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THE EFFECTIVENESS OF ENVIRONMENTAL FUNCTION SPENDING IN IMPROVING WASTE MANAGEMENT EFFICIENCY IN INDONESIA

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Abstract

Waste management continues to pose a significant challenge for Indonesia in achieving sustainable environmental development. Constraints in infrastructure, institutional coordination, and policy coherence make the role of environmental function spending by local governments increasingly important in improving waste management efficiency and delivering better public services. This study investigates the influence of environmental function spending on waste management efficiency in Indonesia using a quantitative approach with panel data from 34 provinces covering the period 2019–2023. A random-effects panel regression model was utilized, selected based on a series of statistical tests to address unobserved heterogeneity across provinces. The findings indicate that environmental function spending exerts a positive and significant effect on waste management efficiency, suggesting that higher fiscal allocations to environmental functions strengthen local governments' capacity in waste collection, processing, and disposal. This relationship suggests that increased and well-targeted environmental spending can promote more efficient and sustainable waste management systems. From a policy perspective, the findings highlight the importance of implementing performance-based budgeting, strengthening institutional capacity, and developing fiscal incentives to ensure that environmental spending effectively supports sustainable waste management and broader environmental goals.

INTRODUCTION

Environmental challenges have increasingly drawn global attention, including in Indonesia, as the amount of waste generated continues to rise. This growth is largely influenced by expanding populations, rapid urban development, and changes in consumption behavior (Han *et al.*, 2019; Wikurendra *et al.*, 2024; Zahrah *et al.*, 2024). According to data released by the Ministry of Environment and Forestry, Indonesia produces over 60 million tons of waste annually, yet the proportion successfully managed is still below the desired benchmark. At the same time, local governments that are responsible for waste management continue to face challenges related to financing, policy implementation, and institutional capacity (Budiyarto *et al.*, 2024; Latanna *et al.*, 2023; Zahrah *et al.*, 2024). These challenges highlight the urgency of improving waste management efficiency through effective and accountable fiscal policies, particularly environmental function spending in the Regional Budget (APBD).



Several studies have examined the role of public sector spending in improving environmental performance. For example, research conducted by Doussoulin and Colther (2022), Ferreira et al. (2020), Honma and Hu (2021), and Sennante et al. (2023) shows that increases in environmental expenditures do not always lead to better waste management outcomes, suggesting the presence of inefficiencies in the use of public funds. This indicates a gap between the expectations of performance-based budgeting and its practical implementation at the local government level. In contrast, the studies by Ma et al. (2018), Suhardono et al. (2025), and Xiao et al. (2023) highlight that data-driven planning, transparent fiscal management, and active community participation can contribute to higher levels of waste management efficiency. These findings imply that the effectiveness of environmental function spending is influenced not only by the size of the budget allocation but also by how strategically and efficiently it is managed.

From a conceptual standpoint, this study is based on Public Expenditure Theory (Musgrave, 1959), which argues that public spending should produce measurable improvements in public service outputs and outcomes. Within the context of waste management, environmental function spending acts as a fiscal instrument intended to increase waste management efficiency through investments in infrastructure, technology, and institutional capacity (Bui *et al.*, 2020; Neto *et al.*, 2024; Wang *et al.*, 2022). The theoretical connection between environmental function spending and waste management efficiency lies in the assumption that higher and more targeted expenditures strengthen waste collection, transportation, and processing efficiency, which represent the core dimensions of waste management efficiency. The proxy for environmental function spending in this study is the percentage of APBD allocation for environmental functions, while waste management efficiency is proxied by indicators such as waste collection coverage or volume of waste managed per capita.

Although there is considerable literature on fiscal performance and environmental policy, empirical studies focusing on the direct relationship between environmental function spending and waste management efficiency in Indonesia remain limited, especially those incorporating longitudinal and cross-regional panel data methods. This shortage of empirical evidence creates an important research gap that this study aims to fill.

