Analysis of the integration pattern of waste management systems in local policies in Ambon city, Indonesia

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Abstract: Waste management remains a persistent challenge for urban areas in Indonesia, including Ambon City. This study aims to analyze the integration pattern of waste management systems as regulated through local policies, specifically the Regional Regulation (Perda) and Mayor Regulation (Perwali) in Ambon. A qualitative descriptive method was employed, using document analysis of relevant legal instruments, supported by semi-structured interviews with key stakeholders from the local government and waste management sector. The findings reveal a partial and fragmented integration between Perda and Perwali, particularly in institutional coordination, operational mechanisms, and community involvement. While both regulations address waste reduction and service improvement, inconsistencies in roles, responsibilities, and implementation procedures hinder effective integration. The novelty of this research lies in its focus on the alignment of multi-level local regulations as a strategic foundation for integrated urban waste governance. It highlights the need for harmonization between policy documents and practical execution to ensure regulatory coherence and efficiency. The study recommends revising existing policies to better define institutional roles, integrate technological support systems, and strengthen public participation frameworks. These measures are expected to enhance the sustainability and responsiveness of waste management in Ambon City.

Keywords: Local policy integration, Perda, Perwali, Urban governance, Waste management.

1. Introduction

The management of municipal solid waste has become a critical global concern as urbanization, industrialization, and population growth continue to intensify [1-3]. Urban areas around the world are increasingly burdened by the accumulation of waste, which poses significant threats to environmental sustainability, public health, and urban liability. Effective waste management is no longer just a technical issue, but also a matter of governance, policy coherence, and stakeholder engagement [4].

In developing countries, particularly in Southeast Asia, waste management systems often struggle due to limited infrastructure, financial constraints, and institutional inefficiencies. Indonesia, as one of the most populous countries in the region, faces acute challenges in ensuring sustainable urban waste governance. National policies provide a broad framework, but their implementation is highly dependent on the capacity and coordination of local governments [5-7].

Local regulations play a crucial role in operationalizing national waste management mandates at the city level. In the Indonesian legal system, regional governments are authorized to issue Peraturan Daerah (Perda) and Peraturan Walikota (Perwali) to govern various sectors, including waste management. Ideally, these regulations should form an integrated framework that supports effective service delivery and policy implementation [8, 9].

However, in practice, discrepancies and overlaps frequently occur between different layers of regulation, especially in terms of institutional roles, responsibilities, and mechanisms of action. These inconsistencies often

result in fragmented policy execution, reduced accountability, and inefficiencies in waste management practices. This situation is further exacerbated in cities with limited administrative capacity or coordination mechanisms [10, 11].

Ambon City, the capital of Maluku Province, exemplifies the complexities of local waste governance in Indonesia. As an urban centre undergoing rapid demographic and spatial changes, Ambon faces rising volumes of waste and mounting pressure on its management systems. While the city has enacted both Perda and Perwali to address waste issues, the effectiveness of these instruments in forming a coherent system remains unclear [12, 13].

Limited scholarly attention has been paid to how these local regulations interact and integrate to create a unified governance structure. Most existing research emphasizes technological or community-based approaches, leaving a gap in understanding the regulatory and institutional integration essential for sustainable outcomes. This gap highlights the need for a policy-oriented study that analyses the coherence and operational alignment of local waste management regulations.

This study aims to analyse the integration pattern of waste management systems as embedded in the Perda and Perwali of Ambon City. Specifically, it investigates the degree of policy alignment, institutional coordination, and procedural consistency across the two regulatory instruments. The study seeks to contribute to the literature on urban environmental governance by offering insights into the regulatory integration of local waste policies, and to propose recommendations for strengthening the legal and institutional framework of waste management in Ambon.

2. Study Literature

The integration of waste management policies is a significant concern for urban sustainability, as it influences the efficiency of waste handling and resource recovery. According to Wilson, et al. [14] an effective waste management system requires coordinated policies at all levels of government—national, regional, and local [14]. In many cities worldwide, fragmented policy frameworks create operational inefficiencies and complicate enforcement. The challenge of aligning different regulatory levels to support sustainable waste management has been well documented in various studies [14, 15]. Furthermore, countries like Brazil and South Korea have demonstrated that integrated waste management policies can result in improved waste practices and environmental outcomes [15].

