahelix-based waste management implementation remains scarce. Most studies emphasize single-actor perspectives or program evaluations, overlooking the dynamic interactions and power relations among stakeholders. Moreover, few have analyzed how contextual factors such as political will, social capital, and media engagement mediate collaborative performance.

This study fills these gaps by proposing an integrative conceptual framework that combines the Pentahelix collaboration model with policy implementation theory to examine the mechanisms, enablers, and constraints of waste management collaboration in South Tangerang City. This framework assumes that effective waste policy implementation emerges from the alignment of actors' roles, adequate resource distribution, transparent communication, and consistent policy commitment supported by community and media participation.

METHOD

This study employed a descriptive qualitative approach to examine the dynamics of stakeholder collaboration in waste management based on the Pentahelix model in South Tangerang City, Indonesia. The qualitative design was chosen because it enables an in-depth exploration of social processes, meanings, and interactions that shape the implementation of collaborative environmental governance (Creswell & Poth, 2018). This approach allows the researcher to interpret the complex interplay among actors and to identify both supporting and inhibiting factors that influence the outcomes of waste management policies.

The research was conducted in South Tangerang City, located in Banten Province, Indonesia, which is an urban area experiencing rapid population growth and increasing waste generation. According to the Ministry of Environment and Forestry (Indonesia, 2024), urban

waste in Indonesia has risen significantly, and local governments are encouraged to strengthen community-based waste management systems. South Tangerang City was selected as the research site because it has implemented various cross-sectoral initiatives such as Waste Banks (Bank Sampah) and TPS3R (Reduce–Reuse–Recycle Processing Centers), which reflect the practical application of the Pentahelix collaboration model.

The study utilized both primary and secondary data sources. Primary data were collected through in-depth interviews with representatives from the five Pentahelix actors government, academia, business sector, community, and media and were complemented by field observations at selected waste management sites. These methods allowed the researcher to capture participants' perspectives, roles, and experiences in collaborative waste management efforts (Yin, 2018). Meanwhile, secondary data consisted of official documents, government reports, policy regulations, and prior academic studies related to public collaboration and waste governance in Indonesia.

The data collection process combined interviews, observations, and document analysis. In-depth interviews were used to explore participants' understanding, perceptions, and practices in applying the Pentahelix approach to waste management, while field observations at TPS3R and Waste Bank sites allowed for direct observation of interactions among stakeholders and operational activities. Document analysis was employed to obtain contextual insights from policy documents, environmental reports, and relevant literature. The combination of these methods enabled a robust triangulation process that ensured comprehensive coverage of the research phenomena (Creswell & Poth, 2018).

Data were analyzed using the interactive model of Miles, Huberman, and Saldaña (2014), which involves three iterative stages data reduction, data display, and conclusion drawing and verification. In the data reduction stage, raw data from interviews, observations, and documents were categorized and simplified according to the research objectives. The data display stage involved organizing the information into matrices, diagrams, and thematic narratives to facilitate interpretation. Finally, the conclusion drawing and verification stage entailed interpreting and comparing emerging themes across data sources to establish valid and meaningful findings.

To ensure the credibility and dependability of the findings, triangulation of sources and methods was applied by comparing information across stakeholder groups and data collection techniques (Denzin & Lincoln, 2018). The researcher also conducted member checking by sharing summarized findings with selected participants for feedback and validation. These strategies enhanced the reliability and authenticity of the study's conclusions.

Ethical considerations were observed throughout the entire research process. All participants were informed about the objectives of the study and their right to withdraw at any stage. Written or verbal consent was obtained prior to data collection, and participants' identities were anonymized to maintain confidentiality. The data collected were used exclusively for academic purposes in accordance with established research ethics principles (Yin, 2018).