The purpose of this study is to empirically examine the impact of environmental function spending on waste management efficiency at the provincial level in Indonesia over the most recent five-year period, using a panel data approach that includes control variables such as population size and land area.

By addressing the identified research gap and applying a longitudinal quantitative framework, this study contributes to the literature on regional fiscal policy and environmental management. The findings are expected to offer both theoretical insights into the efficiency of public expenditure and practical recommendations for local governments in optimizing budget allocations to improve waste management outcomes.

HYPOTHESIS DEVELOPMENT

The concept of effective public sector spending is a fundamental idea in Public Expenditure Theory, which states that government budgets are expected to generate measurable improvements in public service performance (Musgrave, 1959). In this theoretical context, environmental function spending operates as a fiscal instrument that enables local governments to allocate resources for environmental initiatives such as waste management, pollution control, and environmental conservation. Effective allocation and utilization of this budget are expected to strengthen the technical and operational capacity of local institutions to manage waste efficiently through better infrastructure, equipment, and human resources.

Several studies emphasize the link between fiscal allocation and service performance.

Honma & Hu (2021) and Tang et al. (2024) found that environmental investment in waste transport systems, landfill management, and recycling programs significantly improves waste service outcomes. Similarly, Zhao & Xu (2022) showed that increased environmental spending enhances local governments' ability to deliver sustainable waste solutions, particularly when accompanied by strong institutional governance.

Several recent studies further emphasize the positive relationship between environmental fiscal allocation and waste management performance. Guzy et al. (2024) analyzed the efficiency of environmental protection expenditure among EU countries and found that higher government spending on environmental functions significantly improved waste management outcomes and contributed to achieving sustainable development goals. Similarly, Mihaliková et al. (2022) demonstrated that increased public expenditure on environmental protection and infrastructure investment positively affected the recycling rate and energy recovery from municipal waste in the Slovak Republic and other European regions. Conversely, Senante et al. (2023) highlighted that higher spending levels do not always lead to proportional efficiency gains, particularly when budget planning and implementation capacity are weak. This finding reinforces the notion that while environmental spending is crucial, its effectiveness depends on how efficiently resources are allocated and managed. Collectively, these studies indicate that well-targeted and efficiently implemented environmental function spending can enhance waste management efficiency by strengthening infrastructure capacity, optimizing resource utilization, and improving institutional coordination.

From a conceptual perspective, environmental function spending can influence waste management efficiency through two mechanisms. First, direct fiscal input, increased spending expands the availability of waste collection, sorting, and disposal facilities, which directly improves efficiency. Second, indirect institutional effects, sustained budget commitment fosters better coordination, monitoring, and technological adoption within local waste agencies. In addition, control variables such as population and land area may influence the relationship: population represents the scale of waste generation, while land area reflects the spatial complexity of managing waste across provinces.

Based on these theoretical and empirical insights, the conceptual framework of this study is illustrated in Figure 1, depicting the relationship between environmental function spending and waste management efficiency, with population and land area as control variables.

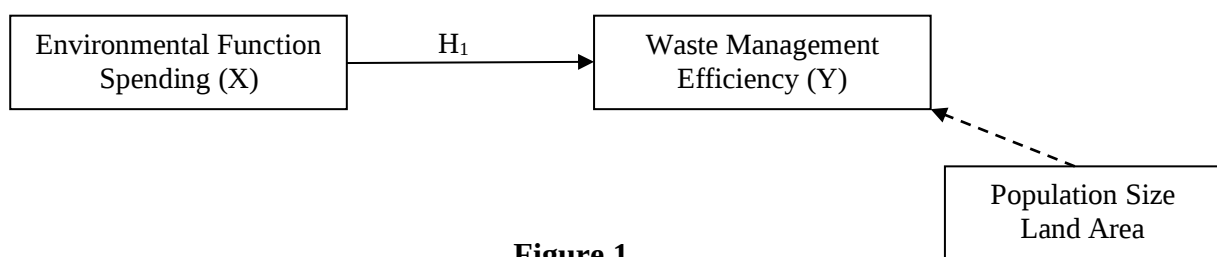


Figure 1.
Conceptual Framework

By considering both the theoretical framework and empirical findings, this study proposes that efficient fiscal allocation toward environmental functions improves waste management performance. Based on this rationale, the hypothesis formulated in this study is as follows:

H₁: Environmental function spending has a positive effect on waste management efficiency.

