



Lessons Learned for Visionary Waste Reduction and Management in Indonesia

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Abstract. The management and reduction of waste in Indonesia present complex challenges amidst a growing population and diverse cultural landscape. This study employs a mixed-method approach, combining moving average and ARIMA forecasting methods, to map future trends in waste accumulation from 2024 to 2026. The analysis considers variables such as waste composition and sources to forecast patterns and potential extremes in waste generation across different regions. Results highlight non-stationary patterns in waste data, necessitating transformations for stationary modelling. Furthermore, policy adoption and community innovation emerge as critical factors influencing waste management outcomes. While Indonesia has implemented policies aimed at reducing plastic waste and improving waste infrastructure, inconsistencies in policy enforcement and community engagement remain significant hurdles. The study underscores the need for strengthened infrastructure, resource allocation, and stakeholder cooperation to stabilize waste generation and enhance sustainable waste management practices nationwide. In conclusion, addressing these challenges requires integrated approaches that align policy frameworks with local innovations and community behaviors.

Keywords: Forecasting, Policy Adoption, Waste Management. First Section

1 Introduction

Waste management in Indonesia is regulated by Undang-undang No. 18 of 2008. This legislation covers various aspects including the types of waste, categorized as household waste, like household waste, and specific waste[1]. Based on data from the Ministry of Environment and Forestry and the Central Bureau of Statistics, Indonesia produced over 28 million tons of waste in 2023. However, this data only represents 239 out of a total of 514 districts/cities, thus not reflecting the national waste volume comprehensively.

In terms of waste composition, more than 41% of Indonesia's waste consists of food leftovers, with a significant portion also being plastic waste at 18.6%, wood/branches/leaves at 11.5%, and paper/cardboard at 10.5%. By source, over 44%

originates from households, 7.3% from offices, and the remainder from traditional markets, business centers, public facilities, and others.

To address this issue, the government has implemented various policies such as waste segregation, expanding landfill and final disposal sites, and promoting recycling. Additionally, Presidential Regulation No. 97 of 2017 outlines the national policy and strategy for managing household waste and similar waste, including specific waste (Jaktranas)[2]. Through this policy, the government aims to reduce waste by 30% by 2025. However, as of 2024, indicators for measuring waste reduction and management levels have not yet been formulated or published [3].

As decision-makers and policymakers, the Indonesian government has established top-down and bottom-up policies that are implemented across all regions[4]. Provinces have the authority to develop localized waste management policies in accordance with local environmental conditions, as granted by Undang-undang No. 18 of 2008. Notably, Jakarta has been granted autonomous waste management authority under Article 46 of this law[1]. To facilitate these efforts, the government has launched a digital platform called SIPSN, which provides waste data and showcases Indonesia's progress in waste reduction.



Figure 1. Platform digital SIPSN oleh Kementerian Lingkungan Hidup dan Kehutanan Indonesia

Figure 1 illustrates that during the year 2023, the government achieved a waste reduction of 15.36%, resulting in 67.12% of waste being effectively managed. However, the platform does not specify the indicators used to calculate these percentages. Notably, 32.88% of waste remains unmanaged, highlighting a pressing issue that the government prioritizes in waste management efforts.

According to research indexed in Web of Science using keywords such as #wastemanagement and #publicpolicy, studies on waste management predominantly focus on its economic, business, environmental science, and management impac



Figure 2. Thematic Research from Web of Science

Research from economic and business perspectives explores innovations in waste handling and management, transforming waste into alternative beneficial forms that contribute to local economic development, such as crafts, fertilizers, and art. Studies focusing on environmental sciences examine the impacts of waste on the environment, including water, soil, and air pollution caused by untreated waste containing hazardous materials. These issues are highlighted in studies which note divergent stakeholder views on waste management, conflicts of interest among stakeholders seeking profit, and discrepancies in waste management practices at landfills that violate regulations[5].

In addition, several studies discuss technological innovations applicable to waste management and reduction. However, the adoption of these technologies by governments faces challenges due to time, cost, resource constraints, and bureaucratic complexities. Previous research often overlooks the crucial aspect of human resources in waste management and reduction efforts in Indonesia. To address these gaps, this study employs a mixed-methods approach combining forecasting [5], [6]and qualitative content[7] analysis to answer three research questions (RQs):

RQ1: What are the projected trends in waste accumulation in Indonesia over the next three years?