RESULTS AND DISCUSSION

Implementation of the Pentahelix Model in Waste Management in South Tangerang City

Field findings indicate that the implementation of the Pentahelix model in South Tangerang's waste-management system remains partial and fragmented. The government represented by the Environmental Agency (DLH) and the City Council functions primarily as a regulator and facilitator; communities participate through waste banks and TPS3R (Reduce–Reuse–Recycle Waste Processing Units); private entities such as PT Abu & Co. independently manage household waste using pyrolysis and mechanical segregation technologies; academia contributes through research and innovations such as the *Teba Modern* composting prototype;

and the media acts as a campaigner and agent of social control. Despite these efforts, synergy among actors has yet to be institutionalized through a permanent coordination forum.

According to DLH data (2024), South Tangerang hosts 439 active waste banks, 54 TPS3R units, and a developing waste-to-energy (PSEL) project. Yet, persistent structural and behavioral barriers hinder system integration, including the limited operational capacity of the Cipeucang landfill and low rates of household waste sorting.

From an analytical standpoint, this pattern reflects what Achillas et al. (2013) identified as a multidimensional coordination challenge in municipal waste systems wherein decision-making tends to emphasize technological or infrastructural priorities while neglecting the social and institutional dimensions of collaboration. The fragmented functioning of South Tangerang's Pentahelix system thus exemplifies a *multi-criteria decision imbalance*, where environmental, economic, and governance considerations are not yet harmonized across actor networks.

Furthermore, Jangre et al. (2023) note that implementation in developing contexts often stalls due to structural barriers such as limited technical expertise, inconsistent waste segregation, and inadequate institutional coordination all of which resonate with the current conditions in South Tangerang. These barriers are intensified by the absence of a systemic incentive mechanism that encourages consistent inter-sectoral participation.

Similarly, Kling et al. (2016) demonstrate through analytic hierarchy and multi-criteria frameworks that effective waste management in low- and middle-income countries requires not only regulatory clarity but also *economic instruments* including extended producer responsibility (EPR) schemes and differentiated tariffs to drive private-sector participation and sustain local innovation. In this context, South Tangerang's reliance on voluntary participation and project-based collaborations limits the city's ability to evolve into a circular-economy model with measurable policy accountability.

In summary, South Tangerang's Pentahelix implementation reveals a *coordination–capacity gap* typical of emerging urban waste systems: while institutional roles are defined, the mechanisms of integrationfinancial, regulatory, and communicative remain weak.

Field Findings Based on Pentahelix Actors

a. Government

Interviews with officials from the Environmental Agency (DLH) and the City Council (DPRD) of South Tangerang revealed that the local government has established a robust legal foundation for waste management through Regional Regulation No. 3/2013, No. 13/2019, and Mayor Regulation No. 83/2022. Despite this, practical implementation continues to face significant challenges, including limited waste collection fleets, a shortage of technical personnel, and weak inter-agency coordination.

DLH confirmed that a permanent forum integrating all five Pentahelix actors has yet to be established, resulting in fragmented and project-based collaboration, primarily through community-based TPS3R and waste bank groups. However, efforts are underway to strengthen institutional coordination through the planned *Cross-Departmental Waste Management Acceleration Team*, which will be formalized by mayoral decree.

Media data also highlight operational challenges. The city faces approximately 700,000 tons Media coverage also highlights operational challenges. South Tangerang City faces around 700,000 tons of accumulated waste at the Cipeucang Final Disposal Site (TPA), with an additional 427 tons of waste generated daily (Jati, 2025). Initiatives such as the "One RW, One Waste Bank" program have faced difficulties due to limited infrastructure and low public participation.

b. Private Sector

The private sector represented by PT Abu & Co.demonstrates innovative waste management through pyrolysis technology and automated segregation, processing around six tons of household waste per day from 4,000 households. As a company technician noted: "We use complete separation machines, such as back openers and trommels, to separate organic and inorganic waste. We have never received any financial or equipment support from the government all machines were self-built." (Interview, 2025)

Despite high operational efficiency, the company operates independently without formal *public–private partnership (PPP)* arrangements or fiscal incentives. According to a City Council informant, "investors remain cautious due to regulatory uncertainty and the absence of long-term contracts" (Interview, 2025).

