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Analysis of Waste Mitigation Policy in South Tangerang City, Indonesia: Challenges and Solutions for Sustainable Management

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ABSTRACT

This study aims to analyze waste mitigation policies implemented in South Tangerang City, Indonesia, which faces significant challenges in waste management. Despite various mitigation efforts, issues such as limited landfill capacity, low community participation in waste sorting, and inadequate treatment facilities continue to hinder effective waste management. Using a case study approach, the research assesses the effectiveness of existing policies and identifies key barriers. The findings show that poor waste management, characterized by a high volume of waste sent to landfills, leads to severe environmental pollution—including air, soil, and water contamination—and increases the risk of disasters such as landfill collapses. This negative impact is not only felt by the environment, but also has an impact on public health and regional budget efficiency. While initiatives such as the 3R (Reduce, Reuse, Recycle) program and organic waste treatment have been introduced, low community engagement and inadequate treatment facilities remain major obstacles. The study also compares successful waste management policies from developed countries such as Germany, Sweden, and South Korea, offering valuable insights for local policy adaptation. Based on these findings, the study recommends increasing government capacity, improving access to and the quality of Reduce, Reuse, Recycle (WPP3R) Waste Treatment sites, providing incentives, encouraging community involvement, and promoting collaboration between the public and private sectors to achieve more efficient and sustainable waste management.

Keywords: Public Policy; Good Environmental Governance; Waste Management; Waste Mitigation

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1. Introduction

According to data from The Economist Intelligence Unit in 2017, Indonesia was the world's second-largest contributor of waste, averaging 300 kilograms of food waste per capita each year [1]. The rapid rate of population growth is one of the reasons for the increase in public consumption, which ultimately influences the growing amount of waste produced [2]. Based on data from the National Waste Management Information System (NWMIS), waste in Indonesia from 2019 to 2024 has shown an increase in the amount of waste generated from various sources and types. The amount of waste generation in Indonesia during this period (in tons) is shown in **Figure 1** [3,4].

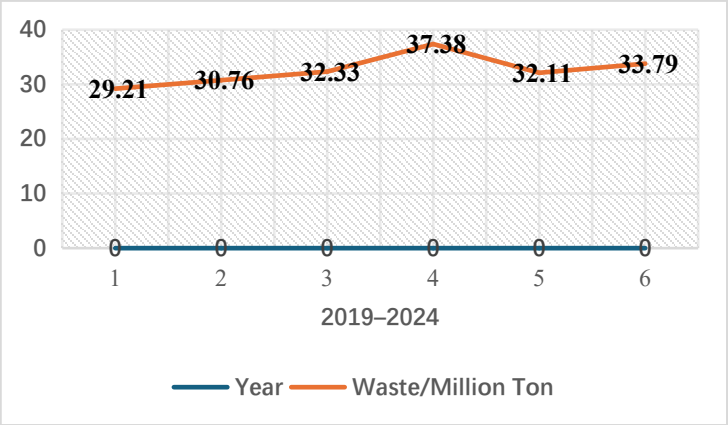

Figure 1. Total Waste Generation in Indonesia in 2019–2024 (Tons) [3,4].

Figure 1 shows that Indonesia has experienced a significant increase in waste generation over the past few years. From 2019 to 2024, waste generation continued to rise, reaching a peak in 2022 at 37.38 million tons—an increase of 8.17 million tons in just four years. This growth is largely driven by rising public consumption, in line with economic growth and urbanization. However, in 2023, there was a slight decrease in waste disposal, dropping to 32.11 million tons. This decline may be attributed to several factors, such as government policies aimed at reducing plastic waste, increasing public awareness of recycling, or changes in consumption patterns due to the pandemic. In 2024, despite the dip in 2023, waste generation rose again to 33.79 million tons, indicating a continuing upward trend. Although the rate of increase was slower than in previous years, it still highlights a major challenge for waste management in Indonesia.

Based on data from NWMIS (2024), the city of South Tangerang—the focus of this study—is among the top 30 districts and cities in Indonesia with the highest waste generation and a high rate of waste disposal to landfills. As of 2024, South Tangerang City has 40 Reduce, Reuse, Recycle (WPP3R) Waste Treatment Sites that process 107 tons of garbage per day [5]. WPP3R is a waste management facility based on the 3R principles: reduce, reuse, and recycle. Its primary goal is to reduce the amount of waste sent to landfills by treating waste beforehand. By 2024, Waste Banks in the city manage 1.48 tons of waste per day [6]. Meanwhile, total waste generation in South Tangerang City in 2024 reached 799 tons per day. This data indicates that a large amount of waste remains unmanaged, leading to a continued high volume of landfill disposal. Therefore, it is important to study waste mitigation policies in South Tangerang City.

Household and food waste are the most significant contributors to waste in this research area. Poor waste management results in 69% of waste being disposed of in landfills [7]. The high volume of landfill disposal shortens landfill lifespan and can lead to environmental, public health, and disaster-related problems. Environmental issues caused by waste in the study area include seawater, soil, and air pollution, as well as climate change due to greenhouse gas emissions from landfills [8]. Gases such as methane (CH_4), ammonia (NH_3), and carbon dioxide (CO_2) released from landfills can also cause respiratory infections [9,10]. Additionally, waste accumulation in landfills can lead to landslides. **Figure 2** be-

low shows the composition of waste by type in South Tangerang City [7]. Food waste, plastics, wood, and paper are the main contributors to waste in the study area, with food waste primarily originating from restaurants and households.

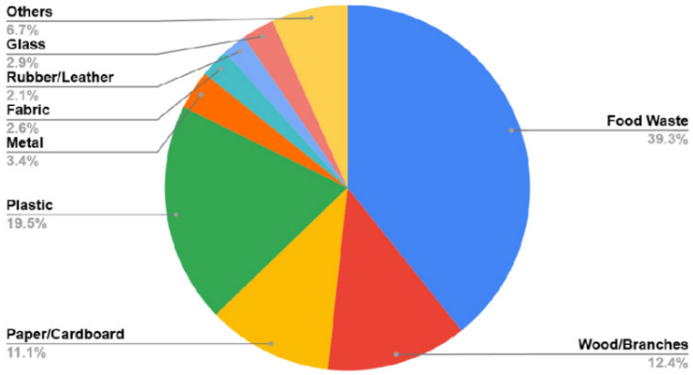

Figure 2. Composition of Waste by Type in South Tangerang City [7].