RQ2: What is the level of community intelligence and innovation regarding waste management and reduction in Indonesia?

RQ3: What are the current policy adoptions for waste reduction and management implemented in Indonesia?

This study represents a pioneering effort utilizing a mixed-methods approach to provide a comprehensive review of waste accumulation trends while considering the state of community intelligence in waste management in Indonesia. Thus, our review contributes significantly to (i) understanding waste reduction and management practices, (ii) informing policymakers of the community's capability to address waste challenges, and (iii) identifying policy adoptions available to the government to tackle waste management and reduction issues in Indonesia.

2 Theoretical Review

Types of waste in Indonesia are classified under UU No. 18 of 2008 into three categories: household waste, similar to household waste, and specific waste. Household waste includes residues from daily household activities such as food scraps, paper, plastic, metals, fabrics, and other discarded items[1]. This type of waste, often referred to as domestic or kitchen waste, contributes significantly to Indonesia's waste accumulation, exacerbated by a population exceeding 275 million as of 2022.

Similar to household waste consists of waste from commercial areas, industrial zones, special areas, social facilities, public amenities, and/or other facilities. Specific waste comprises hazardous materials, toxic waste, disaster debris, or technologically unprocessable waste, now governed by Government Regulation No. 27 of 2020 on specific waste management.

Why does waste accumulation occur, and what are its impacts? Waste accumulation in Indonesia stems from complex factors encompassing social, economic, and environmental aspects: (i) Rapid population growth and urbanization lead to increased consumption of goods and services, resulting in higher waste production[8], [9]; (ii) Economic progress and improved living standards influence consumer patterns, escalating daily waste generation[10], [11]; (iii) Not all regions in Indonesia are equipped with sufficient waste management infrastructure, including collection, transportation, and disposal facilities; (iv) Changing lifestyles favoring single-use and packaged goods have escalated plastic and non-organic waste volumes; (v) Public awareness and recycling practices vary, necessitating improvement across society; (vi) Some areas lack financial and resource capabilities to effectively manage waste, resulting in illegal dumping or suboptimal disposal practices; (vii) Shifts in social and cultural norms affect waste disposal behaviors and overall waste generation[12].

The impacts of waste accumulation extend beyond environmental degradation, affecting local communities living and working near landfill sites. These impacts also manifest in health risks, social implications, and eroding public trust in governmental performance.

3 Materials and Methods

This study employs a mixed-methods approach, combining quantitative and qualitative research techniques [13], [14]. Quantitative research initially forecasts waste conditions from 2024 to 2026 using secondary data sourced from Statistics Indonesia covering 2009 to 2023, focusing on variables such as total waste, annual waste reduction, waste management practices, waste sources, and waste composition. Subsequently, a comprehensive literature review explores various sources including journal articles, news reports, and annual publications from the Ministry of Environment and Forestry.

This research excels in assessing community intelligence and innovation in waste reduction and management in Indonesia[15]. The mixed-methods approach adapts methodologies for analysing waste management literature, as depicted in Figure 3. Detailed procedures for data collection and analysis are elucidated in subsequent sections.

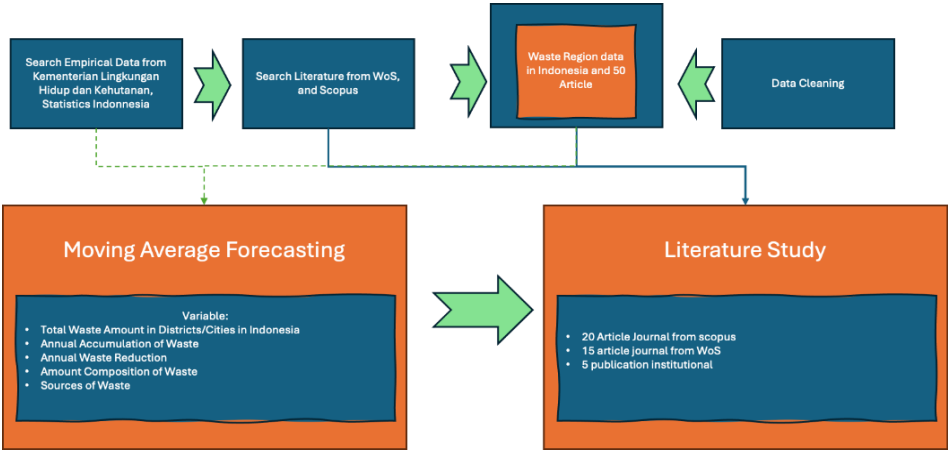


Figure 3. Research framework adopted for mapping healthcare waste (HCW) management research from 1985 to 2021.[16]

