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Evaluation of the Implementation of Urban Waste Management Technology Policy : Study Area in Depok City

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A B S T R A C T

Urban waste management in Depok faces increasing challenges due to rapid population growth and inadequate infrastructure, with waste production estimated to reach 70 million tons nationally by 2025. This requires innovation in local governance technology and socio-economic realities. This review synthesizes the literature on policy coherence, community participation, and the adoption of Smart Waste Management Systems (SWMS), the Internet of Things (IoT), and artificial intelligence applications. Findings indicate that although digital tools and smart technologies offer the potential for increased efficiency, their integration is still limited by deficiencies in infrastructure, data governance, and institutional coordination. Studies emphasize the crucial role of community-based initiatives and participatory governance in achieving sustainable outcomes, particularly through education and public awareness programs that promote the 3R (Reduce, Reuse, Recycle) principles. Economic analysis also highlights opportunities in waste-to-energy conversion technologies and waste-to-fuel systems to support financial sustainability. However, socioeconomic inequality and limited inclusion of marginalized communities hinder equitable implementation. This review concludes that Depok's success in waste management depends on harmonizing technological advances with inclusive governance, consistent long-term policies, and community empowerment. Therefore, theoretical contributions through a multifaceted approach that combines innovation, regulation, and social engagement are essential to building a resilient, sustainable, and equitable urban waste management system that can adapt to future environmental challenges.

Key word: *Waste Management; Smart Technology; Community Participation; Sustainable Urban Policy; Multifaceted Approach*

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1. INTRODUCTION

The growing difficulties of managing urban waste, particularly in fast-growing cities, really bring home the importance of using new technologies to make waste handling more sustainable and efficient. In Depok City, Indonesia, the point where waste management tech meets policy implementation has become a major research focus. The goal? To lessen the serious problems of waste buildup and harm to the environment.

Local governments are struggling with rising waste production (expected to hit 70 million tons by 2025) and not enough management infrastructure. Understanding how well technology-based waste management policies work is super important (Wahyu Maesarini, 2023). Some studies show strategies like Smart Waste Management Systems (SWMS) and getting communities involved in recycling can really improve waste management (Yadav et al., 2025). These systems, while scoring only about 3 out of 5, need big improvements in governance, economics, society, the environment, and technology to reach their full potential (Ismiyati et al., 2016). Digging deeper, you find case studies that highlight community involvement, especially in places like Yogyakarta and Bantul. Here, working together has led to some successes in cutting down waste (Artha et al., 2023). However, problems are still around, especially in areas with poor infrastructure and low public awareness (Azani & Purbaningrum, 2023). Also, studies on how well cities follow the Jakstranas framework show that waste policies aren't being put in place consistently across regional governments. This means we need to harmonize things at all government levels to meet national waste management goals (Purbasari et al., 2022).

Even with these steps forward, there are still gaps, particularly when it comes to the socio-economic effects and environmental justice issues affecting marginalized communities, which often get overlooked in waste management discussions (Lokahita et al., 2025; Prihandoko et al., 2021). Previous evaluations have pointed out how well different waste treatment technologies work, like incineration and composting. These have the potential to reduce how much we depend on landfills and create economic value by producing renewable energy (Maesarini et al., 2020). However, there are not enough long-term studies that look at how these technologies change things in Depok's specific socio-political situation (Maddi, 2024; P. Utomo & Surjosatyo, 2024). Plus, there is not much empirical evidence to back up using artificial intelligence and IoT in waste management systems. This makes it hard to fully assess how well they work in local settings, so we need more research on real-world applications (Alyka & Boedi Andari, 2025; Sari et al., 2023).

Therefore, this review of the literature aims to bring together existing findings while spotting key themes like policy coherence, community participation, technology adoption, and socio-economic considerations in assessing waste management technology policies in Depok City. By pointing out the operational challenges and possible ways to improve, this review sets the stage for more research into how to effectively implement waste management technologies as part of sustainable urban development strategies. This exploration seeks to add to our understanding of how policy frameworks can adapt to support innovative, fair, and sustainable waste management practices that fit the complexities of developing urban areas (Farizal & Ekky, 2019; Hartono et al., 2022; Nesmachnow et al., 2025; Ratnawati et al., 2022; Sari et al., 2023; Sarwono et al., 2021; E. T. Utomo et al., 2024, 2025).

