

Challenges, Policy Implications, and Resilience of Waste Bank: Analysis of Multi Stakeholders' Perception using Content Analysis

Marini Ambo Wellang^{1*}, Hasniar Ambo Radde², Toru Matsumoto¹

¹Graduate School of Environmental Engineering, The University of Kitakyushu, Kitakyushu, 808-0135, Japan, ²Royal Heights 201, 1-12-8, Oura Chome. Yahatanishi-ku, Kitakyushu-shi, Fukuoka-ken, Japan. *Corresponding Author's Email: m.mallagennie@gmail.com

Abstract

The effectiveness and sustainability of Waste Banks are contingent upon collaborative efforts from diverse stakeholders, encompassing individuals, community organizations, local governmental bodies, and private sector entities. This research employs a qualitative approach to investigate the challenges, policy implications, and resilience of Waste Banks through an analysis of multi-stakeholder perceptions. Conducted in Makassar City, Indonesia, the study engaged 16 stakeholders from governmental, academic, non-governmental, and private sectors. Data were gathered via open-ended questionnaires and comprehensive interviews with representatives from each stakeholder group, subsequently analysed through content analysis. The findings revealed four prevalent themes: impediments to waste bank implementation, coordination deficits, opportunities for enhancement, and the resilience of waste bank units. Key challenges include limited community involvement, inadequate resources and infrastructure, market instability, deficits in knowledge and awareness, and geographical logistical constraints. Coordination issues encompass fragmented authority and accountability, communication breakdowns, policy discrepancies, constrained cross-sectoral collaboration, and disparities between informal and formal sector practices. Potential improvements involve upgrading facilities, establishing integrated stakeholder platforms, implementing community education and engagement initiatives, and harmonizing policies. Factors contributing to waste bank unit resilience include diversified waste streams and revenue sources, strong community integration, a supportive policy framework, and advancements in technical capacity and innovation. This study offers significant insights for waste bank administrators, regional, provincial, and municipal governments, NGOs, the private sector, and other entities involved in community-based waste management, particularly government bodies directly responsible for waste bank and waste management regulations.

Keywords: Content Analysis, Multi-stakeholders' Perceptions, Waste Bank, Waste Bank Management.

Introduction

The volume and diversity of waste generated annually are escalating due to population expansion and increasingly complex human requirements, particularly in urban environments. Current global production of municipal solid waste is approximately 1.2 billion tons per year, comprising a 47% significant proportion of food and green waste, 16% paper waste, 11% plastics, 4% glass, 3% metals, and 19% other materials (1). Projections indicate a potential rise to 3.8 billion tons of MSW by 2050 if effective waste reduction strategies are not implemented (1). Inadequate waste management poses a multifaceted, trans boundary challenge, leading to the pollution of surface and subsurface water resources, terrestrial ecosystems, including livestock and agricultural land, and atmospheric quality (1). Pollution

accumulation poses a threat to the ecological equilibrium that supports human life. This ultimately endangers the continued existence of humanity across generations by undermining economic prosperity and human welfare, as well as posing health risks. Globally, it is predicted that between 400,000 and 1 million deaths may occur as a result of inadequate waste management (1). Municipal solid waste management presents a significant challenge for cities around the world, including Indonesia. By 2024, the total waste generated across 290 districts and cities in Indonesia reached 31.9 million tons, with 35.67% (11.3 million tons) remaining unmanaged (2). The volume of urban waste in Indonesia, including in Makassar City, is on the rise, influenced by population growth and constraints in waste

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disposal and management infrastructure. Located on the island of Sulawesi in eastern Indonesia, Makassar City is the largest city and ranks as the eighth largest in Indonesia, producing 1032 tons of waste daily (2). All waste is transported to a single landfill, which has been operating for 32 years and is now over capacity (3). The collected waste is essentially thrown in landfills with no effective waste management, while the rubbish that is not collected ends up in vacant lots, drainage channels, highways, and residential areas (4). Municipal solid waste management poses a considerable challenge for the city government due to the increasing volume of waste. Meanwhile, waste management contributed approximately 3.2% of greenhouse gas emissions in 2016, equivalent to 1.6 billion CO₂ (5). Therefore, a robust waste management system is necessary to minimize the adverse effects of climate change. One such system is the implementation of waste banks, which were introduced in Indonesia by the Ministry of Environment and Forestry.