In addition, the accumulation of millions of tonnes of poorly managed waste has caused numerous problems, including landslides that lead to river pollution and other forms of environmental damage [11]. In May 2020, the Cipeucang Landfill in South Tangerang City experienced a landslide that caused more than 100 tons of garbage to spill and block the flow of the Cisadane River [12]. Such landslides occur when landfills exceed their capacity. **Figure 3** shows the condition of the landslide at the Cipeucang Landfill in South Tangerang City [13].

Figure 3. Landslide at Cipeucang Landfill, South Tangerang City.

Source: See the reference [13].

Landslides are a major problem in many locations, such as the Leuwigajah Landfill in Leuwigajah Village, Cimahi, where a significant landslide occurred. A total of 143 people were killed, and 86 houses were buried under the waste. The Leuwigajah Landfill receives 1.62 million cubic meters of waste every year [14]. Over 20 years, this amount of waste could cover one-fifth of the city's area with piles reaching up to ten meters high. Landslides happen when heavy rainfall causes instability in the waste mound, triggering collapses. Additionally, explosions can occur due to the accumulation of trapped methane gas (CH_4).

Overseas, landfill landslides are also common in some countries. For example, in 2017, a major landslide occurred in a suburb of Addis Ababa, Ethiopia [15]. In 2008, a landslide in Guatemala killed 50 people [16]. Additionally, in 2005, two separate landslides occurred in different countries: one in Medellín, Colombia, which killed 43 people, and another in China, where 13 people died [17,18].

The increase in waste generation in the research area presents significant challenges to achieving efficient and sustainable waste management. One of the biggest issues is reducing single-use plastics and improving recycling

systems. The city government has taken several steps to address this problem, such as launching plastic waste reduction campaigns and upgrading recycling facilities. However, to tackle the waste problem more effectively, stricter policies and stronger cooperation among the government, the community, and the private sector are needed. The modernization process in addressing this issue has not been consistent [19].

Adopting waste management strategies from developed countries such as Germany, Sweden, and South Korea is essential for improving waste management effectiveness. Germany is a global leader in recycling, with a rate exceeding 67% since 2019, surpassing its target. Policies such as the ban on single-use plastics and the Green Dot system have been widely adopted globally. Sweden has been converting waste into energy since the mid-20th century, sending only 1% of its waste to landfills. Of the remaining waste, 52% is converted into energy and 47% is recycled. Sweden even imports waste, generating $100 million annually. South Korea implements a Volume-Based Waste Fee (VBWF) system, which charges citizens based on the amount of waste they generate. This system promotes waste reduction and proper sorting, with fines for non-compliance. These strategies showcase effective waste management practices that can be adapted by other regions.

This research addresses the main challenges in waste management in South Tangerang City and their impact on environmental sustainability and public health. The study also analyzes how waste mitigation policies from developed countries such as Germany, Sweden, and South Korea can be adapted to improve waste management systems in the research area, with a primary focus on implementing the 3R (Reduce, Reuse, Recycle) system combined with the Zero Waste concept as a more efficient waste management model. Finally, the study aims to evaluate the effectiveness of this model in reducing the volume of waste sent to landfills and to provide recommendations for optimizing its implementation.

2. Literature Review

Waste is one of the world's major environmental problems, driven by population growth, rapid urbanization, economic development, and improved living standards—all of which significantly accelerate the generation of solid waste. These challenges have prompted solid waste management experts to adopt the concept of zero waste, which they view as essential for reducing waste through various strategies [20]. Zero waste is a concept aimed at addressing society's solid waste issues by promoting a circular economy, efficient resource utilization, and material recovery [21].

The term *zero waste* was first coined in the 1970s by chemist Paul Palmer, who founded the company Zero Waste Systems to reduce chemical waste in laboratories across the United States [22]. The International Zero Waste Alliance defines zero waste as the conservation of all resources through the production, consumption, reuse, and responsible recovery of all products, packaging, and materials—without burning them or discharging them into the soil, water, or air in ways that threaten the environment or human health (**Figure 4**) [23,24].

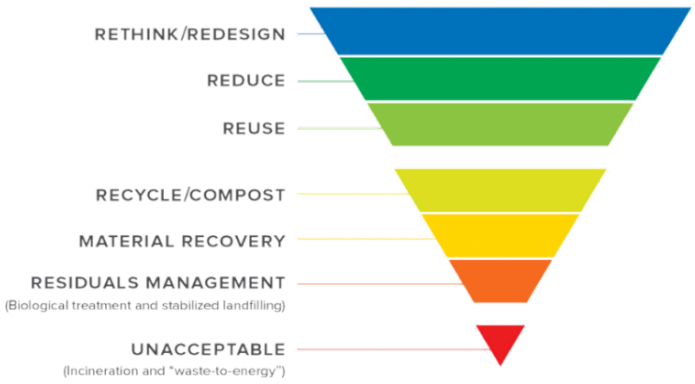

Figure 4. Zero Waste Hierarchy [24].

The Zero Waste concept strives to reduce waste generation and manage waste effectively so that less waste ends up in landfills. Waste handling begins at the source, such as avoiding single-use items, sorting waste, ensuring extended producer responsibility, collecting waste based on the amount discarded, involving the community in waste management, and providing incentives and disincentives. This concept must be integrated into regional policies to ensure effective implementation by both the government and the community [25].