RESEARCH METHOD

This study employs a quantitative research approach and utilizes panel data regression



as the primary analytical method. The use of panel data enables the researcher to observe differences across provinces in Indonesia within a specified timeframe while simultaneously capturing changes that occur from year to year. Panel regression is considered appropriate because it accommodates both cross-sectional and time-series characteristics, allowing the model to account for variations across units and to control for unobserved heterogeneity (Fan *et al.*, 2022; Kurniawan *et al.*, 2025; Tang *et al.*, 2024).

The dataset used in this study consists of annual observations from 34 provinces in Indonesia for the period 2019–2023, resulting in 170 province-year data points. All data employed are secondary in nature and sourced from official government institutions. Information on population and land area is retrieved from the Central Statistics Agency (BPS), while indicators related to waste management performance are provided by the Ministry of Environment and Forestry (KLHK). Meanwhile, data on environmental function spending are obtained from the Directorate General of Fiscal Balance (DJPk). These institutional sources ensure that the dataset is both reliable and consistent, allowing for a comprehensive assessment of fiscal and environmental dynamics across provinces.

The dataset includes one independent variable, one dependent variable, and two control variables. The independent variable is Environmental Function Spending, measured in billion Rupiah according to the environmental function classification in the regional budget (APBD). This proxy is used because it reflects the local government's fiscal effort and commitment to improving environmental services, including waste management infrastructure and operations. The dependent variable is Waste Management Efficiency, expressed as the percentage of total waste managed relative to the total amount of waste produced. This indicator serves as a proxy for waste management efficiency because it captures the extent to which local governments can effectively process, recycle, or dispose of waste compared to the total waste produced. Two control variables are included: Population size (in millions of people) to represent demographic pressure on waste generation, and Land area (in square kilometers) to control for geographical differences that may affect the scale and complexity of waste management.

$$WME_{it} = \alpha + \beta_1 EFS_{it} + \beta_2 POP_{it} + \beta_3 AREA_{it} + \varepsilon_2$$

Where i denotes the province and t denotes the year.

The data analysis is carried out using STATA 17. The procedure for selecting the most suitable panel regression model involves two steps. The first step involved the Chow test, which assesses whether the Pooled Least Squares (PLS) model or the Fixed Effects Model (FEM) provides a better fit. The second step is the Hausman test, which determines whether the Fixed Effects Model or the Random Effects Model (REM) is more appropriate. The final model is chosen based on the p-values obtained from these tests.

Before estimating the model, several classical assumption tests were carried out to verify the validity and reliability of the regression results. These included examinations for multicollinearity, heteroskedasticity, and autocorrelation. The outcomes indicate that there were no major violations of these assumptions, showing that the model satisfies the statistical criteria for unbiased and consistent estimation. After these assumptions were verified, the selected panel regression model was used to analyze the effect of environmental function spending on waste management efficiency, while also incorporating the contributions of the control variables.

RESEARCH RESULTS AND DISCUSSION

This study explores how environmental function spending contributes to variations in waste management efficiency across provinces in Indonesia. Using a panel data approach, the analysis incorporates 170 observations drawn from 34 provinces over the 2019–2023 period.

The composition of this dataset allows the research to observe not only differences between provinces at a given point in time but also changes that occur across years, providing a more comprehensive understanding of fiscal and environmental performance dynamics.