A waste bank functions as a financial and waste management institution, strategically selecting and collecting waste materials to enhance recycling and reuse efforts, thereby attributing economic value to discarded items. The operational basis of waste banks involves the separation of waste into organic and non-organic streams. Organic waste is either appropriately disposed of or repurposed for applications such as composting, while non-organic waste is processed within the waste bank system. Non-organic waste received by the waste bank is quantified by weight, and a corresponding monetary compensation is provided to the waste depositor, reflecting the economic valuation of the waste. The waste bank then facilitates the sale of the collected non-organic waste to waste collectors or directly supplies it to industries with specific material needs.

The existence of waste banks in Indonesia has been outlined in national regulations through the regulation of the Minister of Environment and Forestry number 14 of 2021 concerning waste management in waste banks (6). This regulation aims to establish comprehensive and integrated waste management practices, encompassing a circular economy approach from various stakeholders, including the central and local governments, as well as the community. The

intended outcomes are economic, health, and environmental benefits for society. Technically, the regulation emphasizes collaborative partnerships among communities, business entities, and local governments, facilitated through guidance and development initiatives by local authorities, based on the principles of mutual need, reinforcement, and advantage.

Waste bank management represents an innovative strategy that prioritizes the engagement of governmental bodies and diverse societal actors, alongside the principles of a circular economy. Within Indonesia, the proper administration of waste management through waste banks is imperative, supported by regulations that provide a robust framework for their operation. As of 2022, Indonesia has established approximately 149 parent waste banks and 15,113 waste bank units across its 34 provinces and 336 districts/cities; these numbers are projected to increase to 315 parent waste banks and 20,236 units by 2025 (7). The presence of waste banks contributed to a 2.7% decrease in the volume of waste directed to landfills nationwide in 2021 (6). While this reduction is modest, it inspires optimism for future growth. To optimize waste bank management, further research is needed, particularly concerning the roles of stakeholders involved in waste bank management.

The effectiveness of waste bank management can be critically examined through the theoretical frameworks of participatory governance, social-ecological systems, and institutional resilience. The synthesis of these three perspectives fosters a model of waste bank management that is inclusive, adaptable, and sustainable, thereby facilitating both efficient waste management and community empowerment. From the participatory governance standpoint, the success of waste banks is fundamentally linked to the active engagement of community members and the collaborative efforts among diverse stakeholders throughout decision-making and program execution processes (8, 9). This framework emphasizes the essential roles of transparency, accountability, and cooperative governance in reinforcing the legitimacy and operational efficacy of community-based waste management initiatives. Furthermore, active community participation is instrumental in developing adaptive and sustainable solutions that bolster the resilience of waste management

systems facing dynamic social and environmental challenges (10).

Corroborating the participatory governance perspective, the social-ecological systems theory conceptualizes waste banks as intricate systems composed of interdependent social and ecological components. This approach necessitates ongoing adaptation and learning by community members as integral parts of their physical environments and the implementation of resource management mechanisms responsive to evolving socio-environmental conditions (11, 12). Concurrently, from an institutional resilience perspective, the sustainability of waste bank programs is contingent upon the institutional capacity for adaptation, innovation, and continuity in waste management functions amid fluctuating external and internal pressures (13). Hence, institutional strengthening through capacity building, enhanced funding, and the cultivation of multi-stakeholder networks has demonstrated significant potential in reinforcing both the effectiveness and the longevity of waste bank operations (14, 15).

The operational effectiveness and sustainability of waste banks are predicated on the engagement of diverse stakeholders, such as individuals, community organizations, local government, and the private sector (16). Collaboration and coordination among these entities are crucial for ensuring the enduring viability of the waste bank. In essence, a waste bank represents a community-driven waste management approach that empowers individuals to proactively steward their environment (11).