To explore the theoretical framework, this study incorporates several theories related to environmental policy and waste management as follows:

2.1. Rational Choice Theory

This theory assumes that individuals and organizations make decisions based on cost-benefit calculations to achieve their goals [15]. In the context of public policy and waste treatment:

1) **Rationale:** Effective public policy designs clear incentives and disincentives, encouraging actors (individuals, households, industries) to reduce, reuse, and recycle waste as these actions become economically or socially rational.
2) **Expected connections:**
   - **Incentives:** Policies providing subsidies for environmentally friendly products, tax reductions for companies implementing circular practices, or rewards for communities actively sorting waste.
   - **Disincentives:** Policies imposing fines for littering, carbon taxes, or high waste handling fees for products with short life cycles.
   - **Information:** Policies that offer clear, accessible information about the impact of waste and how to mitigate it, enabling actors to make better choices.
3) **Direction of Causality:** Good environmental governance (through rationally designed policies) → Behavior changes of actors → Effective waste mitigation.
4) **Origins and key thinkers:** The roots of Rational Choice Theory lie mostly in classical and neoclassical economics, especially the concepts of utility and profit maximization. While there is no single inventor, its basic ideas trace back to thinkers such as Adam Smith (e.g., the concept of the "invisible hand" and individuals acting in self-interest).

2.2. Institutional Theory

This theory emphasizes the role of institutions (rules, norms, values, and practices) in shaping individual and organizational behavior [16]. Max Weber (sociology: the concept of bureaucracy and instrumental rationality as an institutional form) is a key contributor. Good environmental governance creates a strong institutional framework for waste management.

1) **Rationale:** Strong and stable institutions (e.g., clear environmental laws, effective law enforcement agencies, recognized waste management standards) shape behaviors and expectations regarding waste mitigation.
2) **Expected connections:**
   - **Regulation and Law Enforcement:** Laws governing waste disposal, recycling quality standards, and strict sanctions for violators.
   - **Social and Cultural Norms:** Public awareness and education campaigns fostering social norms to reduce waste and improve recycling culture.
   - **Organizational Structure:** Establishment of dedicated institutions or units within government responsible for waste management, along with collaboration between sectors (government, private, civil society).
3) **Direction of Causality:** Good environmental governance (through strong institutions) → Creation of norms, rules, and structures that support → Improved waste mitigation.

2.3. Political Ecology Theory

This theory sees environmental problems, including waste, as a result of power relations, inequality, and broader economic-political structures [17].

1) **Key figures:** Wolfgang Sachs (critic of development), Raymond Bryant, Eric Swyngedouw, and Neil Smith are leading scholars applying political ecology to urbanization and environmental crises.
2) **Rationale:** Good environmental governance must consider power and justice dimensions in waste manage-

ment. Effective mitigation depends not only on technology or individual awareness but also on how power is distributed and policies are made and implemented amid competing interests.

3) **Expected Connections**
   - **Public Participation:** Policies enabling active community involvement in formulating and implementing waste policies, especially including vulnerable groups often disproportionately affected.
   - **Environmental Justice:** Ensuring equitable distribution of waste management burdens and benefits, avoiding concentration of waste facilities in low-income areas.
   - **Accountability and Transparency:** Mechanisms ensuring governments and industries are accountable for waste impacts, with transparency in data and decision-making.
   - **Addressing Corporate Powers:** Policies limiting overproduction, encouraging sustainable product design, and curbing *greenwashing*.
4) **Direction of Causality:** Good environmental governance (fair, participatory, and accountable) → Addressing the root causes of structural problems and injustices → Sustainable and equitable waste mitigation.

In general, the expected direction of causality is that good environmental governance serves as a prerequisite and key driver for effective and sustainable waste mitigation. Without a strong governance framework, waste mitigation efforts tend to be sporadic, uncoordinated, and difficult to sustain over the long term.

Good environmental governance creates a conducive environment—through policies, incentives, institutions, and equity considerations—that enables all actors to actively contribute to waste reduction, reuse, and recycling.

3. Materials and Methods

Based on the waste management challenges faced by South Tangerang City, the most appropriate research method is the Case Study Approach. This method allows an in-depth examination of how existing waste mitigation policies in the city can be improved by studying policies successfully implemented in other cities, both within Indonesia and abroad. The case study approach enables researchers to focus on a specific location or problem—waste management in South Tangerang City—to gain a better understanding of its challenges and solutions [18]. Therefore, international comparisons, such as waste management practices from developed countries such as Germany, Sweden, and South Korea, can be used.

Using case studies, the authors can assess how waste management policies from these countries can be adapted to the local context of South Tangerang. For example, Germany has reduced landfill waste through its highly effective Green Dot System and Deposit Refund System policies. Similarly, Sweden converts waste into energy, and South Korea implements volume-based waste disposal charges.

This research begins with

a) Direct observation at landfills, WPP3R sites, and waste banks to monitor waste management processes;
b) Conducting in-depth interviews with relevant parties, including local government officials, landfill managers, communities, and the private sector, to gather information on policies, challenges, and community participation in waste management;
c) Identifying problems such as the lack of active WPP3R, low public awareness, funding issues, and environmental disasters at the Cipeucang Landfill;
d) Based on field findings, developing policy solutions to increase local government capacity, provide community incentives, improve access and quality of WPP3R, and encourage collaboration between the public and private sectors;
e) Designing a waste management model combining the 3R (Reduce, Reuse, Recycle) system with a more effective Zero Waste concept, and compiling a waste reduction roadmap with short- and long-term targets.

Finally, a research report was prepared, including analysis, findings, and policy recommendations for implementation by local governments, communities, and the private sector to effectively and sustainably address the waste problem in South Tangerang. Subsequently, the primary research informants are presented in **Table 1** below.

Table 1. Main Informants of the Research.

