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Collaborative Governance in Plastic Waste Recycling in Medan City: Integrating Informal Sector, Community Participation, and Policy

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Abstract
Medan City faces low household participation in waste sorting—only 20 % regularly—and limited integration of the informal sector, which nonetheless collects approximately 30 % of recyclable materials. This study examines the role of collaborative governance in enhancing community engagement, formalizing the contributions of waste pickers, and improving policy coordination to establish a sustainable plastic recycling system. A qualitative case study design was adopted, comprising 15 in-depth interviews with representatives from government agencies, informal sector actors, recycling businesses, and community members; field observations at three TPS/TPA sites; and analysis of relevant policy documents. Results reveal that inadequate sorting facilities and deficient public education impede household involvement; waste pickers operate without formal incentives, leading to suboptimal participation; and overlapping institutional mandates hinder effective policy implementation. In response, an integrated education campaign with the distribution of 10000 sorting bins over six months, direct subsidies of IDR 50000 per ton for registered waste pickers, and the establishment of a quarterly cross-sectoral coordination forum are proposed. Implementation of these measures is projected to increase sorting rates to 60 % and integrate 80 % of informal actors into the formal recycling framework.

Keywords
collaborative governance, community participation, informal sector, medan city, waste recycling

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Introduction

Waste management, particularly plastic recycling, has become a critical issue in urban areas worldwide, including Medan City, Indonesia (Indirawati et al., 2023). As the third-largest metropolitan city in Indonesia, Medan generates thousands of tons of waste daily, with plastic waste constituting a significant portion due to its widespread use and low recycling rates (Ridho et al., 2019). Recycling holds significant potential to reduce waste volume, minimize environmental pollution, and create economic value through the reuse of materials (Wilson & Velis, 2015). However, the current recycling system in Medan faces numerous challenges, including low community participation in waste sorting, the marginalization of the informal sector, weak coordination among stakeholders, and inconsistent policy implementation (Afroz et al., 2011). These issues highlight the need for a more integrated and collaborative approach to waste management, particularly for plastic waste, which poses unique environmental and health hazards.

Collaborative governance, which emphasizes multi-stakeholder collaboration, has been recognized as an effective framework for addressing complex public issues such as waste management (Ansell & Gash, 2008). In the context of recycling, collaborative

governance can facilitate the integration of the informal sector, enhance community participation, and improve policy coordination (Ostrom, 2010). Despite its potential, the application of collaborative governance in recycling systems, particularly in developing countries like Indonesia, remains underexplored. This study aims to fill this gap by examining how collaborative governance can be applied to develop a sustainable recycling system in Medan City.

Recent studies have emphasized the importance of transitioning from a linear to a circular economy, particularly in managing plastic waste. Almadhi, Abdelhadi, & Alyamani (2023) highlight the role of life-cycle assessment in evaluating plastic waste management systems, demonstrating that circular economy approaches can significantly reduce environmental impacts. Similarly, Gabisa, Ratanatamskul, & Gheewala (2023) argue that recycling plastics is a key strategy to reduce greenhouse gas emissions, microplastic pollution, and resource depletion. These studies underscore the urgency of developing effective recycling systems, especially in urban areas with high plastic consumption.

In the context of collaborative governance, research has shown that multi-stakeholder collaboration is essential for addressing complex waste management challenges. Bernardo et al. (2023) examined household plastic waste management in Wollongong, Australia, and found that selective waste collection systems, supported by community participation and policy integration, significantly improved recycling rates. This aligns with the findings of Konstantoglou et al. (2023), who explored consumer perceptions of deposit-refund systems and concluded that effective policy design and stakeholder engagement are critical for the success of recycling initiatives.

However, the application of collaborative governance in plastic waste management, particularly in developing countries like Indonesia, remains underexplored. While studies such as Liu & Liu (2023) have analyzed plastic management policies in China, identifying challenges such as inconsistent policy implementation and lack of public awareness, there is limited research on how collaborative governance can be adapted to the socio-economic and institutional realities of cities like Medan. This study aims to fill this gap by examining how collaborative governance can be applied to develop a sustainable plastic recycling system in Medan City, with a focus on community participation, informal sector integration, and policy coordination.