Given the importance of waste banks in sustainable waste management and the gap between the potential and reality of the implementation, this study undertakes a qualitative analysis of the challenges, policy implications, and resilience of waste banks through the perspectives of multiple stakeholders. This research is anticipated to yield comprehensive insights into the determinants of success and sustainability for waste banks, offering pertinent policy recommendations aimed at enhancing their efficacy. Numerous studies have underscored the critical role of stakeholders in advancing and enhancing the effectiveness of waste bank management across different regions

in Indonesia. Nonetheless, a review of the literature reveals a scarcity of qualitative investigations that specifically focus on stakeholder involvement within the context of Makassar City. Existing research has demonstrated that the resilience of waste bank organisations is largely contingent upon regulatory frameworks, availability of resources and facilities, as well as the extent of community participation. Furthermore, it has been argued that the management and governance of waste banks are supported by comprehensive and robust regulatory foundations specifically formulated for waste banks. This study employs a qualitative methodology to delve into the role of stakeholders in managing waste banks in Makassar City. Additionally, it aims to identify and analyse the factors that influence the sustainability of waste banks from the viewpoint of stakeholders. Lastly, the study seeks to elucidate the challenges impeding the implementation of waste bank programs despite the presence of strong regulatory mechanisms intended to support their operation. The study investigates the perceptions and experiences of diverse stakeholders, including waste bank managers, community members, local government, and representatives from the private sector. Adopting a qualitative approach, this research seeks to elucidate the intricacies and subtleties inherent in the implementation of waste banks.

Methodology

Research Approach

This study adopts a qualitative approach for the collection and analysis of data to thoroughly explore phenomena related to waste banks. Qualitative research is employed to gain comprehensive insights into the phenomena within their natural settings, ensuring that interpretations remain free from researcher-induced manipulations (17, 18). The data gathered are predominantly descriptive and originate from diverse sources, including verbal narratives, field notes, documentary evidence, photographs, and audio-visual recordings. Subsequent interpretative analysis is conducted in accordance with the contextual framework of the data, enabling the extraction of meaningful findings and conclusive interpretations from the study.

Research Participant and Data Collection

This study was carried out in Makassar City, Indonesia. Data for this study were collected using multiple methods, including the distribution of open-ended questionnaires, interviews, direct observations, and document analysis. The open-ended questionnaires were specifically designed to capture free responses from participants regarding waste bank management. In-depth interviews were conducted with representatives of relevant stakeholders to acquire comprehensive information about their activities, challenges, and interactions in managing the waste banks. Observations involved first-hand monitoring of the waste bank operations to provide an accurate depiction of their current status and management practices. Additionally, document analysis was performed by examining official documents from

the stakeholders to supplement and validate the data obtained from the field.

The data collection commenced with the identification of key stakeholders involved in the waste bank management in Makassar City, including the Makassar City Environment Office, Central Waste Bank, and Development Planning Agency. These entities were initially provided with open-ended questionnaires concerning various aspects of waste bank management. Upon completion, they were requested to identify additional stakeholders who had interacted with them in the waste bank management. Utilizing a snowball sampling technique, a total of 33 stakeholders were ultimately identified and categorized into six distinct groups. Subsequently, in-depth interviews were conducted with 16 stakeholders, who collectively represented all identified stakeholder groups. The list of these participants is presented in Table 1.

Table 1: Participants in In-Depth Interviews

No	Stakeholders	Category
1	P3E	Government: Regional Level
2	PEO	Government: Province Level
3	DPA	Government: City Level
4	CEO	Government: City Level
5	WOM	Government: City Level
6	PWO	Government: City Level
7	DV	Government: City Level
8	CWB	Government: City Level
9	WBU*	Waste Bank Community
10	MOI	Private Business (PB)
11	GC	Private Business (PB)
12	YES	NGO
13	YLM	NGO
14	YPN	NGO
15	CBO	NGO
16	HU	Educational Institutions

Note: *19 waste bank units interviewed were made into 1 entity: WBU

Data Analysis

The primary data obtained comprised interview transcripts, which were complemented by observational records and official documents serving as supporting evidence. The data were analysed using content analysis through a thematically, which involved several systematic steps:

- Organizing the data by categorizing and clustering information based on emerging themes and patterns from interviews, observations, and documents
- Performing data reduction by filtering out irrelevant information and focusing on data pertinent to the research objectives;

- Drawing conclusions through contextual interpretation to identify major themes and underlying patterns within the data;
- Data validation through triangulation, wherein ambiguous or unclear data were cross-verified with the original stakeholders to ensure reliability and credibility of the results.