No	Key Informant	Institution	Quantity
1	Head of the Environmental Agency	South Tangerang City Government	1 person
2	Deputy Head of the Environmental Agency	South Tangerang City Government	1 person
3	Head of Landfill Unit Cipeucang	Landfill Unit Cipeucang	1 person
4	Field Staff of Landfill Unit Cipeucang	Landfill Unit Cipeucang	3 people
5	Community Members	Community around Landfill Unit Cipeucang	5 people
6	Paragon NGO Manager	Paragon NGO	1 person
7	KOMPPI NGO Manager	KOMPPI NGO	1 person
8	LIRA NGO Manager	LIRA NGO	1 person
9	Bintaro Jaya Company	Private Company	1 person
10	Sinar Mas Land Company	Private Company	1 person

4. Results

4.1. Observations at Landfills, WPP3R, and Waste Banks

Based on field observations conducted by researchers at the Cipeucang Final Disposal Site, WPP3R facilities, and the Waste Bank in South Tangerang City, several key findings regarding waste management were identified. A primary issue is the limited capacity of the Cipeucang Landfill, which is nearing full capacity. As the only landfill managed by the South Tangerang City Government, this situation causes a buildup of waste, increasing the risk of environmental pollution affecting air, soil, and water resources in the area.

Although WPP3R facilities in several sub-districts operate to support waste management, their effectiveness remains relatively low. Challenges include limited infrastructure, insufficient active community participation, and a shortage of human resources to manage these centers. As an alternative, waste banks in South Tangerang City serve to recycle household waste (**Figure 5**), but this program has yet to achieve optimal results. Obstacles such as low public awareness, limited facilities, and inadequate support from related stakeholders mean that waste banks currently play a minimal role in reducing the volume of waste sent to landfills.

Figure 5. Optimization of Waste Reduction Through WPP3R and Community Waste Purchase by Waste Banks.
Source: South Tangerang City Environmental Agency, 2024.

Despite government and community efforts, waste management effectiveness remains constrained. Therefore, it is essential to increase landfill capacity, optimize WPP3R operations, and strengthen the role of waste banks to achieve more effective and sustainable waste management in South Tangerang City.

4.2. Interview Results

The researchers interviewed the Waste Manager of South Tangerang City Government, obtaining the following insights:

4.2.1. Waste Management Policy

When asked about the implementation of current waste management policies, the Head of the Environmental Agency stated:

*"So far, **waste management policies in South Tangerang City** have been focused on reducing waste through the 3R (Reduce, Reuse, Recycle) program and more efficient management at the Cipeucang Landfill. We also encourage community-based waste management by involving WPP3R and waste banks in various villages."*

Regarding challenges, the Deputy Head of the Environmental Agency noted:

"The main challenges are the low level of community participation in waste sorting, the limited number of adequate waste management facilities, and funding problems that often hinder the development of better infrastructure. We have socialized and educated the public about the importance of waste sorting through various training programs and campaigns. However, public awareness still needs to be improved."

On obstacles to implementing Zero Waste, they explained:

"The existing waste management policy is quite effective, but the results are still not optimal because there is still a lot of waste that enters the landfill due to the lack of facilities and public understanding. The biggest obstacle in implementing Zero Waste is changing people's mindset and dependence on single-use plastic waste."

Concerning the private sector's role, they commented:

"The private sector has an important role to play in waste management, especially in supporting recycling facilities and providing technology for better waste management. We have plans to develop more WPP3Rs in each village and improve waste sorting facilities at the household level."

4.2.2. Landfill Conditions

When asked about the current state of the Cipeucang Landfill and its management challenges, the Head of the Landfill Unit stated:

***"The condition of the Cipeucang Landfill** is starting to be full, and we are facing the problem of limited capacity to accommodate the increasing volume of waste. We also face a big challenge in environmentally friendly waste management."*

Regarding efforts to reduce landfill waste, the Head of the Landfill Unit explained:

*"To **reduce waste that enters landfills**, we continue to encourage people to sort waste at home and optimize the processing of organic waste into compost."*

The Deputy Head of the Landfill Unit evaluated the existing waste management system:

***"Waste management systems at landfills** already exist, but with the increasing volume of waste, we need more efficient and environmentally friendly systems, such as better recycling facilities and technology-based waste management."*

Looking ahead, the Head of the Landfill Unit shared the long-term plan:

***"The long-term plan** is to expand landfill capacity and develop more efficient waste management technologies, as well as reduce reliance on landfills by improving sorting and recycling facilities at the community level."*

4.2.3. Field Management of the Cipeucang Landfill Unit

Interviews were conducted with three field staff members of the Cipeucang Landfill Unit about the waste management process at the landfill. The field staff explained:

***"The waste management process at landfills** in-*

volves sorting waste from the source, then non-recyclable waste is dumped into the landfill for processing. We also compact and process organic waste into compost."

When asked about the main challenges in managing waste on-site, they responded:

***"The main challenge** is the ever-increasing volume of waste, as well as the lack of tools and infrastructure to handle waste that is not managed properly. We also have difficulty educating the public to be more active in waste sorting."*

Regarding community participation at the household level, they said:

*"**Community participation** in waste management at the household level is still very low. The community has not fully understood the importance of waste sorting and considers waste as a problem that must be solved by the government itself."*

Finally, when asked about their hopes for the future of waste management in South Tangerang City, they shared:

***"My hope for the future of waste management** is that more people will be actively involved in waste sorting and the application of the 3R principles, as well as the development of more WPP3Rs and more environmentally friendly waste treatment facilities."*

4.2.4. The Role of the Community in Waste Management

Five community members around the Cipeucang Landfill Unit were interviewed about the waste management process. Their responses were as follows:

When asked about their views on waste management in South Tangerang City, community members explained:

***"My view of waste management** in this city is still inadequate. Landfills have started to fill up, and there are not enough facilities to recycle waste. Waste management at the household level is still low."*

Regarding their involvement in household waste sorting, they said:

***"I started sorting waste** at home, but it was inconsistent. Sometimes it's hard to tell the difference between types of waste, especially if there's no clear separation facility around the environment."*

When asked about the biggest challenges in neighborhood waste management, they responded:

***"The biggest challenge** is the lack of education about the importance of waste sorting and the absence of enough bins in public areas. Many people still litter."*

About the availability and use of facilities such as WPP3R and waste banks, community members stated:

***"I know there are WPP3Rs and waste banks** in some villages, but I haven't made the most of them because there is no easy access and lack of information about how the system works."*