The informal sector, comprising scavengers and small-scale recyclers, plays a crucial role in plastic waste collection and recycling in Medan. However, these workers often operate without formal recognition or support, limiting their potential contribution to the recycling system (Rodic et al., 2010). Collaborative governance offers a promising solution by fostering cooperation among diverse stakeholders, including government agencies, informal waste workers, recycling businesses, and community members (Emerson et al., 2012). This approach emphasizes shared goals, trust-building, and inclusive participation, which are essential for overcoming the fragmented nature of waste management systems (Ansell & Gash, 2008).

Effective policy coordination is another critical factor in developing a sustainable plastic recycling system. Studies such as Kim, Kim, & Phae (2023) have highlighted the importance of aligning policies across different levels of government and stakeholders to ensure consistent implementation. In Medan, conflicting policies and overlapping responsibilities among government agencies often lead to inefficiencies in waste management. Additionally, infrastructure gaps, such as inadequate waste sorting facilities and overcapacity at final disposal sites, further hinder recycling efforts (Wilson & Velis, 2015).

The novelty of this research lies in its focus on the role of the informal sector and community participation within the framework of collaborative governance. While previous studies have highlighted the importance of stakeholder collaboration in waste management (Agamuthu et al., 2009), few have specifically addressed the integration of informal waste workers and the active involvement of communities in recycling systems. This study seeks to provide new insights into how collaborative governance can bridge the gap between formal and informal sectors while fostering community engagement.

Medan City, with its rapidly growing population and urbanization, faces significant waste management challenges. The city generates approximately 1,500 tons of waste daily, yet only a small fraction is recycled (Arda et al., 2021). The lack of an effective recycling system has led to environmental degradation, including pollution of rivers and public spaces, as well as health hazards for residents. The informal sector, comprising scavengers and small-scale recyclers, plays a crucial role in waste collection and recycling but operates without formal recognition or support (Rodic et al., 2010). This marginalization limits their potential contribution to the recycling system and exacerbates the city's waste management problems.

Collaborative governance offers a promising solution to these challenges by fostering cooperation among diverse stakeholders, including government agencies, informal waste workers, recycling businesses, and community members (Emerson et al., 2012). This approach emphasizes shared goals, trust-building, and inclusive participation, which are essential for overcoming the fragmented nature of waste management systems (Ansell & Gash, 2008). By integrating the informal sector and enhancing community participation, collaborative governance can create a more efficient and sustainable recycling system.

This study contributes to the existing literature by addressing these gaps and limitations. First, it provides empirical evidence on the application of collaborative governance in a developing country context, specifically focusing on Medan City. Second, it highlights the role of the informal sector and community participation within a collaborative governance framework, offering new insights into how these actors can be integrated into formal waste management systems. Third, it identifies the barriers to effective policy coordination among stakeholders, providing practical recommendations for overcoming these challenges.

By bridging these gaps, this study advances the theoretical understanding of collaborative governance in waste management and offers actionable insights for policymakers and practitioners. It underscores the importance of inclusive and context-specific approaches to waste management, emphasizing the need for collaboration among governments, informal actors, and communities to achieve sustainable outcomes.

Literature Review

Collaborative Governance in Waste Management

Collaborative governance has been widely recognized as a framework for addressing complex urban challenges, including waste management. Globally, Ansell & Gash (2008) emphasize trust-building and shared decision-making among stakeholders as critical success factors. In Indonesia, recent studies demonstrate the adaptability of this approach to local contexts. For example, Apriadi et al. (2024) employ system dynamics modeling to evaluate plastic waste mitigation policies in Indonesia, highlighting the need for multi-stakeholder collaboration to balance environmental and economic priorities. Their findings align with Handayani et al. (2024), who document successful triple-helix collaboration (government, private sector, and community) in relocating Rengasdengklok Market in Karawang Regency. These cases underscore Indonesia’s growing emphasis on participatory governance, though challenges such as fragmented authority and resource disparities persist.