Content analysis is used to analyse interview transcripts and responses to open-ended questions through questionnaires. This method allows for the identification of key themes related to coordination challenges, waste bank management, stakeholder interactions, potential operational improvements, and factors influencing the resilience of waste bank units. By systematically examining textual data, researchers

can discern recurring themes, patterns, and narratives that elucidate the underlying drivers of network structure and dynamics (19, 20). This approach provides valuable insights into the socio-political aspects of waste management networks, which are crucial for devising effective, sustainable resource management strategies (21).

Results

Analysis Summary of Stakeholder Interviews

Table 2 provides a content analysis summary, which presents the main issues derived from stakeholder interviews. The issues are categorized by stakeholder groups, showing the frequency and emphasis of the various themes.

Table 2: Content Analysis Summary of Key Issues from Stakeholder Interviews

Issue Category	Specific Issue	Stakeholder Groups Mentioning the Issue	Frequency*	Representative Quotes
Challenges in Waste Bank Implementation	Low community participation	WBU, MOI, CEO, CBO, DV	High	"Many customers explicitly disagree with recycling organic waste at home." --MOI
	Limited infrastructure	WBU, CEO, PWO, PEO	High	"We lack the basic infrastructure. The composting area is too small." --WBU
	Market instability	WBU, PB, CWB	Medium	"Sometimes the price drops so low that collection barely covers our operational costs." -- WBU
	Knowledge gaps	WBU, CBO, HU, CEO	High	"People see organic waste as 'just garbage' rather than a resource." -- NGO
	Geographic challenges	PWO, DV, WBU	Medium	"Collection is a major challenge in neighborhoods with narrow streets." -- PWO
Coordination Problems	Fragmented authority	PEO, WBU, DPA, CEO	High	"There is significant overlap in responsibilities between government departments." -- PEO
	Communication gaps	CBO, WBU, CWB, PB	High	"Each organization operates in its own silo." -- NGO
	Policy inconsistencies	DPA, PB, P3E, PEO	Medium	"Regional and city-level policies sometimes contradict each other." -- DPA
	Limited cross-sectoral collaboration	HU, WOM, CEO, CBO	Medium	"Waste management is treated purely as an environmental issue." -- HU

Potential Improvements	Informal-formal sector integration	YPN, GC, WBU, CEO	Low	"Informal collectors are rarely included in formal planning." - YPN
	Enhanced processing facilities	WBU, MOI, CEO, PB	High	"Maggot cultivation is a promising method for organic waste processing." -- MOI
	Integrated stakeholder platforms	CWB, DPA, CBO, WBU	High	"Regular stakeholder forums would significantly improve coordination." -- CWB
	Education programs	CBO, WBU, HU, WOM	High	"Comprehensive education programs in schools and communities..." -- NGO
	Policy harmonization	P3E, PEO, CEO, DPA	Medium	"A harmonized policy framework that delineates responsibilities..." -- P3E
Resilience Factors	Value-added products	PB, HU, WBU, MOI	Medium	"Developing high-quality compost products from organic waste..." -- PB
	Diversified waste streams	DPA, WBU, CWB, PB	High	"Waste banks that diversified their operations beyond basic recycling..." -- DPA
	Community embeddedness	YLM, DV, WBU, CBO	High	"The most resilient waste banks are those that have become true community institutions." -- YLM
	Supportive policy environment	CEO, WBU, P3E, DPA	Medium	"Supportive local regulations and active government engagement..." -- CEO
	Technical capacity	HU, WBU, MOI, CWB	Medium	"Waste banks that invest in technical training for their staff..." -- HU
	Effective leadership	YES, CWB, WBU, DPA	High	"Strong leadership is perhaps the most critical factor in waste bank resilience." -- YES

Note. *Frequency: High = mentioned by >75% of stakeholders in the relevant groups; Medium = mentioned by 40-75%; Low = mentioned by <40%

Stakeholders' Perception

The content analysis of interviews revealed key themes in stakeholders' perceptions of waste bank management, including challenges and obstacles in implementation, coordination problems, potential improvements, and waste bank unit resilience.