Media reports similarly highlight the need for broader private involvement in waste treatment infrastructure, particularly given land constraints and limited municipal capacity. These findings are consistent with Agamuthu and Babel (2023) and Ezeudu and Ugochukwu (2024), who emphasize that fragmented governance and financial insecurity discourage private investment in the waste sector. Wilson et al. (2006) and Dinçer et al. (2025) likewise conclude that sustainable waste management in developing contexts requires structured PPP frameworks with performance-based incentives.

c. Community and Civil Society

Community participation remains one of the most critical yet weakest components of waste governance in South Tangerang. DLH estimates that only 20% of households practice waste separation at sourcea figure confirmed by PT Abu & Co., whose technician stated:"Around 20% of residents separate their waste at home, while 80% still mix everything together." (Interview, 2025)

An academic informant from Universitas Pamulang noted inconsistencies in collection systems as a major deterrent: "Residents have separated organic and inorganic waste, but during collection, both types are mixed again in the same truck." (Interview, 2025)

Nevertheless, community-driven initiatives such as TPS3R Griya Resik and Bank Sampah Teratai demonstrate high effectiveness, with household-level sorting rates reaching up to 80%. The latter, supported by *Pegadaian*, *Unilever*, and *Mayora*, manages over one ton of inorganic waste monthly and engages 300 registered members (Tribun Tangerang, 2024).

d. Academia

Academic institutions play a knowledge-generating role through research and technological innovation. For instance, students from Universitas Pamulang developed the *Teba Modern* prototype for organic waste processing. However, as one academic informant stated: "The city government has no formal mechanism to review research results or involve researchers in policymaking. Academics are rarely invited to contribute to waste management innovation." (Interview, 2025)

DLH acknowledges existing collaborations with universities but notes that such partnerships are sporadic and disconnected from municipal planning programs. This demonstrates a knowledge–policy gap, where academic research remains isolated from policy formulation. As emphasized Khosravani et al. (2023), sustainable waste governance requires institutionalized mechanisms for knowledge transfer and policy uptake. Simpson et al. (2024) further highlight the importance of inclusive co-creation ecosystems between researchers and practitioners.

e. Media

Media plays an important role in public education and social accountability. As the director of *Tangerangupdate.com* noted: "We perform a social control function through data-based reporting and on-site verification." (Interview, 2024). From a theoretical perspective, Van Meter and Van Horn's (1975) conceptual framework identifies monitoring and feedback as critical for successful policy implementation, reinforcing the relevance of social control functions.

However, media coverage remains largely reactive, with media coverage of issues like the 700,000 tons of waste piled up at the Cipeucang TPST (landfill site) or the postponement of the waste-to-energy plant (PLTSa) project. These reports should serve as a catalyst for policymakers to formulate waste management policies in South Tangerang City.

Analytically, the media act as a deliberative arena shaping environmental discourse and accountability. To strengthen waste governance, media actors should be incorporated into the policy cycle from the planning to evaluation stages. Derdera and Ogato (2023) similarly underscore the importance of cross-sector communication and advocacy networks for sustaining environmental governance in developing countries.

Analysis Based on Van Meter & Van Horn's Policy Implementation Model

The analysis of South Tangerang's waste-management implementation through Van Meter and Van Horn's policy-implementation framework reveals a multidimensional interaction between institutional, behavioral, and contextual variables influencing policy effectiveness. The model emphasizes six interrelated dimensions policy standards and objectives, resources, communication, implementor disposition, characteristics of implementing agencies, and socio-political context five of which are particularly salient in this study.

a. Policy Standards and Objectives

The city government of South Tangerang has articulated clear objectives emphasizing waste reduction at the source, the promotion of 3R (Reduce–Reuse–Recycle) practices, and the advancement of energy-recovery initiatives such as the forthcoming PSEL project. Nevertheless, these objectives are not uniformly internalized across stakeholders. Policy documents are well structured but insufficiently socialized, resulting in uneven interpretation and weak engagement among communities and private actors.