In Indonesia, the decentralization of waste management governance to local authorities has led to the creation of various regional regulations to manage urban waste. Aprilia [16] discuss how Jakarta's waste management system has been hindered by fragmented regulations, where national policies are not always adequately aligned with local ordinances [16]. Tudescu [17] further note that Surabaya's waste management suffers from a lack of synchronization between Perda and Perwali, leading to poor service delivery. Such studies underscore the challenges that arise when local regulations fail to align, which can be exacerbated by weak institutional coordination [17].

The role of local government regulations in urban waste management has been explored in several international studies, particularly regarding their alignment with national laws. London and Cadman [18] argue that regulatory fragmentation between different levels of government leads to inefficiencies in waste management. This issue is especially pertinent in cities where the legal frameworks governing waste management, infrastructure development, and urban planning are not aligned [18]. For effective waste management, local authorities need to ensure coordination between various agencies, including municipal waste management departments, environmental agencies, and the public [19].

Research on waste management policies in Indonesia often highlights the challenges posed by regulatory incoherence and fragmented enforcement. Suryawan, Suryawan and Lee [20] emphasize that discrepancies between national policies and local regulations often lead to inefficiencies in waste management, particularly in terms of resource allocation and policy enforcement. In Ambon, while Perda and Perwali are in place, the lack of clarity in their implementation results in poor coordination among local agencies and a lack of accountability in waste management operations. This issue points to the need for a more integrated approach that aligns regulatory instruments with operational practices [20].

The successful implementation of waste management systems depends not only on legal frameworks but also on effective stakeholder engagement. Joseph [21] argue that policy fragmentation hinders the creation of a comprehensive waste management strategy, especially when local governments fail to engage stakeholders from the private sector, civil society, and the general public [21]. emphasize that stakeholder involvement is key to aligning waste management policies with community needs [22]. This integration of multiple actors in the waste management process helps ensure that policies are both effective and inclusive.

Based on the reviewed literature, although several international and national studies have discussed the challenges and opportunities related to the integration of waste management systems in local policies, there remains a significant gap in research specifically examining how local regulations, such as Perda and Perwali, interact and are implemented in smaller cities in Indonesia, such as Ambon. Most previous studies have focused on larger cities or countries with more established waste management systems, leaving the context of smaller cities and the potential differences in policy implementation underexplored. Additionally, research on the role of stakeholder involvement in the integration of local waste management policies is still limited. Therefore, this study will fill this gap by focusing on the analysis of the integration patterns of waste management policies in Ambon, exploring the alignment between Perda and Perwali, and their impact on sustainable waste management practices in the city.

3. Methodology

This study employed a qualitative descriptive research design to explore the integration pattern of waste management systems within the local regulatory framework of Ambon City, Indonesia. The primary method of data collection was document analysis, focusing on two key legal instruments: the Regional Regulation (Peraturan Daerah or Perda) and the Mayor Regulation (Peraturan Walikota or Perwali) that govern waste management practices in the city. These documents were analyzed to identify alignment and discrepancies in policy objectives, institutional mandates, operational procedures, and provisions for community engagement. To complement the document analysis, semi-structured interviews were conducted with purposively selected stakeholders, including officials from the local environmental agency, waste service operators, and community organization representatives. The interviews aimed to gain insight into the practical implementation of these policies and the extent of coordination among institutions. Data were coded thematically using content analysis to extract key patterns, similarities, and gaps in regulatory integration. The triangulation of data sources ensured the credibility and depth of the findings. This methodological approach enabled a comprehensive examination of how local waste governance is structured and practiced in Ambon City, providing an evidence-based foundation for recommendations toward more cohesive and effective policy integration.

3.1. Household and Collection Officer Survey

A household survey will be conducted using stratified random sampling of household heads (HHs), with stratification based on the type of waste collection system implemented in each area. The sampling method refers to the Indonesian National Standard SNI 19-3964-1995, which outlines procedures for the sampling and measurement of waste generation and composition. This standard permits the use of both stratified random sampling and purposive random sampling, depending on the study context. In parallel, a detailed survey will also be administered to waste collection personnel using a stratified random sampling approach across different waste collection system zones. The questionnaire will collect data on respondent attributes and operational practices within the current waste collection systems. Samples of collection personnel will be drawn from service areas characterized by varying waste collection methods and regional conditions. Equation 1 and Equation 2 are used to justify the sample size calculations for both household waste generation and the number of personnel surveyed.