Role of the Informal Sector

The informal sector remains a cornerstone of waste management in developing nations, contributing significantly to recycling rates despite systemic marginalization. Internationally, Medina (2007) estimates that informal workers handle 30–50% of urban waste in low-income countries. In Indonesia, Ulum et al. (2024) provide a nuanced case study of Bangun Village in Mojokerto Regency, where community-based plastic waste management models integrate informal workers through local cooperatives. Their research reveals that informal collectors achieve 40% waste diversion rates, yet face challenges such as limited access to technology and market linkages. Similarly, Zaki et al. (2024) demonstrate how informal workers in Bangunjiwo Village collaborate with NGOs to transform plastic waste into eco-friendly construction materials, creating livelihood opportunities while reducing environmental pollution. These Indonesian examples contrast with China's top-down formalization strategies (Liu & Liu, 2023), suggesting that grassroots empowerment, rather than forced integration, may yield more sustainable outcomes in Indonesia's socio-cultural context.

Community Participation in Recycling

Community engagement is pivotal for sustainable waste management, yet participation rates remain low in many Indonesian cities. Afroz et al. (2011) attribute this to inadequate awareness and infrastructure, a finding corroborated by Indirawati et al. (2023) in Medan, where only 20% of households sort waste. Recent Indonesian studies, however, highlight innovative approaches to overcoming these barriers. Paripurna Kamiel et al. (2024) analyze household plastic waste recycling in Yogyakarta, showing that incentive-based programs—such as exchanging recyclables for groceries—increase participation by 35%. Similarly, Zaki et al. (2024) report that community training workshops in Bangunjiwo Village improved waste sorting compliance by 50%, emphasizing the role of localized education. These initiatives align with Kirana & Artisa's (2020) findings on collaborative tourism development in Batu City, where community-led decision-making fostered ownership and long-term behavioral change. Such models suggest that blending traditional practices (e.g., gotong royong or mutual cooperation) with modern incentives could enhance recycling participation in Medan.