Descriptive Statistics

Before estimating the regression model, descriptive analysis was conducted to provide an overview of the data distribution. During the 2019-2023 period, the average environmental function spending across provinces in Indonesia reached IDR 223.58 billion, with significant variation between provinces due to differences in fiscal capacity. The average volume of waste managed was 587,258 tons, indicating that approximately two-thirds of generated waste was successfully collected, processed, or disposed of. The mean population size was 7.99 million people, while the average land area was 54,652 km², reflecting Indonesia's broad demographic and geographical diversity. These descriptive results confirm that fiscal and demographic disparities are likely to influence variations in waste management efficiency, thereby justifying the inclusion of control variables in the model.

Model Estimation Results

Fixed Effects Test

The results generated from the Fixed Effects model indicate that none of the independent variables exhibit a statistically significant impact on the dependent variable. The coefficient for environmental function spending amounts to $-1.14e-07$ with a p-value of 0.170, suggesting that variations in this expenditure do not meaningfully influence the outcome within the fixed-effects framework. Likewise, the population variable produces a coefficient of 19.71 ($p = 0.701$), and land area shows a coefficient of 0.044 ($p = 0.977$), both of which are statistically insignificant. The within R-squared value of 0.015 indicates that the model explains only a very small share of the changes observed within provinces over time.

Despite these results, the F-test for the joint significance of the provincial fixed effects yields a p-value of 0.000, confirming that substantial differences exist across provinces. These differences are not entirely captured by the variables included in the model, indicating the presence of unobserved heterogeneity. This implies that provincial characteristics, such as institutional capacity, policy implementation effectiveness, or local governance quality, may vary considerably and influence the dependent variable beyond what the included predictors can explain.

Random Effects Test

The Random Effects model produces more robust and persuasive statistical results. The coefficient for environmental function spending is $2.80e-07$ with a p-value of 0.000, indicating strong significance at the 1 percent level. This suggests that each additional one million Rupiah allocated to environmental functions contributes to an increase of roughly 0.28 tons of waste that can be effectively managed. The magnitude and significance of this coefficient highlight the important role of fiscal allocations in strengthening environmental programs and improving waste management performance.

The population variable also yields a positive and statistically significant effect, with a coefficient of 60.91 ($p = 0.000$). This means that an increase of 1,000 residents is associated with an additional 60 tons of waste being properly handled. This result reflects the idea that larger populations often coincide with better-developed waste management infrastructure, or increased fiscal capacity, allowing for improved service performance. However, the land area variable remains statistically insignificant (coefficient -0.815 ; $p = 0.192$), suggesting that the physical size of a province does not have a strong or direct relationship with waste management efficiency.

Table 1.



Random Effects Regression Estimates on Managed Waste

Variables	Koefisien	Std. Error	z-statistik	p-value	95% CI
Environmental Spending	2.80E-07	4.49E-08	6.24	0	1.92e-07 – 3.68e-07
Population	60.91	3.25	18.73	0	54.54 – 67.28
Land Area	-0.815	0.625	-1.31	0.192	-2.04 – 0.41
Constant	82,649.05	58,070.51	1.42	0.155	-31,167 – 196,465

Source: Author's computation using STATA 17, 2025

Table 1 shows that environmental function spending and population both produce positive and statistically significant coefficients in explaining the volume of waste that is successfully managed. These results indicate that greater fiscal allocations toward environmental functions, as well as provinces with larger populations, tend to exhibit better waste management performance. In contrast, the land area variable does not show statistical significance, suggesting that the geographic size of a province is not a major factor influencing the effectiveness of waste management activities.

Model Selection and Diagnostic Tests

To identify the model that best fits the data, a Hausman test was performed. The test yielded a chi-square value of 1.10 with a p-value of 0.5782, indicating that the Random Effects model is the more suitable and efficient option for this study. This outcome implies that the unobserved cross-sectional differences across provinces operate as random rather than fixed effects, and that the discrepancy between the Fixed Effects and Random Effects estimates is not statistically significant.

Furthermore, additional diagnostic checks conducted in STATA confirmed that the model fulfills the key classical assumptions, including the absence of multicollinearity, no evidence of autocorrelation, and homoscedastic residuals. Meeting these assumptions supports the validity and reliability of the model's estimation results.