Challenges and Obstacles in Waste Bank Implementation

Stakeholders have identified five challenges in the implementation of waste banks. First, there is low community participation. This has been consistently noted as the most substantial impediment to waste bank success by various

stakeholders, including WBU, MOI, CEO, CBO, and DV, as evidenced by the following statements.

"The biggest challenge we face is convincing households to participate consistently. People are initially enthusiastic, but maintaining that commitment over time is difficult, especially for organic waste separation." -- WBU –

"Many customers explicitly disagree with recycling organic waste at home. They consider it messy, smelly, and inconvenient." -- MOI –

Secondly, waste bank operations are limited by inadequate infrastructure and resources. Deficiencies in facilities, equipment, and financial resources impede operations, especially in the processing of waste, as highlighted by WBU, CEO, PWO, and PEO. Here were two statements that indicated this:

"We want to expand our organic waste processing capacity, but lack the basic infrastructure. The composting area is too small, and we do not have proper equipment for efficient processing." -- WBU –

"The financial resources allocated for waste banks are insufficient, especially for organic waste management, which requires more complex handling systems." – CEO–

Third, market instability. Fluctuations in the prices of recycled materials introduce economic instability for waste bank operations, as noted by WBU, CEO, and CWB. The following statements illustrate this concern:

"The market prices for recyclables fluctuate significantly. Sometimes, the price drops so low that the collection barely covers our operational costs. This uncertainty makes planning difficult." --WBU—

"Unlike plastic or paper, the market for organic waste products like compost is less developed and more unpredictable." --CEO—

Fourth, gaps in knowledge and awareness exist. Community members demonstrate a limited understanding of appropriate waste sorting and recycling procedures. These statements were articulated by WBU, CBO, HU, and CEO. Here were two statements that indicated this:

"Many people still do not understand how to sort their waste properly. They mix organic and inorganic materials, which creates additional work for us and reduces efficiency." -- WBU—

"There is a significant knowledge gap about the value of organic waste. People see it as 'just garbage' rather than a resource that can be converted into valuable products." --CBO--

Fifth, geographic and logistical obstacles pose significant challenges, particularly in regions with constrained accessibility, as highlighted by PWO, DV, and WBU. The subsequent statements corroborate this issue:

"Collection is a major challenge in some neighbourhoods with narrow streets. Our vehicles cannot access these areas easily, which limits our ability to collect waste regularly." -- PWO—

"The distance between households and waste banks is too great in some areas, making it inconvenient for residents to participate regularly." -- DV—

Problem in Coordination

Stakeholders identified several coordination challenges, primarily stemming from fragmented authority and responsibility. The lack of clear role delineation among government agencies, as voiced by PEO, WBU, DPA, and CEO, exemplifies this issue. The following statements further illustrate this concern.

"There is significant overlap in responsibilities between different government departments. The Environmental, Public Works, and Health Office has some jurisdiction over waste management, but coordination is poor." --PEO—

"Sometimes, we receive contradictory directives from different government agencies. This creates confusion and inefficiency in our operations." -- WBU—

Secondly, communication inadequacies were evident due to the limited exchange of information and dialogue between relevant parties. This concern was voiced by the CBO, WBU, CWB, and MOI, as highlighted in the following statements.

"We rarely meet with other stakeholders to discuss shared challenges and solutions. Each organization operates in its silo." -- CBO—

"Information about policy changes or new initiatives is not effectively communicated to all stakeholders. We often learn about important developments too late." --WBO—

Third, policy inconsistencies can arise from misalignments between waste management policies at the regional, provincial, and city levels, as expressed by DPA, MOI, P3E, and PEO. The following two are examples of statements that highlight this issue:

“Regional and city-level policies sometimes contradict each other, creating confusion about which standards or procedures to follow.” – DPA-

“Organic waste management regulations vary significantly between administrative levels. This inconsistency makes compliance difficult.” --MOI-

Fourth, cross-sectoral collaboration is limited due to weak coordination among the environmental, health, education, and economic development sectors, as expressed by HU, WOM, CEO, and CBO representatives. The following two are examples of statements that highlight this issue:

“Waste management is treated purely as an environmental issue, without recognizing its connections to public health, education, and economic development.” --HU—