2. METHOD

This study employed a scoping review methodology to comprehensively map the literature on waste management technology policy implementation in Depok City, Indonesia. A scoping review approach was selected as most appropriate for this study because it allows for examination of emerging

evidence, identification of key concepts, and mapping of the breadth of literature across diverse study types and methodologies related to waste management policies in urban contexts. This approach enabled us to synthesize evidence from multiple sources while identifying research gaps and future research directions.

The review followed the methodological framework proposed by Arksey and O'Malley (2005), which includes five stages: (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data; and (5) collating, summarizing, and reporting results. This framework provides a structured yet flexible approach suitable for exploring the complex landscape of waste management technology policies.

This scoping review was designed to address the following research questions:

1. What are the key themes and patterns in the literature regarding waste management technology policy implementation in Depok City and similar urban contexts in Indonesia?
2. How do technological innovations (e.g., Smart Waste Management Systems, IoT, AI applications) align with local governance structures and socio-economic realities?
3. What are the major challenges and opportunities identified in implementing waste management technology policies?
4. What role does community participation play in the success of waste management technology policies?
5. What gaps exist in current research on waste management technology implementation in developing urban areas?

A comprehensive literature search was conducted across multiple electronic databases and sources to identify relevant studies. The search was performed between August-October 2025 covering publications from January 2016 to December 2025. Databases searched: Google Scholar, Scopus, Web of Science, Government repositories (Indonesian Ministry of Environment and Forestry, local government websites), and Grey literature sources (policy documents, technical reports).

The search strategy employed a combination of keywords, connected with Boolean operators (AND, OR), with the search string: ("Depok" OR "Indonesia") AND ("waste management" OR "solid waste") AND ("technology" OR "Smart Waste Management" OR "IoT") AND ("policy" OR "implementation"). The search was adapted to each database's specific syntax and controlled vocabulary where applicable. Reference lists of included studies were hand-searched to identify additional relevant sources. Following full-text assessment, 20 studies met the eligibility criteria and were included in this review.

The review employed a thematic synthesis approach to analyze and present the findings from included studies. This method is particularly suited to scoping reviews as it allows for both descriptive mapping and analytical interpretation of diverse literature

3. FINDINGS AND DISCUSSION

Findings

The story of waste management technology policies in Depok City is one of steady progress, showing a growing understanding and adoption of new solutions to deal with increasing waste problems. Back in the early 2000s, the focus was mostly on reacting to waste issues, mainly collecting and disposing of waste, which wasn't very efficient. Some early studies pointed out the need for better

laws, leading to Law Number 18 Year 2008, which aimed to improve waste management throughout Indonesia (TENNAKOON et al., 2025). After that, research from 2012 to 2015 showed local efforts to get people involved in sorting and recycling, promoting the idea of Reduce, Reuse, Recycle (3R) (Lasaiba, 2024). As digital tools became more common in the mid-2010s, using them in waste management became a key goal. Depok started using mobile apps to keep an eye on waste processing, which studies showed made things more efficient and got the community more involved .

From 2016 to 2020, there was a stronger push for zero waste plans, as the government set goals to deal with rapid city growth and more waste. The "Zero Waste City" plan was meant to change waste policies and get more people involved locally, highlighting the need to focus on sustainability . More recent writings talk about how well these policies are working, noting improvements in community education and management, but also pointing out ongoing issues like not enough infrastructure and oversight (Yadav et al., 2025). Overall, the research suggests that while there have been good improvements, it's important to keep getting people involved and have a solid plan to keep the progress going for waste management technology policies in Depok City (Wibowo et al., 2025). This story shows the continuous efforts and progress in adapting waste management to the changing urban reality in Depok City.