Discussion

The results of this study show that environmental function spending contributes positively and significantly to improving waste management efficiency. This outcome aligns with Musgrave (1959) Public Expenditure Theory, which emphasizes that government spending should generate observable advancements in public welfare and the performance of public services. The positive coefficient obtained from the Random Effects model indicates that higher fiscal allocations for environmental programs strengthen waste management capacity through improved processes of collection, sorting, recycling, and final disposal.

This outcome is in line with the findings of Rivero et al. (2025) and Syahputra et al. (2025), who emphasize that the success of environmental spending is influenced not only by the size of the budget but also by the precision and effectiveness of its allocation. In the context of this study, the empirical evidence demonstrates that environmental function spending acts as a fiscal input that produces tangible environmental service outputs, strengthening the argument that fiscal policy is a governance instrument rather than a purely financial mechanism.

The inclusion of population and land area as control variables helps ensure the robustness of the model. The positive relationship between population and managed waste confirms the expected demographic effect: provinces with larger populations generate and manage more waste. However, since population serves as a control variable, this relationship is interpreted as contextual rather than causal. The insignificance of land area implies that physical size alone does not determine waste management efficiency once fiscal and demographic factors are controlled. This aligns with Budiarto et al. (2024), who emphasize that institutional capacity and the quality of fiscal management are more decisive than geographical

characteristics.

The difference in significance between the Fixed Effects and Random Effects models provides additional theoretical insight. The insignificance of environmental function spending in the FE model but significance in the RE model suggests that cross-provincial fiscal disparities play a greater role than short-term variations within provinces. This indicates the presence of a lagged fiscal effect, where the benefits of environmental spending materialize gradually as infrastructure and institutional capabilities improve over time. This reinforces the notion that evaluating fiscal policy effectiveness in environmental sectors requires a longitudinal perspective rather than a purely annual analysis.

From a theoretical standpoint, the results strengthen the allocative function of Musgrave's Public Expenditure Theory, showing that effective government spending allocation toward environmental programs can produce measurable efficiency improvements in waste management. This study also expands the empirical application of the theory by incorporating environmental outcomes as an extension of fiscal performance analysis.

In terms of policy implications, the findings of this study suggest that local governments need to strengthen performance-based budgeting mechanisms so that increases in environmental spending are directly linked to measurable improvements in waste management efficiency, rather than merely reflecting nominal budget expansion. This fiscal commitment should be accompanied by institutional capacity-building efforts, including the development of human resources, enhancement of data management systems, and improved coordination across agencies involved in waste management. Furthermore, the central government can play a strategic role by designing conditional fiscal transfers or performance-based incentives to encourage provinces with relatively low efficiency to align their spending priorities with environmental outcomes. To ensure the sustainability of these efforts, continuous monitoring and evaluation mechanisms are essential, enabling policymakers to verify whether fiscal allocations in the environmental sector effectively translate into tangible progress in waste collection, processing, and recycling performance.

CONCLUSION

Based on the empirical assessment of environmental function spending and waste management efficiency in Indonesia, this study determines that environmental function spending has a positive and statistically significant influence on waste management efficiency. The evidence indicates that higher and more strategically directed budget allocations for environmental functions enhance the capacity of local governments in managing waste, thereby contributing to progress in sanitation and environmental sustainability objectives. The results suggest that local governments need to strengthen performance-oriented budgeting practices, allocate environmental funds more effectively, and invest in institutional capacity. At the same time, the central government can foster regional efficiency by providing fiscal transfers that are linked to performance incentives. Despite the contributions of this research, several limitations remain, particularly the reliance on provincial-level secondary data, which may not fully capture variations occurring at the municipal level or reflect qualitative aspects of governance. Future research is recommended to incorporate micro-level data or mixed-method approaches to gain a more detailed understanding of waste management performance. Expanding the scope to include other environmental indicators, such as air quality, water treatment, and circular economy initiatives, may also provide a broader perspective on environmental outcomes.

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