“Each sector operates independently, with minimal collaboration on waste management initiatives that could benefit from a multi-sectoral approach.” --WOM—

Fifth, coordination between the informal and formal sectors presents a challenge, particularly in integrating informal waste collectors into formal waste bank systems. This issue was raised by YP, GC, WBU, and CEO, as highlighted in their statements. The following two are examples of statements that highlight this issue:

“Informal waste collectors are essential to the system but are rarely included in formal planning or decision-making processes.” --YPN—

“There is often competition rather than collaboration between formal waste banks and informal collectors, which reduces overall system efficiency.” --GC—

Potential Improvements

Stakeholders proposed several operational enhancements for waste banks. First, improve

facilities. Included expanding composting, biogas production, and other organic waste conversion methods to improve facilities. This suggestion was voiced by WBU, MOI, CEO, and GC, as indicated by their statements. The following two are examples of statements that highlight this issue:

“We need dedicated facilities for organic waste processing, including proper composting systems and potentially biogas digesters. These investments would significantly increase our capacity to handle organic waste effectively.” --WBU—

“Maggot cultivation is a promising method for organic waste processing that can generate additional value. We need support to scale up these operations.” --MOI—

Second, utilize integrated stakeholder platforms. It is important to establish routine communication and coordination forums among various stakeholders, as expressed by CWB, DPA, CBO, and WBU. The following two are examples of statements that highlight this issue:

“Regular stakeholder forums would significantly improve coordination. Monthly meetings where all actors can share updates, challenges, and opportunities would strengthen the entire waste management ecosystem.” --CWB—

“We need a unified digital platform where stakeholders can share information, coordinate activities, and track progress toward shared goals.” --DPA--

Third, community education and engagement programs. Implementing targeted initiatives to increase awareness and participation in the community. CBO, WBU, HU, and WOM expressed this through their statements. The following two are examples of statements that highlight this issue:

“Comprehensive education programs in schools and communities would increase awareness about proper waste management, particularly for organic waste.” --CBO—

“We need to develop more engaging approaches to community participation, perhaps through

competitions, public recognition, or additional economic incentives.” --WBU-

Fourth, a policy harmonization. Aligning of waste management policies across various governmental tiers and industries is crucial, as emphasized by P3E, PEO, CEO, and DPA. The following two are examples of statements that highlight this issue:

“A harmonized policy framework delineating responsibilities and standards across all government levels would significantly improve coordination and effectiveness.” --P3E—

“We need integrated policies that address waste management as part of broader environmental, health, and economic development strategies.” --PEO—

Fifth, value-added product development. The creation of higher-value products from processed waste is essential to improve economic returns, as noted by CEO, HU, WBU, and GC. The following two are examples of statements that highlight this issue:

“Developing high-quality compost products from organic waste could create new market opportunities and improve the economic viability of organic waste management.” --GC—

“Research partnerships with universities could help identify innovative products and applications for processed organic waste, increasing its market value.” --HU—

Waste Banks Unit Resilience

Several factors have been identified as contributing to waste bank unit resilience. First, diversified waste types and revenue sources. The waste bank units that managed different types of waste while participating in various activities that added value showed great stability, as expressed by DPA, WBU, CWB, and CEO. The following two are examples of statements that highlight this issue:

“The waste banks that have survived economic downturns are those that diversified their operations beyond basic recycling.

Those that process organic waste into compost, cultivate maggots for animal feed, or create handicrafts from recyclable materials have multiple revenue streams.” --DPA—

“Our resilience comes from not depending on a single waste stream or market. When plastic prices drop, we can focus more on organic waste processing or paper recycling.” --WBU—

Second, strong community embeddedness is crucial. The waste bank units that are deeply rooted in their communities and actively participate locally have demonstrated greater resilience, as noted by YLM, DV, WBU, and CBO. The following two are examples of statements that highlight this issue:

“The most resilient waste banks have become true community institutions, where participation is part of local identity and social norms.” --YLM—

“When the waste bank is seen as belonging to the community rather than an external entity, participation remains high even during challenging times.” --DV—

Third, a supportive policy environment is crucial. Governmental policies that bolster waste bank operations contribute to their sustainability, as noted by CEO, WBU, P3E, and DPA. The following two are example statements that exemplify this point:

“Waste banks in areas with supportive local regulations and active government engagement tend to be more sustainable over time.” --CEO—

“Policies that provide tangible support, such as land allocation, tax incentives, or integration with formal waste management systems-significantly enhance waste bank resilience.” --WBU—

Fourth, technical capacity and innovation are key. The waste banks units demonstrating advanced technical expertise and employing innovative waste processing methods have shown increased adaptability, which tends to be satisfying. This

point was highlighted by HU, WBU, MOI, and CWB. The subsequent two statements were examples that further indicated this:

"The waste banks that invest in technical training for their staff are better able to adapt to changing conditions and improve operational efficiency." --HU—

"Innovation in processing methods, particularly for organic waste, has helped us remain viable even as market conditions change." --WBU—

Fifth, effective leadership and management are crucial. The waste bank units that were well-managed and had capable leaders were more successful in overcoming obstacles, as noted by YES, CWB, WBU, and DPA. This is supported by the following two examples of statements:

"Strong leadership is perhaps the most critical factor in waste bank resilience. Leaders who can motivate communities, build partnerships, and adapt to changing circumstances make all the difference." --YES—

"Financial management skills are essential. Waste banks that maintain accurate records, manage costs effectively, and plan for contingencies have much better survival rates." --CWB—

Discussion

This study provided findings on challenges and obstacles in waste bank implementation, problems in coordination, potential improvements, and waste bank unit resilience. This discussion section examines these findings. This study found that low community participation, limited resources and facilities, unstable markets, knowledge and awareness gaps, and geographical and logistical challenges are challenges and obstacles in waste bank implementation. Low levels of active community membership in waste banks remain a critical challenge for waste bank management in Makassar City. Encouraging residents to become members is essential, as it institutionalizes their engagement in waste bank activities. However, this

study reveals that community participation in joining waste banks is still limited. Active involvement of the community has been shown to significantly contribute to the sustainability of waste bank programs (22, 23). Therefore, strategic interventions are necessary to enhance and promote active community participation in waste bank initiatives.

Several strategies can be implemented to enhance active community participation in waste bank management. Providing educational programs aimed at raising public awareness on waste separation can effectively reduce the amount of waste disposed of in open dumping sites (24). The inherent dynamics of social networks, along with established social norms, can be leveraged strategically to increase community engagement in waste management initiatives at all societal levels (25). Communities with strong environmental awareness related to waste reduction and recycling tend to develop a culture of environmental responsibility (26, 27). Furthermore, improving the availability of resources and facilities significantly supports efforts to foster greater community involvement in waste bank activities. Facilitating easy access to information and guidance, such as techniques for waste sorting and practical recycling tips, is essential to empower the community (28).

The government holds a pivotal role in regulating waste bank operations. In Indonesia, Ministry of Environment and Forestry Regulation No. 14 of 2021 specifically addresses the operational procedures of waste banks, including budget allocation for waste management. To overcome current challenges, it is imperative that the government refines policies by introducing additional technical guidelines (29), aimed at enhancing infrastructure and fostering collaboration with relevant stakeholders to boost community participation (30, 31). Targeted investment in advanced waste processing infrastructure, such as recycling and composting facilities, is crucial to achieving efficient waste management. Moreover, public education initiatives focused on waste recycling are essential to raise environmental awareness and encourage active community involvement in recycling efforts (32). Policymakers and community stakeholders must work in unison to build public trust and awareness regarding sustainable practices in

waste bank management (23). Geographical and logistical factors are also found to be one of the challenges and obstacles in waste bank implementation in this study. Transportation distances, topographical features, and accessibility limitations can impede the efficient collection and transport of waste, particularly in geographically isolated or densely populated regions (33). Urban areas often encounter challenges related to space, access, and distance, affecting logistical operations, which are significantly influenced by the development and availability of transport systems and infrastructure (34).