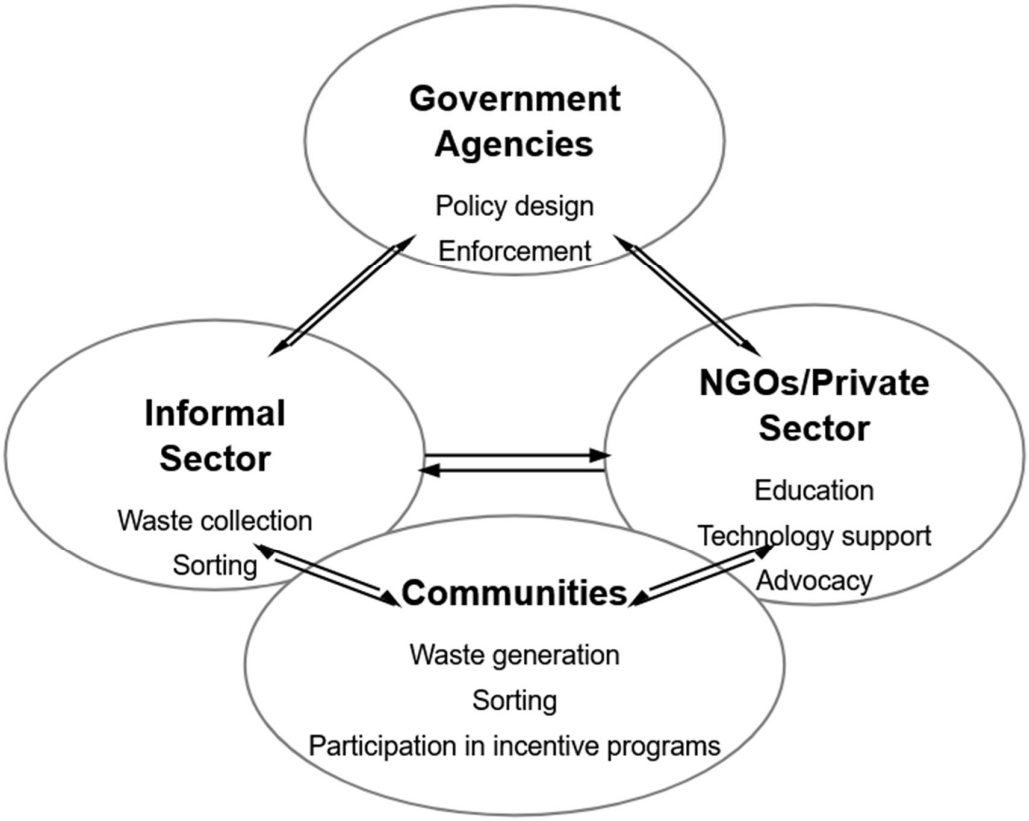
Policy Integration Challenges

Fragmented policies and weak interagency coordination continue to hinder waste management efforts in Indonesia. Internationally, Kim et al. (2023) stress the importance of vertical and horizontal policy alignment, while Bernardo et al. (2023) advocate for selective waste collection systems. In Indonesia, Apriadi et al. (2024) identify conflicting regulations between national ministries and local governments as a key barrier to plastic waste mitigation. For instance, the Ministry of Environment and Forestry's national targets often clash with Medan City's limited enforcement capacity, resulting in inconsistent implementation. Ulum et al. (2024) propose decentralized policy frameworks, as seen in Bangun Village, where village-level regulations empower communities to manage waste independently. This approach mirrors Ostrom's (2010) polycentric governance theory, advocating for localized solutions within broader national frameworks. However, scaling such models requires stronger institutional support, as noted by Ridho et al. (2019), who call for standardized metrics to evaluate policy effectiveness across Indonesian cities.

Conceptual Model

To synthesize these insights, Figure 1 (proposed for inclusion) illustrates a stakeholder interaction model tailored to Indonesia's context. The model positions government

agencies as policy enablers, informal workers as operational backbone, communities as active participants, and NGOs/private sector as innovation drivers. Bidirectional arrows emphasize collaborative flows: for example, informal workers supply recyclables to NGOs for upcycling, while communities provide feedback to governments on infrastructure needs. This model adapts Emerson et al.'s (2012) integrative framework but incorporates Indonesian cultural elements, such as community cooperatives (koperasi) and grassroots advocacy.



Picture 1.
Conseptual model of collaborative Governance on Plastic Waste Recycling

Method

This study employed a qualitative case study design to explore the application of collaborative governance in Medan City's plastic waste recycling system. The case study approach was selected to provide an in-depth understanding of complex, multi-stakeholder dynamics (Yin, 2018). Data were collected through in-depth interviews, field observations, and document analysis. Semi-structured interviews were conducted with 15 participants, comprising 4 government officials (from the Medan City Environmental Agency and the Ministry of Environment and Forestry), 6 informal sector workers (waste pickers and small-scale recyclers), and 5 community members from neighborhoods with varying recycling participation rates. Interview questions focused on community engagement, the informal sector's role, and policy coordination challenges. All interviews were recorded, transcribed, and analyzed. Field observations were carried out at 5 locations, including temporary waste disposal sites (TPS), final disposal sites (TPA), and informal recycling hubs, to document waste management practices and stakeholder interactions. Policy documents, agency reports, and statistical data were sourced from the Medan City Environmental Agency and the Ministry of Environment and Forestry to

triangulate findings. Thematic analysis (Braun & Clarke, 2006) was applied, involving four stages: (1) transcription and initial coding of interview transcripts and observation notes to identify key concepts, (2) theme development by grouping codes into categories (e.g., “lack of community incentives,” “marginalization of informal workers”), (3) theme refinement to ensure coherence with research objectives, and (4) interpretation of themes within the collaborative governance framework and Medan’s contextual realities. Data validity was ensured through triangulation of interviews, observations, and documents, alongside member checking, where preliminary findings were validated by participants. Reliability was maintained via an audit trail detailing the research process. Potential researcher subjectivity in data interpretation and resource constraints limiting the number of observation sites were acknowledged. However, the case study design prioritized contextual depth over generalizability. Medan City was selected as a representative case due to its status as Indonesia’s third-largest metropolitan area, generating 1,500 tons of daily waste, with plastic waste posing significant environmental challenges (Arda et al., 2021). Its struggles with low community participation, informal sector marginalization, and fragmented policy coordination mirror issues faced by many rapidly urbanizing Indonesian cities, making it a critical context for studying collaborative governance in waste management.

Results

Community Participation in Waste Recycling

Community participation in waste recycling in Medan City remains a significant challenge. According to the data collected, only 20% of households actively sort their waste, while the majority do not engage in waste separation practices. This low participation rate is primarily attributed to a lack of awareness and education about the benefits of recycling. Many residents are unaware of how to properly sort waste or the environmental impact of their actions. For example, one respondent stated, "We were never taught how to separate waste, so we just throw everything together" (Interview, Community Member, 2024). This highlights the need for comprehensive educational campaigns to increase public awareness.