Finally, when asked how to improve public awareness and participation in waste management, they suggested:

***"To raise public awareness**, I think the government should do more socialization and provide easily accessible facilities, as well as incentivize those who actively sort waste."*

4.2.5. The Role of NGOs in Waste Management

Interviews were conducted with three NGOs familiar with waste management at the Cipeucang Landfill. The key findings are as follows:

The Paragon NGO representatives highlighted the role of NGOs as educational partners and facilitators:

***"The role of NGOs in waste management** is as an educational partner and facilitator in developing waste reduction programs in the community. We also provide training on the importance of waste sorting and the environmental impact caused by waste that is not managed properly."*

At LIRA NGO, the main challenges in educating the community were discussed:

*"**The biggest challenge** is the low awareness of the public who consider waste management as a problem that must only be overcome by the government, not a personal responsibility. In addition, the lack of waste management facilities is also an obstacle."*

Representatives from KOMPPI NGO commented on the cooperation among NGOs, government, and community:

*"**Cooperation between NGOs, the government, and the community** already exists but is still limited to certain programs. There is still a lot of room to improve collaboration, especially in implementing policies that involve the community."*

When asked for recommendations to improve South Tangerang's waste management system, the NGOs collectively suggested:

*"**We recommend** that the government improve WPP3R facilities in each village, provide more intensive training to the community, and encourage the active participation of the private sector in waste management and recycling."*

4.2.6. Private Sector Involvement

Interviews were conducted with representatives from two companies managing Waste Banks in South Tangerang City: Bintaro Jaya Company and Sinar Mas Land. Key insights include:

Regarding the role of the private sector in waste management, they explained:

*"**The role of the private sector** in waste management is as a partner that helps process waste into reusable products, such as compost or alternative fuels. We are also involved in the provision of waste management technology and infrastructure."*

When asked about challenges faced by the private sector, their responses highlighted:

*"**The main challenge** is the lack of public awareness to sort waste properly, as well as low government support in providing adequate waste management facilities so that a lot of waste is not processed properly."*

On collaboration with the government to improve waste management, they stated:

*"**Collaboration with the government** can be done by providing better waste recycling technology and helping to build more efficient waste management facilities at the regional level. We are also ready to support educational campaigns for the public about the importance of good waste management."*

Regarding future expectations for waste management policies, they expressed**:**

"The private sector hopes that there will be policies that support more incentives for companies involved in waste processing and recycling, as well as the development of infrastructure that can reduce the volume of waste that goes into landfills."

4.2.7. Summary of Main Problems in South Tangerang City Waste Management

Based on interviews and direct observations, the following key issues were identified:

a) **Lack of Active WPP3R:** The number and capacity of WPP3Rs are limited across villages. Despite the program's introduction, many WPP3Rs operate below capacity due to insufficient facilities and low community participation. Consequently, recyclable waste often ends up in landfills, undermining waste reduction efforts.

b) **Low Public Awareness:** Public understanding of waste sorting is inadequate. Despite socialization efforts by the government and NGOs, many residents lack knowledge on proper waste sorting. The scarcity of sorting facilities at homes and public spaces worsens this, with many still perceiving waste management as the sole responsibility of the government.

c) **Funding Issues:** Financial constraints hinder the development of infrastructure such as WPP3R facilities, technology-based waste management, and improved

sorting systems. Without sufficient investment, waste management effectiveness remains limited.

d) **Environmental Disaster at Cipeucang Landfill:** The landfill's limited capacity leads to waste accumulation and environmental pollution, including landslides that contaminate soil and water, posing health risks. This situation underscores the urgent need for waste reduction solutions and improvements in landfill management.

The interview results reveal that waste management in South Tangerang City centers on waste reduction through the 3R (Reduce, Reuse, Recycle) program but faces significant challenges. These include low community participation in waste sorting, limited waste management facilities, and funding constraints. The Cipeucang landfill is nearing capacity, struggling to accommodate the increasing volume of waste. Although efforts are made to reduce waste by sorting and processing organic materials, more efficient waste management remains a challenge. Household-level community involvement is still minimal, highlighting the need for enhanced education and socialization to boost public awareness. NGOs and the private sector contribute to community education and the provision of waste treatment technologies but encounter limitations due to low public awareness and insufficient facilities. To improve the system, informants recommend upgrading WPP3R facilities, providing more community training, and strengthening collaboration between the public and private sectors.

5. Discussion

5.1. Waste Mitigation in South Tangerang City

Environmental hazards due to waste are latent conditions that can pose future threats. These hazards are largely caused by human behavior, such as the habit of littering and poor waste management. The risk of disaster from waste arises when waste is dumped into landfills without prior treatment at WPP3R facilities. The accumulation of waste in landfills continues to increase, resulting in environmental pollution and public health risks. Poor waste management can lead to environmental degradation and disturbances for communities living near landfills. Landslides at the Cipeucang Landfill serve as evidence that poor waste management can cause waste-related disasters that threaten both human life and the environment [19].

The vulnerability to disasters caused by waste increases when the capacity of local governments and community participation to anticipate and address waste issues is lacking. Waste management systems, infrastructure, and community waste disposal habits are key factors in minimizing this vulnerability. Capacity building among all stakeholders to manage and mitigate disaster risks caused by waste must be improved [20]. This includes infrastructure, institutions, human knowledge and skills, and collective attributes such as social relations, leadership, and management [21].

According to research by Satispi and Samudra (2022), waste management in Indonesia faces three main problems: (a) the traditional landfill-based waste management system of collection, transportation, and disposal is no longer effective; (b) public understanding is limited, as many people do not recognize the added value of waste through waste banks and continue to dispose of waste carelessly [22]; and (c) waste management does not align with environmental changes, meaning sustainable waste management must be based on resource capabilities, ecological conditions, the economy, and future-oriented strategies. Several control measures must be implemented, one of which is reducing the amount of waste sent to landfills—an effective municipal waste management and mitigation strategy to lower disaster risk [23].