Waste generation samples:
$$Ps = Cd. \, Cj. \, \sqrt{Pt} \qquad\qquad (1)$$

Where:
Ps   = sample population (people)
Cd   = density coefficient
Cj   = million coefficient
Pt   = Total population (people)

Total sample of officers:

$$Ps = Cd.\sqrt{Pt} \qquad\qquad\qquad (2)$$

The survey is conducted by distributing questionnaires that cover several key areas: (a) respondent attributes, the current waste collection system received, and the respondent's level of awareness regarding waste management; (b) waste generation by type; and (c) willingness to participate, willingness to segregate, and willingness to pay for improved waste management services. In addition to the questionnaire distribution, a time-motion study will be carried out on selected waste collection workers operating in different areas with varying waste collection patterns. This study will observe and measure specific movements, including (a) the act of transferring waste into collection carts, (b) movements between households, (c) the route from the storage point to the first house and from the last house to the temporary disposal site (TPS), and (d) the return route from the TPS to the first house for the next collection round. Furthermore, waste generation sampling will be conducted to quantify the volume of waste, which serves as a critical input for waste management planning and system optimization.

3.2. Implications of Integration of Collection and Transfer Systems

The implications of integrating collection and transfer systems in Ambon City are centered on optimizing the efficiency and sustainability of municipal solid waste management. By analyzing the current transportation system from Temporary Disposal Sites (TPS) to the Final Disposal Site (TPA), the study identifies key operational gaps and inefficiencies that hinder effective waste flow. Integration efforts also include scenario development for optimizing the number of waste transport trips and projecting future transport needs based on waste generation trends. This strategic approach aims to streamline coordination between collection and transfer stages, reduce operational costs, minimize environmental impact, and improve service coverage across diverse urban areas. Ultimately, the integration supports data-driven planning for a more resilient and responsive waste management system.

4. Results and Discussion

4.1. Fragmentation of Legal and Institutional Frameworks

The analysis of Ambon City's waste management policies—specifically the Regional Regulation (Perda) and Mayor Regulation (Perwali)—reveals a fragmented legal structure. While both regulations address waste reduction, service improvement, and public participation, inconsistencies in institutional mandates and implementation procedures are evident. The Perda focuses more on regulatory norms and obligations, whereas the Perwali elaborates on operational procedures without clearly aligning roles and responsibilities with the higher regulation. This fragmentation creates ambiguity in authority delegation among waste management institutions, which undermines inter-agency coordination and efficiency. The lack of harmonization between the two documents reflects a gap in the city's policy integration strategy and weakens the potential for systemic improvement in waste governance. Table 1 shows a comparison of the substance of the Regional Regulation and the Mayoral Regulation on waste management in Ambon City.

The comparison table between Ambon City Regional Regulation Number 11 of 2015 (Perda) and Mayor Regulation Number 39 of 2018 (Perwali) highlights the fragmented nature of policy integration in waste management governance. The Perda generally outlines broad normative concepts, while the

Perwali attempts to provide more technical and operational clarity. However, there remains a lack of harmonization in key aspects such as institutional structure, where the Perda refers to general agencies and the Perwali specifies technical units without clear alignment. The role of society is also inconsistently defined, with the Perda providing conceptual guidance and the Perwali detailing specific activities, which leads to disjointed implementation. Waste collection mechanisms suffer from insufficient operational linkage due to the Perda's general descriptions and the Perwali's procedural focus. Furthermore, neither regulation sufficiently addresses the need for a robust reporting and evaluation system, and both lack strong emphasis on technology and innovation, which are crucial for enhancing waste management performance. This analysis suggests that without regulatory coherence, efforts to establish an integrated and efficient waste governance system in Ambon City may remain ineffective [23].

Table 1.
Comparison of the substance of the regional regulation and the mayoral regulation on waste management in Ambon city.

Aspect/Substance	Ambon City Regional Regulation Number 11 of 2015 (*Perda*)	Ambon City Mayor Regulation Number 39 of 2018 (*Perwali*)	Integration Notes
Definition and Scope	General and normative	More technical and operational	Need for harmonization of terminology
Institutional	Referring to the relevant agencies in general	Appointing the technical implementing unit (UPT)	Lack of structural synchronization
Role of Society	Conceptually regulated	Organized through specific activities	Not synchronized in mechanism
Waste Collection Mechanism	Arranged in outline	Developing technical procedures	Need operational alignment
Reporting and Evaluation System	Not detailed	Not available	Needs to be added in both
Technology and Innovation	Not mentioned	Only mentioned in general	Lack of concrete encouragement

4.2. Waste Generation Characteristics and Community Awareness

The household survey reveals a variety of waste types predominantly consisting of organic waste (54.3%), plastics (23.6%), paper (11.8%), and others (10.3%). Waste generation rates vary across neighborhoods and correlate strongly with income levels and access to waste collection services. In terms of awareness, over 70% of respondents acknowledge the importance of proper waste management; however, only 39% actively participate in source segregation. This discrepancy highlights the gap between awareness and behavioral practice. The willingness to participate (WTPa), willingness to segregate (WTS), and willingness to pay (WTP) indicators reflect moderate support from the community, with WTPa at 68%, WTS at 59%, and WTP at 41%, respectively. These findings emphasize the need for targeted education and incentive programs embedded within local regulations. Figure 1 shows the level of public awareness and willingness in waste management (%).