In addition to a lack of awareness, inadequate infrastructure also hinders community participation. Many neighborhoods in Medan lack proper waste sorting facilities, such as separate bins for organic and inorganic waste. As a result, even motivated households find it difficult to participate in recycling efforts.

Another barrier to participation is the absence of incentives for households to recycle. Unlike in some cities where residents receive financial rewards or tax reductions for recycling, Medan has no such system in place. A local resident explained, "If there were some kind of reward, more people would probably participate, but right now, there’s no motivation" (Interview, Resident, 2024). Introducing incentive-based programs could significantly boost community engagement in recycling activities.

The role of local leaders and community organizations is also critical in promoting participation. However, the study found that many community leaders lack the resources and training to effectively advocate for recycling.

Finally, cultural attitudes toward waste management also play a role in low participation rates. In some communities, waste is seen as a low-priority issue, and recycling is not considered a social norm. Changing these attitudes will require long-term efforts, including public awareness campaigns and the involvement of religious and community leaders to promote recycling as a collective responsibility.

Role of the Informal Sector

The informal sector, particularly scavengers and small-scale recyclers, plays a crucial role in Medan's waste management system. Field observations revealed that informal workers collect approximately 30% of recyclable materials, such as plastics, paper, and metals, from waste disposal sites. These workers often operate in hazardous conditions, sorting through waste without protective equipment. One scavenger shared, "We work long hours in dirty environments, but this is the only way we can earn a living" (Interview, Scavenger, 2023). Despite their contributions, informal workers remain marginalized and unrecognized by the formal system.

The economic impact of the informal sector is significant, as it provides livelihoods for thousands of individuals in Medan. Many scavengers and recyclers come from low-income backgrounds and rely on waste collection as their primary source of income. However, their work is often undervalued, and they receive little to no support from the government. A small-scale recycler explained, "We help reduce waste, but no one acknowledges our role or provides us with tools to work better" (Interview, Recycler, 2023). Integrating these workers into the formal system could improve their working conditions and enhance the overall efficiency of waste management.

One of the key challenges faced by the informal sector is the lack of legal recognition and protection. Informal workers often operate in a legal gray area, making them vulnerable to exploitation and harassment. For example, some scavengers reported being chased away from waste disposal sites by authorities. Another issue is the limited access to resources and technology. Informal recyclers often rely on manual labor and basic tools, which limits their efficiency and productivity.

Finally, the informal sector's potential for innovation and entrepreneurship is often overlooked. Many informal workers have developed creative solutions for recycling and waste processing, but they lack the support to scale up their operations. For instance, one group of scavengers has started a small business turning plastic waste into handicrafts. "We have ideas, but we need funding and training to grow our business" (Interview, Scavenger, 2023). Supporting such initiatives could unlock the full potential of the informal sector in Medan's recycling system.

Policy Coordination Challenges

Policy coordination among stakeholders in Medan's waste management system is a major challenge. The study found that conflicting policies and overlapping responsibilities often lead to inefficiencies. For example, while the Medan City Environmental Agency is responsible for waste collection, the Ministry of Environment and Forestry oversees national waste management policies.

Another issue is the inconsistent implementation of policies at the local level. Despite the existence of national regulations on waste management, many local governments lack the capacity or resources to enforce them. One official explained, "We have the policies, but we don't have the manpower or budget to implement them properly" (Interview, Local Official, 2024). Strengthening the capacity of local governments is essential to ensure effective policy implementation.

The study also identified a lack of stakeholder engagement in policy-making processes. Many community members and informal workers reported feeling excluded from decision-making. Inclusive policy-making processes that involve all stakeholders could improve the relevance and effectiveness of waste management policies.

In addition, the absence of a clear regulatory framework for the informal sector creates challenges for policy coordination. Informal workers operate outside the formal system, making it difficult to monitor and regulate their activities. One government official noted, "We need a clear framework to integrate the informal sector into our waste management

system" (Interview, Medan Official Government, 2024). Developing such a framework could enhance coordination and collaboration among stakeholders.

Finally, the study highlighted the need for better data and information sharing among stakeholders. Many officials reported that the lack of accurate data on waste generation and recycling rates hinders effective planning and decision-making.