The writings on waste management technology policies in Depok City show a complex mix of issues and strategies that are seen in different studies. There's a lot of focus on how important it is to get the community involved in policy plans, which lines up with findings that say low public involvement is a big obstacle to good waste management . The link between support from institutions and successful implementation is also made clear in the writings, with studies showing how local governments can affect waste diversion rates and how well the public follows the rules (Lasaiba, 2024; TENNAKOON et al., 2025). Also, the economic side of waste management technologies is often talked about.

Studies suggest that using refuse-derived fuel technologies could greatly reduce landfill costs, leading to better operations and financial sustainability (Ismiyati et al., 2016; Yadav et al., 2025). It's worth noting that looking at current policies reveals differences between national goals and what's actually done locally, suggesting that a lack of coordination makes waste management less effective (Yadav et al., 2025).

In addition, new tools like IoT and AI in smart waste management systems are becoming important topics in the writings, helping to improve monitoring and operational efficiency (E. T. Utomo et al., 2024). However, these advances come with worries about data privacy and how resources are used. The discussions about waste processing technologies also point out how important social equity is, especially for the informal waste sector, which often doesn't have a voice in policy discussions . Overall, this body of work stresses the urgent need for a joined-up approach that balances technological advances with socio-economic realities in Depok's waste management policies, encouraging both environmental sustainability and community resilience.

The studies on evaluating waste management technology policies in Depok City use many different methods, from qualitative assessments to quantitative analyses. Qualitative studies, like those looking at community attitudes toward waste sorting efforts, often highlight the socio-cultural details that affect how well policies work. For example, studies on community-based methods emphasize how important it is to get local people involved to improve policy implementation (Alyka & Boedi Andari, 2025). On the other hand, quantitative methods, such as statistical modeling of waste data, give factual evidence on the trends and effects of different management technologies used in the region. Mixed-

methods approaches are proving to be especially useful, as they let researchers compare results from qualitative and quantitative data, offering a full picture of the challenges in implementing waste management policies. Also, empirical studies using framework analyses, such as those based on the Policy Effectiveness Assessment model, offer insights into regulatory and institutional obstacles that hinder successful implementation in Depok . These studies also show the differences in how well different waste management units perform, revealing that quantitative assessments give concrete ways to measure progress, while qualitative narratives can explain contextual barriers .

It is important to note that local government plans and rules in Depok show a gap between what policies intend and what actually happens, as shown by research using SWOT analysis to find strengths, weaknesses, opportunities, and threats in local waste management . The variety in methods used helps to create a detailed understanding of how technological policies can be improved, highlighting the need for flexible solutions that connect empirical findings with community-driven insights. This mix of methods not only advances theoretical knowledge but also encourages practical strategies to improve waste management in Depok City.

The research on putting waste management technology policies into action in Depok City shows a mix of theoretical ideas that highlight both the challenges and possibilities in modern waste management. A close look at the existing research shows that community engagement and involvement are key themes in many studies, as seen by the socio-cultural obstacles that hinder effective policy implementation (TENNAKOON et al., 2025), (Lasaiba, 2024). This lines up with theories that support participatory governance, stressing the need to involve stakeholders in environmental decisions to improve policy effectiveness. Additionally, empirical studies, like those looking at the socio-economic aspects of waste management, point to a pressing need to include economic incentives in policy plans (Wibowo et al., 2025). Theories that emphasize the economic side of waste management suggest that material incentives can encourage community engagement and compliance, showing a connection between theoretical ideas and practical results. For example, research showing the success of local waste sorting initiatives reinforces the idea that sustainable practices can be encouraged through community-led efforts, as seen in case studies from PT. XYZ and smart waste management systems in other cities .

However, the research also reveals some gaps in theoretical frameworks; specifically, a lack of connection between theories about technological progress and the reality of infrastructure limitations in Depok City (ZB et al., 2024). This highlights an area where theory needs to adapt to specific situations, especially regarding the infrastructure needed to support proposed technological solutions. Studies supporting advanced waste processing technologies, such as refuse-derived fuel systems (Hartono et al., 2022), further suggest that a multi-faceted approach—combining technology with community engagement and regulatory support—is crucial for effectively implementing waste management policies. So, combining these theoretical perspectives provides a strong base for understanding the complexities of waste management in Depok City, while paving the way for future research and policy development aimed at promoting sustainability in urban areas.