Such a *policy–practice gap* reflects findings from other contexts. Cervantes et al. (2021) identified similar issues in Mexican municipalities, where regulatory frameworks were comprehensive but inadequately disseminated, leading to inconsistent compliance. Tamasila et al. (2020) further argue that waste-management performance depends not only on the existence of well-defined standards but on their prioritization and stakeholder consensus. Consequently, in South Tangerang, the lack of a shared understanding among pentahelix stakeholders diminishes the effectiveness of an otherwise coherent policy framework. This observation aligns with Lee and Paik (2011), who highlight that clarity and mutual comprehension among actors are essential determinants for the successful implementation of household waste management and recycling practices.

b. Resources

Resource availability remains a fundamental constraint. Although municipal (APBD) and national (APBN) budgets, supplemented by corporate social responsibility (CSR) funds, provide partial financial backing, they are insufficient to sustain continuous operations. Human-resource shortages, limited waste-collection fleets, and maintenance delays exacerbate inefficiencies.

This phenomenon underscores structural challenges identified in earlier research. Specifically, in Indonesia's urban satellite regions, Fitriani, Windusari, and Putri (2024) observed that disparities in resource allocation substantially undermined the operational effectiveness of

community-based waste management initiatives, such as TPS3R programs.. Globally, Bilgili and Çetinkaya (2023) in Turkey highlight that insufficient financial, technological, and logistical capacities remain persistent barriers to achieving circular waste systems. Moreover, Koska and Erdem (2023) emphasize that effective waste-resource allocation must integrate circular-economy performance indicators, not merely budgetary inputs.

c. Inter-organizational Communication

Coordination among stakeholders occurs through public hearings (*RDP*), TPS3R forums, and waste-bank networks facilitated by the Environmental Agency (DLH). However, these mechanisms remain temporary and non-institutionalized, weakening both vertical (government–community) and horizontal (inter-agency) linkages.

As Setiadi et al. (2020) observe, effective communication across environmental institutions requires institutionalized dialogue frameworks rather than ad hoc consultations. Similar to findings in the Mexican case (Cervantes et al., 2021), South Tangerang's fragmented coordination limits policy coherence and collective learning. Furthermore, Berenjkar et al. (2021) demonstrate through system-dynamics modeling that cross-organizational feedback loops significantly enhance adaptability in waste systems something still missing in Tangsel's governance structure. Therefore, while the city exhibits multiple consultation channels, the absence of a formalized collaborative platform hampers sustained policy alignment and continuous knowledge transfer among the pentahelix actors.

d. Character

The characteristics of implementing institutions play a critical role in policy success, as emphasized in the Van Meter and Van Horn implementation model. In Tangerang Selatan, the Department of Environment (DLH) serves as both regulator and facilitator for municipal waste management, overseeing the full cycle from collection to final disposal at TPA Cipeucang. While the centralized authority of DLH allows for comprehensive oversight a key factor in effective waste management (A. Ali et al., 2023) coordination between internal units such as the Cleanliness Division and the UPT TPA Cipeucang remains sectoral and fragmented.

Operational constraints further undermine institutional effectiveness. Field staff shortages, aging equipment, and insufficient technical capacity impede timely waste collection, sorting, and disposal. The gap between organizational structure and operational resources mirrors patterns observed in urban areas of Africa and other developing regions (Shabani et al., 2023; Sserubula et al., 2025).

e. Disposition of Implementors

The attitudes and motivations of implementors significantly shape operational outcomes. Field evidence suggests that DLH officers and TPS3R community leaders demonstrate high commitment to waste sorting and recycling, whereas some implementors focus primarily on recyclable materials with immediate economic value. Such behavioral divergence parallels Adu-Gyamfi et al. (2023), who found that employee motivation and organizational norms strongly influence waste-sorting intentions in Ghana. Similarly, Ali (2022) reveal that cognitive and motivational factors are critical determinants of policy uptake and performance in complex waste systems.