The diagram illustrates the distribution of household responses regarding waste management behavior and attitudes in Ambon City, segmented into four key aspects: awareness of waste issues, willingness to participate (WTPa), willingness to segregate (WTS), and willingness to pay (WTP). The highest percentage is represented by awareness of waste issues at 72%, indicating a strong cognitive recognition of environmental concerns among residents. This is followed by willingness to segregate waste (WTS) at 59%, reflecting a moderately high readiness to adopt waste separation practices at the source. Meanwhile, willingness to participate in waste management activities (WTPa) accounts for 48%, suggesting that although awareness is high, active involvement still requires enhancement. The lowest proportion is seen in willingness to pay (WTP) at only 41%, highlighting a potential challenge in implementing financial mechanisms or user-based service models [24]. Overall, the chart demonstrates

a positive trend in public awareness and passive support, but also underscores the need for targeted strategies to foster deeper community engagement and financial commitment.
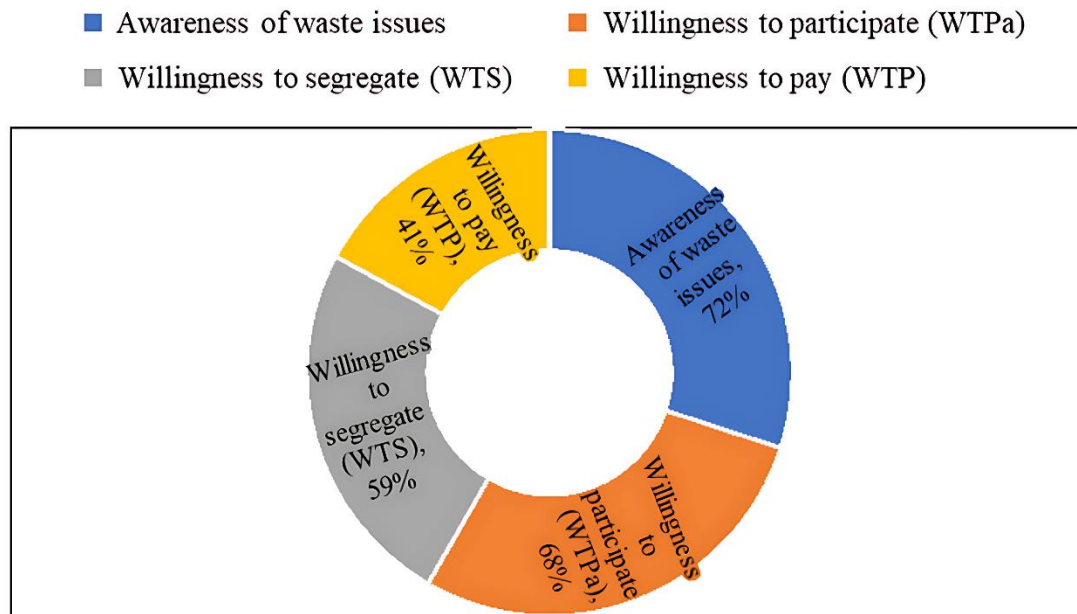

Figure 1.
Level of public awareness and willingness in waste management (%).

4.3. Operational Insights from Waste Collection Workers

Results from the stratified survey and time-motion studies among waste collection personnel show significant variation in operational efficiency depending on area characteristics. Collection movements are found to be most time-consuming during household-to-household transitions and the return trip from the Temporary Disposal Site (TPS) to the first household on the next route cycle. Workers in dense, unstructured settlements spend up to 40% more time per collection cycle compared to those in planned residential areas. Furthermore, inconsistencies in equipment, route planning, and communication between agencies exacerbate inefficiencies. These issues are currently under-addressed in both *Perda* and *Perwali*, suggesting a missed opportunity for policy-backed standardization and support for frontline operational workers.