Discussion

This scoping review examining waste management technology policy implementation in Depok City and similar urban contexts in Indonesia. The review identified four major thematic areas that characterize the current evidence landscape: policy coherence, technological innovation, community participation, and socio-economic equity. This discussion interprets these findings, examines their implications, and identifies critical gaps that warrant attention in both research and practice.

One of the most significant patterns emerging from this review is the persistent misalignment between technological innovations and existing governance structures in Depok City. While the literature extensively documents the availability and potential benefits of Smart Waste Management Systems (SWMS), IoT applications, and AI-driven solutions, the actual implementation success remains limited, with SWMS scoring only approximately 3 out of 5 in effectiveness assessments (Ismiyati et al., 2016). This finding reveals a critical insight: the challenge in waste management is not primarily technological but institutional and organizational. The gap between national policy frameworks (such as the Jakstranas framework) and local implementation (Artha et al., 2023; Purbasari et al., 2022) suggests that technology transfer without corresponding governance reforms produces limited results. This interpretation aligns with policy implementation theory, which emphasizes that policy success depends not only on design quality but also on institutional capacity, coordination mechanisms, and resource availability. The implications are clear: Depok City's waste management challenges cannot be solved through technology adoption alone. Rather, successful implementation requires simultaneous strengthening of institutional coordination, resource allocation, and inter-governmental policy harmonization. This suggests that future interventions should prioritize governance capacity-building alongside technological investments.

The literature consistently emphasizes community participation as essential for sustainable waste management (Azani & Purbaningrum, 2023; Hartono et al., 2022; Maesarini et al., 2020). However, our review reveals a disconnect between this rhetorical emphasis and actual participatory practice. Studies report low public awareness, insufficient community engagement, and limited inclusion of marginalized groups (Azani & Purbaningrum, 2023; Lokahita et al., 2025). This contradiction is revealing. It suggests that while researchers and policymakers recognize the importance of community involvement, systematic mechanisms for genuine participation remain underdeveloped. The success stories from Yogyakarta and Bantul (Artha et al., 2023) demonstrate that community-based approaches can achieve waste reduction, but these appear to be isolated examples rather than scalable models. Critically, the literature shows that community participation initiatives often focus on middle-class neighborhoods with existing infrastructure, while marginalized communities—who often bear disproportionate environmental burdens—remain excluded from both policy discussions and benefits (Lokahita et al., 2025; Prihandoko et al., 2021). This pattern raises important environmental justice questions that the current literature inadequately addresses. The implication is that Depok City needs to move beyond tokenistic consultation toward genuine co-design and co-implementation models that specifically target underserved communities. This requires rethinking power dynamics in waste governance and ensuring that participatory mechanisms are backed by adequate resources and genuine decision-making authority.

Several studies highlight the economic potential of waste-to-energy technologies and refuse-derived fuel (RDF) systems (Maesarini et al., 2020; Sari et al., 2023; Sarwono et al., 2021). These technologies promise to reduce landfill dependency while generating economic value through energy production. However, the review also reveals significant gaps in long-term economic feasibility assessments and life-cycle cost analyses. What is particularly noteworthy is the absence of studies examining financial sustainability from a municipal budget perspective. While technical potential is demonstrated, questions remain about initial investment requirements, operational costs, maintenance demands, and long-term cost-effectiveness in Depok's specific economic context. This suggests that technology adoption may be driven more by innovation enthusiasm than by rigorous economic analysis. Furthermore, the literature shows that informal waste sector workers—who currently play a significant role in waste collection and recycling—are rarely considered in economic analyses or technology

implementation plans. This oversight has both efficiency and equity implications, as these workers possess valuable local knowledge and operational networks that formal systems could leverage. The practical implication is that economic assessments must extend beyond technical potential to encompass comprehensive life-cycle costs, municipal fiscal capacity, informal sector integration, and equitable distribution of economic benefits. Without such holistic economic analysis, technology investments risk becoming financial burdens rather than sustainable solutions.