To strengthen policy implementation, the city must institutionalize incentive mechanisms that align economic motivations with environmental objectives, ensuring that individual commitment translates into collective sustainability outcomes.

f. Socio-Political and Economic Environment

The broader socio-political context further shapes policy performance. Although the City Council provides consistent political support, the continuity of waste-management priorities across mayoral administrations remains weak. Fluctuating political commitment leads to discontinuities in budget allocation and program focus. Moreover, low public awareness and limited household income constrain participation in waste sorting and recycling.

Such contextual barriers are consistent with findings from Bao and Lu (2023), who argue that waste-management effectiveness follows an *environmental Kuznets curve* improving only when socioeconomic conditions and institutional maturity reach a certain threshold. Likewise, Bui et al. (2023) highlight that technological progress alone cannot ensure sustainability without supportive governance and public engagement.

Therefore, achieving a conducive socio-political environment in South Tangerang requires long-term political consistency, public education, and inclusive mechanisms that bridge administrative transitions. The empirical and comparative analysis confirms that waste-management implementation in South Tangerang is a multidimensional process influenced by structural, behavioral, and contextual variables.

Integration of Empirical Findings and Theory

The study reveals that the success of *Pentahelix* collaboration in South Tangerang relies heavily on the government's leadership as the primary coordinating actor (*lead sector*). When the government actively facilitates programs such as waste banks and TPS3R forums multi-actor collaboration strengthens. Conversely, when coordination and communication weaken, stakeholders tend to operate independently.

Theoretically, this reinforces that public policy effectiveness depends not only on institutional structures but also on the quality of actor interaction and the adaptive capacity of policy networks. Van Meter & Van Horn's model proves useful in explaining performance variations across TPS3R units and private sector initiatives.

Policy Implications

a. Institutionalize a Permanent Pentahelix Forum at the City Level

Establishing a permanent Pentahelix Forum under a mayoral decree is crucial to ensuring consistent, multi-actor coordination in waste management. Such an institutional mechanism enables structured collaboration between government, academia, business, community, and media sectors, aligning with the principles of collaborative governance (Emerson et al., 2012). Empirical findings from Indonesia demonstrate that formalized Pentahelix structures foster information exchange, conflict resolution, and shared accountability in local environmental governance (Chaerani et al., 2022). Similarly, Cervantes et al. (2021) argue that governance mechanisms that formalize stakeholder interaction enhance transparency and policy compliance in waste systems. Therefore, a legally mandated forum would institutionalize the Pentahelix model as a sustainable governance instrument for waste reduction in Tangerang Selatan.

b. Develop Performance-Based Incentives for Communities, Media, and Businesses

Performance-based incentives are vital for sustaining community and corporate engagement in waste reduction. Evidence from multi-criteria decision analysis (Achillas et al., 2013) shows that incentive mechanisms financial or reputational drive participation and innovation in waste segregation and recycling initiatives. In the Indonesian context, integrating reward systems into waste bank operations has been proven to increase sorting consistency and participation. Moreover, Kamanga et al. (2024) highlight that targeted incentives for informal and small-scale recyclers create inclusive participation while improving overall system efficiency.

By aligning incentives with performance indicators, local governments can embed motivation into community-led waste reduction programs, ensuring sustained behavioral change (Thakur & Onwubu, 2024).

c. Integrate Academic Research Outputs into DLH Policies

Linking academic research to local environmental policy is essential for evidence-based decision-making. As noted by Carayannis and Campbell (2012), knowledge co-production between universities and local governments strengthens innovation capacity and policy legitimacy. In Indonesia, academic institutions have played a pivotal role in developing localized waste processing models and sustainability frameworks under the Pentahelix approach (Irawan et al., 2024). The establishment of structured policy brief mechanisms through which research outputs inform the design and evaluation of waste management programshas been recommended to enhance adaptive governance (Setiadi et al., 2020).