Infrastructure and Resource Limitations

Infrastructure gaps are a major barrier to effective waste management in Medan. The study found that only 40% of TPS locations are equipped with proper waste sorting facilities. This limits the ability of households and informal workers to separate recyclable materials. One resident stated, "Even if we want to recycle, there's no place to put the sorted waste" (Interview, Resident, 2023). Investing in waste sorting infrastructure is essential to support recycling efforts.

The capacity of Medan's TPA is another critical issue. Field observations revealed that the TPA is operating beyond its capacity, with waste piles exceeding 10 meters in height. This not only poses environmental and health risks but also limits the space available for future waste disposal. The lack of waste collection vehicles is another infrastructure challenge. Many neighborhoods in Medan experience irregular waste collection services, leading to the accumulation of waste in public spaces.

Finally, the study highlighted the need for technological innovation in waste management. Many existing waste processing technologies are outdated and inefficient, limiting their ability to handle the growing volume of waste. One expert suggested, "We need to invest in modern technologies, such as waste-to-energy plants, to improve waste management in Medan" (Interview, Waste Management Expert, 2023). Adopting innovative technologies could enhance the efficiency and sustainability of waste management efforts.

Emerging Themes from Stakeholder Perspectives

Stakeholders in Medan's waste management system expressed diverse perspectives on the challenges and opportunities they face. Community members emphasized the need for education and incentives to increase participation in recycling. One resident stated, "If people understand the benefits of recycling and are rewarded for their efforts, more will participate" (Interview, Resident, 2024). This highlights the importance of awareness campaigns and incentive-based programs. Informal workers, on the other hand, called for legal recognition and support to improve their working conditions. Many expressed frustration at being excluded from formal systems and policies.

Government representatives highlighted budget constraints and the complexity of coordinating with multiple agencies as major challenges. One official explained, "We have the policies, but implementing them requires coordination and resources that we often lack" (Interview, Government Official, 2024). Strengthening inter-agency coordination and securing additional funding could address these challenges.

Non-governmental organizations (NGOs) and community leaders emphasized the importance of grassroots initiatives in promoting recycling. Many NGOs are already working to educate communities and support informal workers, but they face resource limitations.

Finally, stakeholders agreed on the need for a collaborative approach to address Medan's waste management challenges. One expert summarized, "No single actor can solve this problem alone. We need to work together—government, communities, informal workers, and NGOs—to create a sustainable waste management system" (Interview, Waste Management Expert, 2023). This aligns with the principles of

collaborative governance, which emphasize the importance of multi-stakeholder collaboration in addressing complex issues.

Discussions

The findings on low community participation in waste recycling align with previous studies that highlight the importance of awareness and infrastructure in promoting recycling behavior (Afroz et al., 2011). The lack of education and facilities in Medan mirrors challenges observed in other developing cities, where inadequate resources hinder effective waste management (Wilson & Velis, 2015). However, this study adds nuance by emphasizing the role of cultural attitudes and the absence of incentives as additional barriers. For instance, the finding that recycling is not yet a social norm in Medan underscores the need for long-term behavioral change programs, as suggested by Ostrom (2010) in her work on collective action. The implication is that collaborative governance must prioritize community engagement through education, infrastructure development, and incentive-based programs to foster sustainable recycling practices.

The study by Handayani, Purbaningrum, & Milka (2024) further supports this argument, as their research on market relocation in Karawang Regency highlights the importance of community engagement and stakeholder collaboration in achieving sustainable outcomes. Their findings suggest that involving local communities in decision-making processes can lead to more effective and inclusive governance, which is equally applicable to waste management systems.

The significant contribution of the informal sector to Medan's recycling system is consistent with findings from other developing countries, where informal workers play a crucial yet underrecognized role in waste management (Medina, 2007). However, this study reveals the extent of marginalization faced by informal workers, including lack of legal recognition and access to resources. These findings resonate with Scheinberg et al. (2010), who argue that integrating informal workers into formal systems can enhance waste management efficiency. The implication is that collaborative governance must include mechanisms to recognize, protect, and support informal workers, ensuring their contributions are valued and their working conditions improved.