4 Result and Discussion

Based on the research questions underlying the forecasting analysis, the aim is to map the projected waste conditions in Indonesia for the next three years: 2024, 2025, and 2026. Using the moving average method and variables such as total waste volume, waste composition, and waste sources, the forecasting results are obtained as follows:

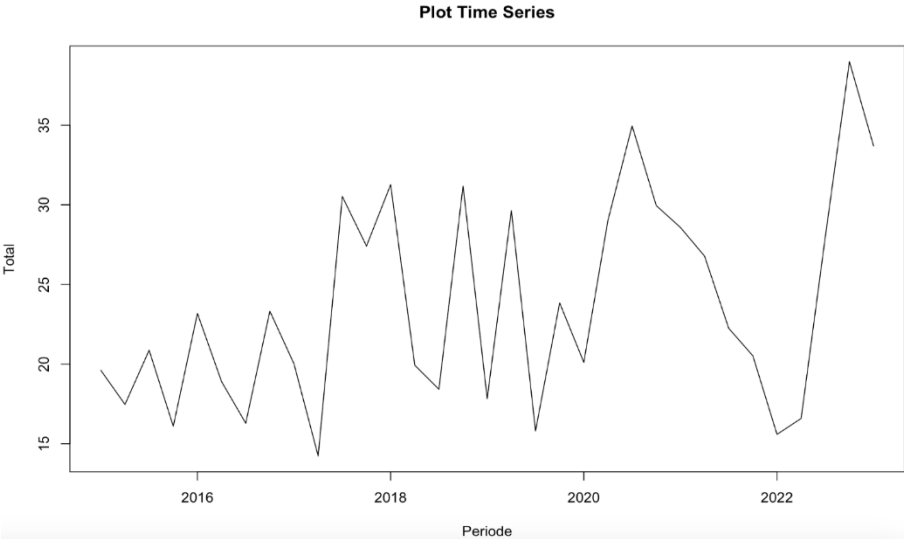


Figure 4. Time Series Data of Waste Production

The forecast indicates trends in the composition of waste types, such as organic, plastic, paper, metal, and others, highlighting changes over the forecasted period. Analysis of waste sources forecasts the contributions from different sectors such as households, commercial areas, industries, special zones, social facilities, public amenities, and other sources. The moving average method is applied to smooth out variations in data and provide a clearer trend analysis for each variable across the specified years. These projections serve to inform policymakers and stakeholders about future waste management needs and challenges in Indonesia.

Based on Figure 4, it can be observed that in 2024, there is a valley pattern occurring between April-September and a peak between October-March. Similarly, in 2025, there is also a valley pattern between April-September and a peak between October-March. However, in 2026, a valley pattern occurs between June-November and a peak between December-May. These patterns indicate that the data series exhibits non-stationary behavior, thus requiring transformation to adjust to a stationary model.

Based on the time series analysis above, forecasting the waste weight in Indonesia can be conducted using a Seasonal ARIMA (0,1,1)(0,1,0) model. The forecasting utilizes all historical data of waste weight in Indonesia from January 2009 to December 2023. Here is a summary of the results obtained.