d. Digitize Waste Management Data for Transparent, Indicator-Based Monitoring

Digital transformation is increasingly recognized as a key enabler of effective waste governance. System dynamics and data-driven modeling approaches improve the traceability and transparency of waste flows, facilitating real-time monitoring and evaluation. According to Mujtaba et al. (2024), digitized information systems allow policymakers to prioritize waste management scenarios based on performance metrics and sustainability indicators. Furthermore, digital integration enables public participation through open access to environmental data, thus reinforcing accountability and collaboration (Bilgili & Çetinkaya, 2023).

e. Strengthen Local Human Resource Capacity through Training and Certification

Human resource capacity remains a determining factor for effective implementation of waste management policies (Agamuthu & Babel, 2023). Research indicates that ongoing professional development for managers of community-based waste management programs, including waste banks and TPS3R, enhances both operational effectiveness and the introduction of innovative practices at the local level (Fitriani et al., 2024). Certification programs, coupled with technical workshops, have proven to elevate service quality and ensure compliance with environmental standards in developing contexts (Jangre et al., 2023). Within the Pentahelix framework, capacity development should be co-managed by academia and local government, ensuring that updated knowledge and skills are transferred effectively.

CONCLUSION

This study demonstrates that collaborative governance in urban waste management, while formally involving multiple stakeholders, remains largely fragmented and operates primarily at the level of coordination rather than integrated collaboration. Government actors continue to dominate regulatory and facilitative roles, while private sector initiatives, community participation, academic contributions, and media engagement function in parallel with limited institutional linkage. Key barriers identified include weak inter-stakeholder communication, unclear role distribution, resource constraints, and the absence of permanent collaborative mechanisms, all of which constrain the effectiveness and sustainability of waste governance efforts in urban Indonesia.

These findings highlight the importance of strengthening institutionalized multi-stakeholder frameworks to move beyond ad hoc coordination toward more integrated and accountable governance arrangements. Establishing permanent collaborative platforms, clarifying stakeholder roles, improving resource alignment, and enhancing the integration of knowledge into policy processes are critical steps for improving urban waste management

outcomes. By providing empirical insights into the operational limitations of collaborative governance, this study contributes to the broader discourse on sustainable urban environmental management and offers practical guidance for policymakers seeking to enhance collective action in complex governance settings

Policy Recommendations

To improve the effectiveness of urban waste management, policymakers should prioritize the institutionalization of multi-stakeholder collaboration through the establishment of permanent and clearly mandated collaborative platforms. Such platforms should be supported by formal regulations that define stakeholder roles, decision-making authority, and accountability mechanisms, ensuring consistent coordination beyond ad hoc initiatives. Strengthening communication channels, improving data-sharing systems, and aligning resource allocation across stakeholders are essential to reducing fragmentation and enhancing collective action in waste governance.

In addition, policy efforts should focus on integrating knowledge and innovation into governance processes by strengthening partnerships between government, academia, and the private sector. Incentive-based mechanisms, performance monitoring frameworks, and digital tools can be utilized to encourage sustained stakeholder engagement and transparency. Media engagement should be leveraged strategically to support public awareness and behavioral change, while community participation must be supported through capacity-building and long-term sustainability measures. Together, these strategies can enhance the resilience and sustainability of urban waste management systems in Indonesia.

Limitations and Future Research

It is important to acknowledge limitations: this study was conducted in one urban municipality (South Tangerang), and thus findings may not generalise to rural or different socio-economic settings. Also, while rich qualitative data was collected, the study did not measure quantitatively the causal impact of pentahelix collaboration on waste volumes or cost-efficiency. Future research might employ a mixed-methods or longitudinal design to assess the long-term effects of pentahelix governance structures in diverse urban and rural contexts. Moreover, comparative studies across municipalities with varying levels of stakeholder coordination could yield insights into best-practice configurations.

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