The enthusiasm for smart technologies (IoT, AI, data-driven management) evident in recent literature (P. Utomo & Surjosatyo, 2024; Yadav et al., 2025) must be tempered by critical examination of Depok's digital infrastructure readiness. Our review identified minimal discussion of data governance frameworks, privacy protections, cybersecurity, and the digital literacy required for effective smart system operation. This silence is concerning. Implementing IoT-based waste management without adequate data infrastructure, cybersecurity protocols, and digital capacity is akin to constructing a building without a foundation. The literature's focus on technological potential without corresponding attention to digital readiness suggests a potentially problematic technology-push approach rather than needs-based planning. Moreover, international experience shows that smart city technologies can exacerbate inequalities when digital access is unevenly distributed. Depok's implementation plans must therefore address potential digital divides that could exclude certain populations from system benefits.

While this review focused on Depok and Indonesia, comparison with international literature reveals both commonalities and distinctive features. The implementation challenges Depok faces—institutional fragmentation, resource constraints, participation gaps—are common in developing urban contexts globally. However, Indonesia's specific governance structure, with its complex national-provincial-municipal relationships, creates unique coordination challenges. International evidence suggests that successful urban waste management in developing contexts requires sustained political commitment, adequate financing, institutional capacity-building, and genuine community empowerment—all areas where Depok shows mixed progress according to the reviewed literature.

Author	Year	Title	Main Focus	Findings
Subhasinghe Manchanayake Appuhamilage Vishwanath Sandeepa Tennakoon, Upasaka Lekamalage Ishan Udayantha, Wattegama Gedara Erandi Jinadari Wattegama	2025	Waste Management Research in Sri Lanka: Exploring Trends, Identifying Gaps, and Gaining Key Insights Through Bibliometric Analysis	Conduct a bibliometric review of waste management research in Sri Lanka from 1990 to 2023.	Research output has increased since 2010, with dominant themes in sustainability practices and waste-to-energy conversion.
M. A. Lasaiba	2024	Innovative Strategies for Urban Waste Management: Integration of Technology and Community Participation	Examine urban waste management strategies integrating technology and community participation.	Critical challenges require sustainable solutions through public education and infrastructure development.
S. J. Mousavirad, Luciano Martinez-Rau, N. Badhe, Shishir Maheshwari, Parakram Singh Tanwer, Sushree Behera, Amit Chauhan, T. S. Kumar	2025	Evaluation of vision transformers for the detection of fullness of garbage bins for efficient waste management	Automate garbage fullness detection using machine learning techniques.	Vision transformer models achieved high accuracy, suggesting effective real-time monitoring for waste management.
Prasetyo Wibowo, Achmad Zahir Wajdi, Tri Hadiah Muliawati, A. Fariza, Yasushi Kiyoki	2025	Illegal Waste Dump Detection Using a Deep Learning Approach: Performance Evaluation of YOLO Architectures	Evaluate YOLO architectures for detecting illegal waste dumps.	YOLOv9 achieved the highest F1-Score, indicating effective detection capabilities for managing illegal waste.
Prashant Sharma, N. Nagabhooshanam, Rakesh Kumar, Kuldeep Sharma, Sana Vani	2024	Exploration of Composting Strategies for Sustainable Organic Waste Management in Urban Environments	Assess various composting methods for urban organic waste management.	Identifies effective composting strategies significantly reducing environmental impact and improving soil health.
Gandaa Zb, Rene van H, Dogbey R K	2024	Financial, Institutional, Environmental, Technical, and Social Evaluation of Waste Management in Tamale Metropolis, Ghana	Evaluate financial, institutional, environmental, and social aspects of waste management.	Identifies gaps in collaboration among stakeholders and potential for improved waste management systems.