5.2. Zero Waste as Waste Mitigation

Reducing the negative impact of waste requires the participation of all parties: the community, the business sector, and the government. When waste is not properly managed, a large amount ends up in landfills. Accumulated waste in landfills negatively affects the environment through pollution of water, soil, and air, which can lead to human health problems. Landfills are one of the most common and widely used waste management methods. As the volume of waste increases, the role of landfills becomes even more critical, and the resulting negative impacts are difficult to avoid [21]. Before waste is disposed of in landfills, it should first be processed through the 3R approach

at waste treatment sites. The City of South Tangerang follows the waste handling stream as described in **Figure 6**:

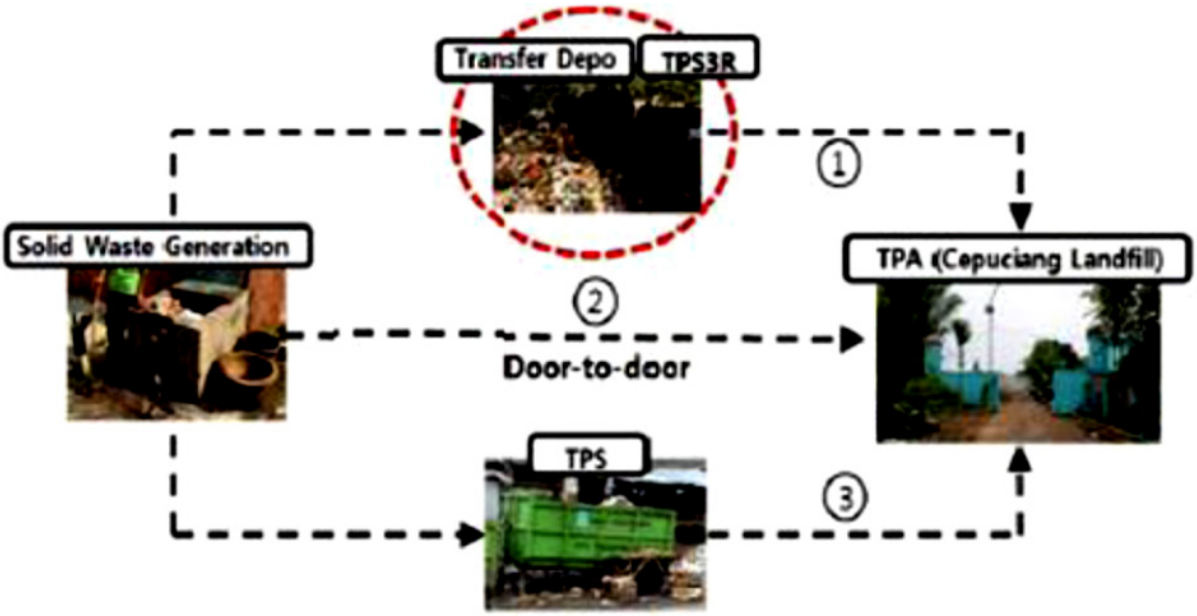

Figure 6. Waste Processing Flow in South Tangerang City.

Figure 6 shows that waste reduction remains low, while the amount of waste disposed of in landfills is very high. In terms of the Zero Waste approach, South Tangerang City still has ineffective waste management, as a large volume of waste is sent directly to landfills. Based on the waste management flow, there are stages where waste is disposed of directly from the source to the landfill without undergoing a separation process. The scheme of directly disposing of waste to landfills in South Tangerang City suggests that the waste is not processed beforehand. As a result, the effectiveness of reducing waste through WPP3R and waste banks remains very limited. Referring to the data in **Table 2**, the average waste reduction from 2022 to 2024 was only 16%. This figure is still below the national waste reduction target of 30% [24].

Table 2. Waste Management in South Tangerang City.

Year	Waste Generation	WPP3R		Bank-Managed Waste	Waste Reduction	Waste to landfill	
		Dikelola	Remnant				
2022	376,412	27,545	11,513	615	46,307	330,105	88%
2023	390,754	33,465	14,058	516	45,281	345,473	88%
2024	291,659	39,420	19,345	541	71,294	220,365	76%

Source: South Tangerang City Environmental Agency, 2024.

Therefore, the South Tangerang City Government needs to develop waste processing flows to reduce the amount of waste sent to landfills (**Figure 7**). This development must interrupt the current process in which waste collected from door to door and from temporary waste shelters is directly disposed of in landfills. All waste collected from households and temporary shelters should first undergo a waste sorting process. Waste that has no economic value or cannot be reprocessed will be sent to landfills. Meanwhile, waste with economic value should be sold to factories for further processing into products, with any remaining factory waste then disposed of in landfills. In this way, only residual waste ends up in the landfill [14].

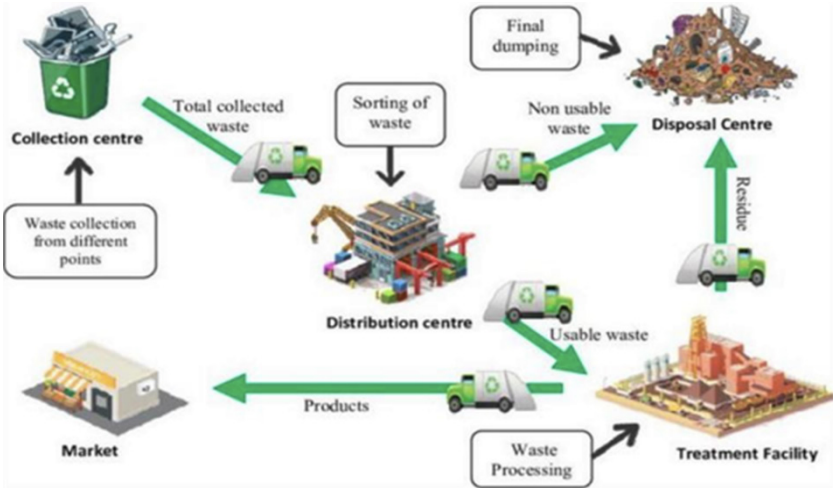

Figure 7. Waste Management Flow [26].