The weak coordination among stakeholders in Medan's waste management system reflects broader issues of fragmented governance observed in other urban contexts (Ansell & Gash, 2008). The study's finding that conflicting policies and overlapping responsibilities hinder effective implementation aligns with Emerson et al. (2012), who emphasize the importance of clear roles and shared goals in collaborative governance. The implication is that Medan needs a unified policy framework that aligns local and national efforts, supported by mechanisms for regular dialogue and coordination among stakeholders.

The infrastructure gaps identified in this study, such as insufficient waste sorting facilities and overcapacity at TPA, are consistent with challenges documented in other rapidly urbanizing cities (Wilson & Velis, 2015). However, this study highlights the critical role of financial and technological constraints in exacerbating these gaps. The implication is that collaborative governance must prioritize investments in infrastructure and technology, leveraging partnerships with the private sector and international organizations to mobilize resources. This aligns with Ostrom's (2010) argument that polycentric governance systems can effectively address resource limitations through multi-stakeholder collaboration.

The diverse perspectives of stakeholders in Medan's waste management system underscore the complexity of implementing collaborative governance. The finding that community members, informal workers, and government officials have differing priorities and challenges is consistent with Ansell and Gash's (2008) observation that

stakeholder diversity can both enrich and complicate collaborative processes. However, this study adds value by highlighting the potential for grassroots initiatives and NGO-led programs to bridge these differences. The implication is that collaborative governance must create inclusive platforms for dialogue and decision-making, ensuring that all voices are heard and integrated into policy development.

The findings of this study have significant implications for the application of collaborative governance in waste management. First, they highlight the need for a holistic approach that addresses both structural and behavioral barriers to recycling. This includes investing in infrastructure, providing education and incentives, and fostering cultural change. Second, the study underscores the importance of integrating informal workers into formal systems, recognizing their contributions, and improving their working conditions. Third, the findings emphasize the need for clear policy frameworks and coordination mechanisms to align the efforts of multiple stakeholders. Finally, the study highlights the potential of grassroots initiatives and multi-stakeholder partnerships to drive innovation and sustainability in waste management.

This study contributes to the growing body of literature on collaborative governance by providing empirical evidence from a developing country context. While previous studies have focused on high-income countries (Emerson et al., 2012), this research sheds light on the unique challenges and opportunities in cities like Medan. It also advances the understanding of the informal sector's role in waste management, offering practical insights for integrating informal workers into formal systems. Additionally, the study highlights the importance of inclusive policy-making processes and multi-stakeholder collaboration in addressing complex urban challenges.

Conclusion

This study underscores the transformative potential of collaborative governance in addressing Medan City's plastic waste management challenges. The findings reveal that systemic barriers—such as low community participation due to insufficient education and infrastructure, the marginalized yet indispensable role of informal waste workers, and fragmented policy coordination—require holistic interventions rooted in multi-stakeholder collaboration. By integrating the informal sector into formal systems, enhancing community engagement through targeted incentives, and aligning policies across governance levels, Medan can transition toward a sustainable recycling framework. Concrete policy measures are critical to operationalize these insights. First, local governments should establish a multi-stakeholder coordination forum comprising representatives from the Medan City Environmental Agency, informal worker associations, recycling businesses, and community leaders. This platform would facilitate dialogue, resolve jurisdictional overlaps, and monitor policy implementation. Second, formal recognition and support for informal workers—through safety training, access to protective equipment, and microfinancing opportunities—are essential to harness their contributions while improving livelihoods. Third, community participation can be strengthened through city-wide educational campaigns on waste sorting and the introduction of incentive mechanisms, such as tax rebates for households that consistently recycle. Lastly, addressing infrastructure gaps, including the expansion of waste sorting facilities and adoption of modern waste-to-energy technologies, must be prioritized to alleviate pressure on overburdened disposal sites. Future research should build on this study by examining the economic implications of integrating informal workers into formal recycling systems, particularly their impact on income stability and circular economy outcomes. Comparative studies across Indonesian cities with similar urbanization challenges could further elucidate context-specific strategies for collaborative governance. Additionally, longitudinal assessments of incentive-based

programs would provide valuable insights into their long-term efficacy in sustaining behavioral change. By adopting these recommendations, Medan City can serve as a pioneering model for urban waste management in Indonesia, demonstrating how collaborative governance bridges institutional divides, empowers marginalized actors, and fosters environmental sustainability.

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There is no conflict of interest relating to the research.

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