4.4. Integration Challenges in Collection and Transfer Systems

The study's scenario modeling shows suboptimal integration between the collection and transfer stages. Transport vehicles often operate below optimal capacity, leading to excessive trips and increased fuel consumption. Analysis of data from TPS-to-TPA transfers indicates that a more coordinated scheduling and loading system could reduce daily trips by up to 30%, particularly if waste sorting at the source is improved. The absence of a centralized data system for tracking waste volumes and truck rotations further complicates coordination. Integration between the collection schedule and transfer logistics remains informal and reactive rather than policy-driven, highlighting a need for stronger regulatory alignment and technological support such as GIS-based route optimization and digital monitoring systems. Table 2 shows the simulation of TPS–TPA transportation trip optimization scenario.

Table 2.
simulation of Tps-Tpa transportation trip optimization scenario.

Scenario	Type of Region	Waste Volume/Day (m³)	Truck Capacity (m³)	Number of Ritations	Ritation Efficiency
A	Dense Urban	90	9	10	Basic references
B	Optimization Scheme 1	90	12	8	20% reduction
C	Optimization Scheme 2	90	15	6	40% reduction

4.5. Policy Gaps and Recommendations for Harmonization

The divergence in policy content between the Perda and Perwali underscores the absence of a shared framework or strategic roadmap for integrated waste governance. For example, while both documents refer to community participation, they offer different definitions and operational scopes, leading to implementation inconsistencies at the sub-district level. Moreover, provisions related to technology adoption, performance indicators, and institutional accountability are either vague or missing entirely. The study recommends a policy revision process that establishes clearer institutional roles, synchronizes procedural standards, and includes performance-based metrics. Establishing an integrated regulatory framework that consolidates both planning and operational domains is essential for long-term sustainability and accountability.

In addition to regulatory misalignment, the lack of integration between Perda and Perwali hampers the broader goals of environmental management, particularly in ensuring effective waste reduction, segregation, and resource recovery. Environmental management requires coordinated actions across regulatory, institutional, and operational levels to manage environmental impacts holistically. However, in the case of Ambon City, fragmented policies and unaligned governance mechanisms result in suboptimal waste handling and limited public compliance. For example, the absence of a unified reporting and evaluation system limits the ability to monitor environmental indicators such as landfill diversion rates, greenhouse gas emissions, and pollution levels. These weaknesses obstruct the city's ability to fulfill national and global environmental targets, including the Sustainable Development Goals (SDGs) related to sustainable cities and responsible consumption and production (SDG 11 and SDG 12).

Furthermore, an integrated policy framework would serve as a critical enabler for aligning local waste governance with the principles of adaptive environmental management. Adaptive management emphasizes learning-based policy cycles, stakeholder involvement, and responsiveness to environmental feedback—elements that are currently lacking due to institutional fragmentation. Without a shared set of goals and metrics, policies remain reactive rather than proactive, with little room for iterative improvements based on performance evaluations or community feedback. Therefore, bridging the regulatory divide between Perda and Perwali is not only a matter of bureaucratic efficiency but also a necessary condition for embedding environmental resilience and sustainability into Ambon's waste management system. Encouraging cross-sectoral collaboration, investing in monitoring technologies, and integrating environmental performance metrics into municipal planning will greatly strengthen both the regulatory coherence and environmental outcomes of the city's waste governance framework.

5. Conclusion

This study highlights the critical need for an integrated approach to waste collection and transfer systems in Ambon City, revealing inconsistencies between regulatory instruments (Perda and Perwali), operational inefficiencies in waste transport, and gaps in public engagement. By combining stratified survey methods, time-motion studies, and optimization modeling, the research provides a comprehensive analysis of both household and collector-level waste behaviors and system performances. The findings indicate that current fragmentation in policy and practice limits the effectiveness of solid waste management (SWM) and hampers progress toward environmental sustainability goals. The study's novelty lies in its cross-sectional integration of behavioral, operational, and regulatory

dimensions, offering a multi-scalar assessment that bridges technical optimization and institutional analysis.

The practical benefits of this research are evident in its potential to inform municipal planning and policymaking. Specifically, it provides evidence-based recommendations for optimizing truck capacity and reducing the number of waste collection rotations, which directly translates into cost and energy savings. Furthermore, it identifies key areas where policy synchronization and community participation can be strengthened. As a follow-up, this study recommends the development of a unified waste management roadmap that harmonizes regulatory instruments, incorporates performance-based metrics, and enhances public communication strategies. Future research should explore real-time monitoring systems, such as IoT-based tracking for waste transport, and assess the environmental impact of optimized scenarios through life cycle analysis (LCA), thereby contributing to more adaptive and resilient urban waste governance.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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