The model can be applied in South Tangerang City. However, waste sorting locations such as WPP3R and waste banks are still limited, and the existing infrastructure is inadequate. One of the advantages of waste reduction efforts in South Tangerang City is the presence of WPP3R, although many are inactive in implementing the 3R principles. While WPP3R facilities have been built, they have not been optimized, as waste processing activities are not being carried out. Therefore, attention must be given to all relevant parties to reactivate and operate these facilities.

The existence of both active and inactive WPP3R facilities indicates that institutional aspects related to maintenance are not functioning optimally (**Table 3**). Issues such as unclear land ownership, damaged buildings, difficult access, and changes in function have contributed to WPP3R inactivity. Another factor behind the lack of maintenance is the constraint on operational and maintenance costs. The funds used to implement WPP3R come from the government, public donations, and the private sector [27].

Table 3. WPP3R and Active and Inactive Waste Banks in South Tangerang City.

Year	Number of WPP3Rs		Number of Waste Banks	
	Active	Active	Active	Active
2020	37	14	219	71
2022	38	15	227	79
2023	41	15	228	105
2024	40	15	254	135

Source: South Tangerang City Environmental Agency, 2024

Referring to data from the Central Statistics Agency of South Tangerang City (2024), the population of South Tangerang City is 1,367,405 people. Based on the Indonesian National Standards for Waste Management in Residential Areas, the required number of polling stations is as follows (**Table 4**):

Table 4. Service Capacity and WPP3R Needed in South Tangerang City.

No	TPS	Service Capacity		WPP3R Required
		Volume	Number of people	
1	TPS Type I	100 m2	500	2735
2	TPS Type II	±300 m2	6000	228
3	TPS Type III	±1000 m2	24000	57

Source: City Government Data Based on SNI Calculations (2024).

Table 4 shows that the number of WPP3Rs in South Tangerang City has not met the needs of all city residents. Therefore, the government must increase the number of WPP3Rs to maximize waste processing. The availability of good access will encourage community behavior in managing waste. Access can be viewed in terms of the availability and accessibility of waste treatment sites [28].

Based on previous research, the lack of WPP3Rs can be caused by limited land availability. This is due to the fact that waste management facilities and infrastructure have not been included in the local government's Detailed Spatial Plan. Therefore, WPP3R locations must be incorporated into the Detailed Spatial Plan [29]. By maximizing the function of WPP3Rs, the waste disposed of in the landfill will be limited to residue, making the Cipeucang Landfill more sustainable in the long term and minimizing the risk of environmental disasters caused by waste.

5.3. Findings and Results of Waste Management Analysis in South Tangerang City

Waste management in South Tangerang City faces various significant challenges that hinder the realization of sustainable management, but there are also solutions and efforts that are being or can be implemented.

5.3.1. Main Challenges

a) Limited Capacity and Conditions of Landfills:

- Final Processing Sites (TPA), such as the Cipeucang Landfill, are facing capacity limitations and are overloaded due to the increasing volume of unmanaged waste.
- This results in groundwater and air pollution due to the uncontrolled accumulation of waste.
- There have been repeated conflicts and temporary closures of the Cipeucang Landfill due to management issues. This is consistent with reviews from waste management market analyses [30].

b) Less Optimal Waste Collection and Sorting System:

- Many waste collection methods still use a direct (*door-to-door*) system, with waste being sent directly to landfills without adequate initial sorting.
- Waste management procedures still allow direct disposal to landfills without a prior selection process.
- Communities have not yet consistently separated organic and non-organic waste at the source, and participation in waste bank programs remains low.
- There is a lack of adequate waste management infrastructure, including limited numbers of Temporary Shelters (TPS), TPS3R facilities (Reduce, Reuse, Recycle), and insufficient waste bins, especially in market areas.

c) Limited Resources and Infrastructure:

- The number of waste transport vehicles (trucks) operated by the South Tangerang City Sanitation Office is very limited and not proportional to the volume of waste.
- The welfare and safety of waste collectors are also inadequate.
- There is a shortage of human resources (HR) in the waste management sector.

d) Low Public Awareness and Participation:

- There are performance obstacles and inadequate facilities, as well as a lack of public awareness regarding waste separation at the source [31].
- Weak communication from higher to lower levels causes the intended goals to be unachieved.
- The practice of burning waste by residents still occurs, leading to environmental pollution.

5.4. Comparative Analysis of Waste Management in Developed Countries and Indonesia

From 2020 to 2024, Germany, Sweden, and South Korea have continued to strengthen their waste management policies and systems to achieve ambitious recycling targets and reduce the amount of waste disposed of in landfills. Each country has taken a different approach, but all focus on efficiency and sustainability in waste management [32].

Germany, long recognized as a world leader in recycling, continues to exceed its targets. In 2022, Germany recorded a recycling rate of 67.7%, surpassing the national target of 65% set for 2020–2035 [33]. In fact, the country has exceeded this target since 2019. Policies supporting this achievement include the Green Dot System, which makes manufacturers responsible for packaging waste, and

the Deposit Refund System (DRS), applied to plastic bottles and cans. The DRS system has been highly successful, achieving a return rate of 87.6% by 2024 [34]. In addition, Germany banned the use of single-use plastics in 2022, promoting environmentally friendly alternatives. These efforts reflect Germany's strong commitment to reducing waste and promoting sustainability [35].

Sweden, known for its highly efficient waste management policies, also recorded significant achievements from 2020 to 2024. In 2022, Sweden's household waste recycling rate reached around 47% [36], slightly below the EU average but still reflecting strong efforts in waste management. Sweden has a unique waste management system, with incineration as the primary method of waste treatment, generating energy from waste combustion. In addition, Sweden implemented a Deposit Refund System for bottles and cans, achieving a return rate of 87.6% by 2024 [37]. By 2024, Sweden also required all households and businesses to separate food waste for processing into biogas. This policy demonstrates Sweden's success in reducing waste and utilizing it for sustainable energy production [38].