This study also found problems in coordination and waste bank implementation. There is fragmented authority and responsibility, communication gaps, policy inconsistencies, limited cross-sectoral collaboration, and informal vs formal sector coordination. A successful waste management system necessitates collaboration between governmental bodies, private industries, and community groups to guarantee a comprehensive and integrated strategy (26). Insufficient infrastructure and a lack of coordination among relevant stakeholders, such as local governments and the private sector, can impede the implementation of effective waste management initiatives (26, 35). Furthermore, inter-organizational coordination may encounter difficulties because of the underutilization of formal and informal processes, resulting in delays, diminished quality, and resource depletion (36). Consequently, it is essential to develop a well-coordinated and standardized solid waste management plan for implementation by all stakeholders (35). This plan should guide policy development and harmonize all urban solid waste management concerns, including the establishment of waste banks. In Makassar City, governmental institutions play a pivotal role in waste bank management, exerting considerable influence over information exchange within the network of bank management stakeholders (37). The results of this research offered valuable insights for the government to foster coordination among all stakeholders involved in waste bank management within Makassar City.

This study highlights areas for enhancement in waste bank management practices within Makassar City: Enhanced facilities, integrated stakeholder platforms, community education and

engagement programs, and policy harmonization exist. Several research studies support this finding. Effective waste bank management necessitates collaborative efforts among governmental bodies, local communities, and the private sector (38, 39). This study also revealed key determinants of resilience in waste bank units. Stakeholder perceptions suggest that diversified waste streams and revenue sources, community embeddedness, a supportive policy environment, and technical capacity and innovation are key factors in fostering the resilience of waste bank units. The good performance of a waste bank unit can be evaluated based on waste sales volume, revenue generation, and customer participation (40). Diversifying the types of waste materials managed by the waste bank can enhance its revenue streams, as relying on a single waste type makes it susceptible to market volatility (41). Customer numbers reflect the community's engagement in waste bank initiatives, necessitating on-going innovative strategies such as educational programs, community outreach, and partnerships with local leaders and organizations to encourage broader participation (42, 43). Furthermore, a favourable policy framework from governmental bodies, including financial incentives and transparent regulations, fosters an enabling environment for the expansion of waste banks (44), coupled with the willingness of these banks to integrate advanced technologies that can optimize operational effectiveness and create value-added recycled goods (45).

This research offered significant findings for a variety of stakeholders, including waste bank administrators, regional and local government bodies, non-governmental organizations, private sector entities, and other participants in community-based waste management initiatives. This is particularly salient for government institutions, which are typically the direct mandate holders of regulations governing waste banks and waste management practices. These results highlight potential avenues for future research aimed at deepening the understanding of waste bank management in Makassar City. For example, one sub-theme reveals stakeholders' perception of limited community engagement in waste banks. Subsequent studies could investigate the underlying factors contributing to low levels of community participation in waste bank membership. The

other example for next research is also warranted to explore why different stakeholders experience challenges variably and what implications these differences hold for the sustainability of waste banks. Beyond providing valuable practical recommendations for government and related stakeholders, this study also offers several directions for further scholarly inquiry.

This study's findings align with those from waste bank implementations in Thailand and Vietnam. One significant challenge observed in Thailand is the limited availability of facilities and infrastructure, along with the need to further develop community participation (46). Similarly, in Vietnam, uneven infrastructure distribution, coupled with suboptimal regulatory support and public education efforts, has been noted as a constraint (47). These findings contrast markedly with waste bank implementations in European countries such as the Netherlands and Denmark, where integrated automated collection and sorting systems, structured waste management logistics, and incentive programs supported by extensive public education have resulted in high recycling rates and reduced landfill disposal (48, 49).

Conclusion

The results of this study found four common themes: challenges and obstacles in waste bank implementation, problems in coordination, potential improvements, and waste bank unit resilience. Low community participation, limited resources and facilities, unstable markets, knowledge and awareness gaps, and geographical and logistical challenges are challenges and obstacles in waste bank implementation; the problems in coordination in the waste bank implementation are fragmented authority and responsibility, communication gaps, policy inconsistencies, limited cross-sectoral collaboration, and informal vs. formal sector coordination; potential improvements in waste bank management, are enhanced facilities, integrated stakeholder platforms, community education and engagement programs, and policy harmonization; the factors that can make a waste bank unit resilient are diversified waste streams and revenue sources, community embeddedness, supportive policy environment, and technical capacity and innovation.

Abbreviations

None.

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Author Contributions

All authors equally contributed.

Conflict of Interest

The authors declare no conflicts of interest.

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