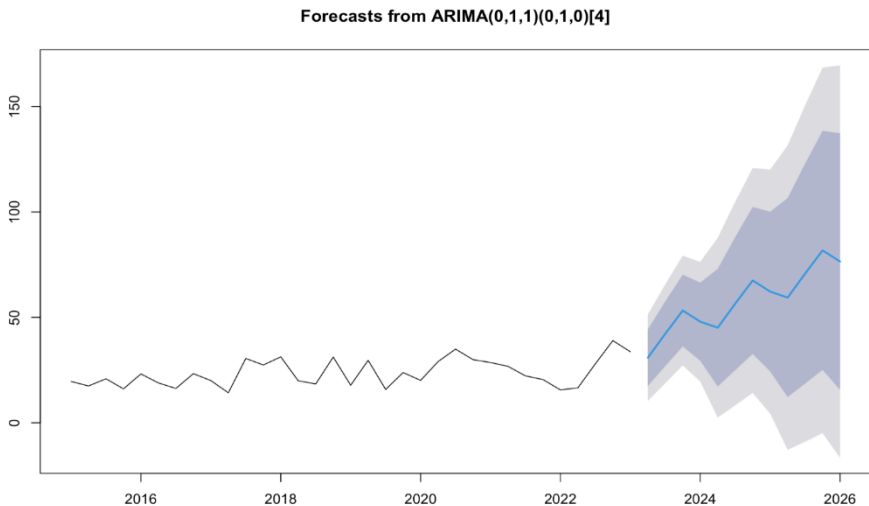


Figure 5. Forecasting Result of Waste Production using ARIMA (0,1,1) (0,1,0) until 2026

Figure 5, three forecasting trends are evident: rapid increase, moderate, and gradual decline. From these categories, it can be explained that there is a possibility of extreme increase in waste volume in Indonesia due to the absence of waste management regarding waste composition and sources. Based on this statement, the researcher reviewed 5 articles which explain that the government's inability to control waste composition and sources can backfire, leading to an increase in extreme waste, and this impact also triggers poorly managed final waste disposal sites[17], [18]. With weaker policies, communities will struggle to manage waste according to its composition, and waste management stakeholders will find it difficult to identify waste sources. However, if the

government maintains the current condition, the increase in waste will stabilize in the following years. Based on these findings, 7 articles have been collected and further analysed, highlighting that strengthening infrastructure, resources, resolving conflicting interests[5], [14], and adjusting waste management bureaucracy are key to stabilizing waste quantities in Indonesia.

Regarding the third category, waste quantities could experience a significant decrease if and only if the government implements waste management policies tailored to regional needs. This is exemplified in the study [13] on waste management, which showed improvement when government policies focused on handling, socialization, and community support for waste management starting from the smallest level, such as households. Household waste can be separated based on its composition and placed in different containers. Conversely, the situation in DI Yogyakarta, particularly at the Piyungan landfill, serves as an example of government and community failure, along with the role of relevant stakeholders, in addressing waste issues[19], [20].

Indonesia, as a country with a large population and cultural diversity, faces unique challenges in waste management. Firstly, there is an increasing awareness among the populace about the importance of waste management and its environmental impact. This is reflected in the growing participation in recycling programs in several major cities. For instance, local communities and grassroots initiatives in various areas have independently adopted recycling and composting practices to reduce the amount of waste going to landfill[21].

Secondly, there are emerging innovations in waste management at a smaller scale. Examples include the use of applications to facilitate waste collection and management at the community level, as well as the development of recycling products by small and medium enterprises that support sustainable economic practices. However, there remain challenges in transforming societal behaviours comprehensively and integrating these innovations into broader national policies [3].

Additionally, several policies have been adopted to address waste management and reduction issues. One of the key policies involves implementing plastic waste reduction programs, such as banning plastic bag usage in several major cities and prohibiting plastic straw usage in various public places. The government has also been proactive in enhancing more efficient waste management infrastructure, including the development of integrated recycling systems and managing household waste, similar to that of the household and specific waste. Therefore, there is great potential for further development in waste reduction and management policies in Indonesia by engaging more stakeholders and enhancing coordination among the government, civil society, and private sector.

5 Conclusion

Based on the time series analysis conducted using moving average and ARIMA methods, it reveals varying patterns in waste generation in Indonesia for the upcoming years. These patterns reflect challenges in managing waste amidst changing economic and social conditions. Therefore, it can be concluded that despite the potential for increased

awareness and innovation in waste management within some communities, major challenges still include handling diverse waste compositions and uncontrolled waste sources. This situation could potentially lead to a significant increase in waste if appropriate management actions are not taken. Moreover, the adoption of plastic waste reduction policies and efforts to enhance waste management infrastructure have impacted several major cities in Indonesia. Addressing the complexity of waste management in Indonesia requires strengthening infrastructure, resources, and stakeholder coordination. Initiatives to raise public awareness, support local innovation, and reinforce waste management policies are key to achieving more sustainable and effective waste management in the future. Thus, further research should focus on conducting in-depth case studies on the implementation of waste management policies in various cities or provinces in Indonesia to understand challenges, successes, and lessons learned.

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