South Korea, known for its strict waste management policies, has also achieved high recycling rates. In 2022, the country's recycling rate was recorded at 65.77% [39], with most waste processed through incineration and the remainder disposed of in landfills [40]. One of the most influential policies in South Korea is the Jongnyangje System, which requires waste to be separated into several categories, such as food waste, general waste, recyclables, and bulky goods. The community must use different garbage bags for each category. Violations of this system are subject to substantial fines, while those who report violations may receive rewards. In addition, South Korea implements a Deposit Refund System for plastic bottles and cans, with a recycling target of 70% by 2030 [41].

These three countries demonstrate an outstanding commitment to waste management and recycling through supportive policies, innovative technologies, and effective incentive systems. Although their approaches differ, their goals are the same: reducing the environmental impact of waste, encouraging recycling, and promoting greater sustainability worldwide.

5.5. Internal Solutions for City Government Policies to Improve Waste Management

Based on field findings obtained through interviews and direct observations, this study compiles several policy solutions to overcome waste management problems in South Tangerang City, including:

1) **Capacity Building of Local Governments**: Local governments need to enhance waste management capacity, both in terms of human resources and budget. This includes providing further training for waste management officers and allocating greater funds to build more efficient waste management infrastructure, including more and better WPP3R facilities**.**
2) **Incentivizing Communities**: To encourage active community participation in waste sorting and reduction, the government should reward individuals or communities that are active in waste management. These incentives can take the form of discounts on waste service fees or additional facilities such as special trash bins for household recycling.
3) **Improving WPP3R Access and Quality**: A key solution is to improve the accessibility and quality of WPP3R facilities in each village. The government must ensure WPP3Rs operate properly, provide adequate facilities, and carry out ongoing maintenance and repairs so that more people will use them. Increasing the number of WPP3Rs should also be prioritized, especially in densely populated areas.
4) **Fostering Collaboration between the Public and Private Sectors**: To achieve more effective waste management, close collaboration between governments, communities, and the private sector is essential. The private sector can assist by providing advanced waste treatment technologies and infrastructure, such as recycling technology. Additionally, private companies can support funding for waste management and public education campaigns about the importance of waste sorting and reduction.

With these policy solutions, waste management in South Tangerang City can become more efficient and sustainable, reduce reliance on landfills, increase recycling rates, and minimize negative environmental impacts.

6. Conclusions and Recommendations

Waste management in South Tangerang City faces several significant challenges that require immediate attention. The primary issue is the limited capacity of the landfill, which has already reached its maximum, leading to garbage buildup. Consequently, recyclable waste continues to be sent to landfills, contributing to environmental damage, including water, soil, and air pollution. Low community participation in waste sorting further hampers effective waste management. Although the government has initiated the 3R program, its impact remains limited due to inadequate facilities and insufficient public education. In addition, many WPP3Rs do not operate optimally, leaving a large amount of waste unprocessed. Despite the implementation of several waste mitigation policies, such as waste sorting and organic waste processing, their execution remains inadequate. Therefore, there is an urgent need for more comprehensive policies and stronger collaboration between the public and private sectors to enhance waste management efforts. Strengthening policies, improving public training, and integrating stricter regulations can significantly increase the efficiency and sustainability of waste management. This study further recommends applying the Zero Waste principle as a mitigation strategy to reduce landfill dependency and extend landfill lifespan.

6.1. Recommendations

a. **Local Government Capacity Building:** Strengthen waste management capacity by increasing training for waste management officers and allocating a larger budget to develop more adequate WPP3R facilities.
   - The South Tangerang City Government needs to implement stricter waste management procedures, prioritizing sorting at WPP3R so that only residue waste is sent to landfills.
   - Increase education and socialization efforts to raise public awareness about the importance of waste sorting through intensive campaigns and training that reach all levels of society.

b. **Improving WPP3R Access and Quality:** Enhance facilities and increase the number of WPP3Rs in each sub-district to ensure communities have easy access to separate and process waste.

c. **Providing Incentives for Community Participation:** Offer incentives to individuals or communities actively engaged in waste management, such as rebates on waste service fees or performance-based awards.

d. **Collaboration between the Public and Private Sectors:** Encourage the private sector to take a more active role in waste management, including providing more efficient waste treatment technologies and supporting funding for waste management infrastructure.

e. **Infrastructure and Facility Improvements:**
   - Improve the quantity and quality of waste management infrastructure, including the construction of modern recycling centers.
   - Implement a modern, reliable, and efficient waste management system using environmentally friendly technologies.

f. **Community Education and Empowerment:**
   - Intensify public education and awareness campaigns to improve waste sorting at the source and increase participation in programs such as waste banks.
   - Strengthen human resources and increase budgets to adequately support employees working in the waste sector.

g. **Multistakeholder Collaboration:**
   - Establish close cooperation between communities, government, and the industrial sector to promote sustainable waste management.
   - Encourage participation from diverse groups, including students, in research, policy advocacy, and concrete actions to drive change.

By addressing these challenges through well-planned policies, adequate infrastructure, and active participation from all segments of society, South Tangerang City is expected to progress toward more effective, environmentally friendly, and sustainable waste management.

Author's Contributions

Conceptualization, R.S., A.A.S., E.S.; methodology, R.S., A.A.S., E.S.; software, R.S., A.A.S.; validation, R.S., A.A.S.; formal analysis, R.S., A.A.S.; research, R.S., A.A.S.; resources, R.S., A.A.S.; data curation, R.S., A.A.S.;

writing—preparation of original drafts, R.S., A.A.S.; writing—reviewing and editing, R.S., A.A.S.; visualization, R.S., A.A.S.; supervision, A.A.S.; project administration, A.A.S.; All authors have read and approved the published version of the manuscript.

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Institutional Review Board Statement

This research was conducted with the approval of the Muhammadiyah University Jakarta Ethics Committee No. 186-2024 and has obtained written consent from stakeholders.

Informed Consent Statement

Not applicable.

Data Availability Statement

No new data were created or analyzed in this study.

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Conflict of Interest

The authors declare no conflict of interest.

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