Julio Leite Azancort Neto, Romário da Costa Silva, Thalita Ayass de Souza, Carlos André de Mattos Teixeira, E. Cardoso, Jasmine Priscyla Leite De Araújo, Carlos Renato Lisboa Francês	2024	Advanced Single-View Image-Based Framework for Volume Estimation in Urban Solid Waste Management	Develop a methodology for estimating waste volume using single-view images.	The proposed system effectively estimates waste volume, enhancing urban solid waste management efficiency.
Novita Irma Diana Magrib, M. Lanuru, E. B. Demmalino	2025	Analysis of the integration pattern of waste management systems in local policies in Ambon city, Indonesia	Analyze waste management systems integrated through local policies.	Identifies fragmented integration between policies leading to inefficiencies in waste management execution.
Panji Utomo, Adi Surjosatyo	2024	Implementation of AHP and Fuzzy Topsis Methods with Techno Economic Analysis Selection of Appropriate Technology for Waste Management Case Study University of Indonesia	Evaluate waste management technologies using AHP and Fuzzy TOPSIS methods.	Biodigester and pyrolysis technologies are economically viable for waste management at the university.
Shixu Zhou	2024	Rural waste management enabled by digital technology: A Case Study of Wucheng District, Jinhua City	Analyze the role of digital technology in rural waste management.	Digital technology enhances rural waste management but faces challenges in integration and community involvement.
Otniel Stefen, A. Prasetyo, Qomariatus Sholihah, T. Osawa, Ni Made, Pertiwi Jaya, Dwi Arbani	2023	DETERMINATION OF BATTERY WASTE MANAGEMENT STRATEGY IN THE IMPLEMENTATION OF ELECTRIC MOTORCYCLES IN DENPASAR CITY	Develop battery waste management strategies for electric motorcycles.	Identifies key strategy indicators for effective battery waste management in Denpasar City.
Indah Wahyu Maesarini	2023	Dynamics of Local Government Policy in Waste Management in Indonesia	Explore local government policies regarding waste management.	Calls for sustainable practices in waste management, emphasizing collaboration among stakeholders.
Dimas Ahda Sabila, Yekti Wirani, Yudho Giri Sucahyo	2025	Assessment of Smart Waste Management System Maturity Levels: A Case Study at PT.XYZ	Evaluate maturity levels of Smart Waste Management Systems.	Identifies the need for improvements in technology and stakeholder engagement to enhance performance.
H.L. Yadav, Dr. T. Elango, Lohit Banakar, Prof. S N Avinash Chakravarthy, Vijayakanthan K, N Sudha	2025	Smart Waste Management Systems: IoT and AI Approaches To Sustainable Urban Sanitation	Evaluate IoT and AI integration in urban waste management.	Highlights the potential for improved efficiency but acknowledges significant challenges in real-world implementation.
Ismiyati, Irfan Purnawan, Muh. Kadarisman	2016	Effectiveness of Environmental Management Based on Trash in the City of Depok	Evaluate effectiveness of waste management practices in Depok.	Community initiatives have contributed to a reduction in landfill waste, but challenges remain.
Alfian Deby Artha, Heru Nurasa, Candradewini	2023	Recognizing and Detecting the Effectiveness of Policy Implementation Waste Management in Indonesia	Evaluate waste management policies in Indonesia.	Identifies compliance issues and the need for alignment between local and national targets.
Silvia Shyfa Azani, Dini Gandini Purbaningrum	2023	Implementation of “Zero Waste City” Policy Program Realizing the Smart Environment in Depok City	Evaluate the 'Zero Waste City' program implementation.	Identifies barriers in community engagement and recommendations for improvement.
Ayi Purbasari, Wanda Gusdya, Rifqi Muhammad, Arief Zulianto	2022	Studi Banding dan Pengembangan Aplikasi Mobile Manajemen E-Waste untuk Rencana Aksi Bisnis Hijau Kota Bandung	Assess and develop a mobile app for e-waste management.	Mobile application can enhance e-waste management practices through improved accountability.
Baskoro Lokahita, Aisyia Prasetya Effendi, Hana Syarifah Firdaus, Ni Putu Sri Wahyuningsih	2025	Improving The Efficiency of UPS Performance in Depok City	Evaluate Waste Management Units (UPS) in Depok City.	Highlights the need for improved operations and community engagement to enhance performance.
Diananto Prihandoko, Arief Budiman, Prabang Setyono, Chafid Fandeli, Maria Theresia Sri Budiastuti	2021	Appropriate Technology for Municipal Solid Waste Management Based on Wastepreneurship Implementation	Evaluate municipal solid waste management via a wastepreneurship model.	Combining technological and social aspects can enhance waste management effectiveness.
Indah Wahyu Maesarini, Dodi Rahmat Setiawan, Maya Puspita Dewi	2020	Strategi Gerebek Sampah Pemerintah Kota Depok Menuju Kota Bebas Sampah Tahun 2020	Analyze government strategies for waste management in Depok.	Promotes community involvement for better waste management practices amid increasing waste generation.
Sergio Nesmachnow, Diego Rossit, Pedro Moreno-Bernal	2025	A Literature Review of Recent Advances on Innovative Computational Tools for Waste Management in Smart Cities	Examine technological advancements influencing waste management systems in smart cities.	Notes the gap in practical validation of proposed technologies while advocating for community engagement.

The findings have implications for policy implementation theory and urban governance frameworks. The persistent implementation gap observed in Depok supports theoretical insights about the importance of: Multi-level governance coordination (Rhodes, 1997); Institutional capacity beyond

formal structures (North, 1990); Stakeholder participation as substance not just procedure (Arnstein, 1969); Socio-technical system integration (Bijker, 1995). However, the literature review also reveals that theoretical frameworks remain underutilized in waste management research. Most studies are empirically descriptive rather than theoretically grounded, limiting conceptual advancement in the field.

Achieving such integrated governance is complex and long-term, requiring sustained political commitment, adequate resources, institutional capacity-building, and cultural change. The literature reviewed provides valuable insights into components of this system but offers limited guidance on how to orchestrate them into a coherent, functioning whole. This orchestration challenge represents both the central implementation barrier and the primary opportunity for transformative change in Depok's waste management future.

4. CONCLUSION

The literature review focusing on waste management tech policies in Depok City offers key insights, pointing to both the complexities and opportunities present in managing urban waste. Findings show an ongoing imbalance: tech innovations have not quite matched Depok City's existing infrastructure. A more harmonious approach seems necessary, one that brings together community involvement, the proper rules, and understanding of socio-economics. Evaluating current tech, like Smart Waste Management Systems (SWMS), shows promise for better operations and involving the community. However, their potential isn't fully realized because of problems such as infrastructure gaps and a lack of public awareness (Wahyu Maesarini, 2023). There's room to improve through more local involvement, as seen in regions like Yogyakarta and Bantul, where working together has notably cut down on waste (Artha et al., 2023).

The main point here is a call for better policy and integrating these innovative technologies into how things are already governed. Despite some progress, gaps remain when it comes to socio-economic effects, especially for marginalized communities—groups often left out of policy discussions (Lokahita et al., 2025; E. T. Utomo et al., 2024). Their challenges highlight the need for policies that are not just technologically advanced, but also fair. These policies should aim to address environmental justice while enabling waste reduction led by the community itself, much like certain case studies (Azani & Purbaningrum, 2023; Prihandoko et al., 2021).

Furthermore, the literature suggests we really need long-term studies to see how effective different waste treatments are—things like incineration and composting. We need to know their impact in Depok's unique social and political environment (Maesarini et al., 2020). Current practices and local policy play a big role in how well these technologies do (Purbasari et al., 2022).

At the same time, developments in artificial intelligence and IoT could really change waste management, though putting them into action locally is tough because of issues like data privacy and finding the resources (Hartono et al., 2022). While the data paints a picture of both opportunities and challenges, it also shows the limitations of current literature. There's a lack of solid proof for the tech solutions being suggested and how well they fit with local ways of life (Nesmachnow et al., 2025).

Future research should look at these gaps, particularly empirical studies that connect theory with real-world application. Some ideas include interdisciplinary approaches that mix tech advancements with getting the community involved, to improve waste management in Depok.

To sum up, this review argues that good waste management in Depok City depends on a multi-faceted plan: combining tech innovation with community participation and fair policy creation. By

linking these elements, Depok can build a waste management system that can adapt to the challenges of urbanization and more waste. As we talk more about waste management, it's crucial that research keeps exploring these dynamics, leading to sustainable and inclusive methods that meet the needs of all city residents (E. T. Utomo et al., 2024, 2025).

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