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ECONOMIC GROWTH EFFECT ON ENVIRONMENTAL POLLUTION IN INDONESIA

Normanda Eka Shakti [*1]
Prayudi Setiawan Prabowo [2]

[1,2] Faculty of Economics and Business, State University of Surabaya, Indonesia
*e-mail: normanda.21024@mhs.unesa.ac.id, prayudiprabowo@unesa.ac.id

Abstract

This study examines the impact of economic growth on environmental pollution across Indonesia's provinces, utilizing Gross Regional Domestic Product (GRDP) at current market prices as the primary economic indicator and population density as a control variable. Employing a quantitative approach with cross-sectional secondary data from Indonesia's Central Statistics Agency (BPS), the research conducts multivariate regression analysis on data from all 34 provinces. Comprehensive diagnostic tests, including assessments of normality, multicollinearity, autocorrelation, and model specification, were performed to validate the statistical model. The findings reveal that both GRDP and population density exert statistically significant positive effects on environmental pollution, though the magnitude of these effects is relatively modest. The model explains approximately 44.35% of the variation in environmental pollution, suggesting that additional factors beyond economic and demographic variables contribute substantially to pollution dynamics. This research provides contemporary empirical support for the Environmental Kuznets Curve (EKC) hypothesis in the Indonesian context, emphasizing the necessity for integrated policy approaches that balance economic development with environmental sustainability.

Keywords: *economic development, environmental pollution, GRDP, population density, EKC, Indonesia*
JEL: Q53, O13

INTRODUCTION

In the development of a country, the economy is one of the important aspects that needs to be considered, especially in terms of people's livelihoods (Feigenberg et al., 2013). Economic development in various countries has diverse impacts, one of which is environmental pollution (Fofack et al., 2019), partly due to industrial growth (Akbar Maulana Ramadhan, 2023). Studies from various countries have produced relatively similar results. This hypothesis is based on research by (Fofack et al., 2019), (Cheikh, S., & Latifa, 2017), (Maojun et al., 2011), (Akinrogunde et al., 2025).

Indonesia's economic development in recent decades has shown significant progress, reflected in consistent Gross Domestic Product (GDP) growth. However, behind these successes, concerns have arisen about their impact on environmental quality. Industrial activities and intensive exploitation of natural resources are suspected to be the main causes of environmental degradation occurring in various regions.

National economic development in recent years has shown a positive impact on improving the economic sector, as indicated by the increase in the Gross Regional Domestic Product (GRDP) value in various provinces in Indonesia. Based on data recorded on the official website of the Central Statistics Agency (BPS), a consistent increase in GRDP occurred in almost all provinces. Several provinces experienced rapid growth; for example, Riau showed GRDP growth of 35.0% (from IDR 760.2 trillion in 2019 to IDR 1,026.5 trillion in 2023) (BPS, 2019)(BPS, 2020)(BPS, 2021b)(BPS, 2022)(BPS, 2023). Similarly, East Kalimantan grew by 29.3% (from IDR 652.5 trillion to IDR 843.6 trillion) in the same period (Central Statistics Agency, 2019-2023). Other provinces such as West Java and DKI Jakarta also recorded significant growth, by 23.6% and 22.3% respectively (from IDR 760.2 trillion in 2019 to IDR 1,026.5 trillion in 2023) (BPS, 2019)(BPS, 2020)(BPS, 2021b)(BPS, 2022)(BPS, 2023).

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However, despite this rapid economic growth, analysis of environmental pollution data reveals alarming impacts. Data show a 91.7% increase in the number of villages affected by water pollution nationally between 2014 and 2018, from 8,786 to 16,847 (Central Statistics Agency, 2014, 2018). This pattern appears to coincide with economic growth in several regions. As an illustration, Central Java, whose GRDP reached IDR 1,695.6 trillion in 2023 (from IDR 760.2 trillion in 2019 to IDR 1,026.5 trillion in 2023) (BPS, 2019)(BPS, 2020)(BPS, 2021b)(BPS, 2022)(BPS, 2023), experienced an increase in the number of villages with water pollution from 932 villages in 2014 to 1,900 villages in 2018 (BPS, 2014)(BPS, 2018) A similar pattern was observed for cases of soil pollution in the same province, which increased from 183 villages to 380 villages in the same period (BPS, 2014)(BPS, 2018) This gap between the sustainable development agenda and the reality of environmental degradation worsens the condition of the ecosystem, especially in the area main industry.

However, based on 2021 data, the number of villages with water pollution decreased to 10,683 villages in 2021, which is still 21.6% higher than in 2014. At the provincial level, Central Java actually reported an increase to 1,310 villages in 2021, while DKI Jakarta showed progress with a decrease to 78 villages (or -38.1% from 2018) (BPS, 2021a).

This phenomenon is in line with the Environmental Kuznets Curve (EKC) theory which states that in the early stages of economic development, environmental degradation will increase along with economic growth (Simon Kuznets, 1955). This inverted U-shaped relationship pattern has been the basis of many studies on the relationship between the economy and the environment, although the results still vary depending on the country context and the analytical methods used. Several previous studies have provided inconsistent results regarding this relationship. Research by (Dinilhaq & Azhar, 2024) and (Chamid & Damayanti, 2016), as well as similar research in Canada (Fofack et al., 2019) International studies in several developing countries (Borhan, Ridzuan, Subramaniam, & Amin, 2021), and research in Algeria (Cheikh, S., & Latifa, 2017) provide supporting results but research by (Susanti, 2018) and (Akbar Maulana Ramadhan, 2023)) provide conflicting results.

Of the various types of research that are available, the aspects that are often used as research themes are water and air pollution, however, land pollution is usually not studied directly but can be concluded through research that takes the area of the river delta.

Based on this background, this study aims to provide additional perspectives in analyzing the impact of economic growth on environmental pollution in Indonesia using provincial-level data. Its contribution lies in the use of cross-sectional provincial data, which provides a comprehensive picture of variations in economic-environmental relationships at the regional level.

METHOD

This study uses a quantitative approach with a cross-sectional design to analyze the relationship between economic growth and environmental pollution in Indonesia. The data used are secondary data obtained from official publications of the Central Statistics Agency (BPS, 2024a) (BPS, 2024c) and (BPS, 2024b) covering 34 provinces in Indonesia. The sample was selected using a purposive sampling technique, adjusting for the availability of complete data for all study variables.

The dependent variable in this study is environmental pollution, operationalized as the proportion of polluted villages to the total number of villages in each province. The primary independent variable is economic growth, measured using Gross Regional Domestic Product (GRDP) at current prices in billions of rupiah. The second independent variable used is population density, calculated as the number of residents per square kilometer in each province.

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Data analysis was carried out using multiple linear regression with the following equation model:

$$\textbf{(i)} \qquad Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \varepsilon_i$$

Y_i = proportion of environmental pollution (number of polluted villages divided by the total number of villages)
X_{1i} = PDRB
X_{2i} = provincial population density
β_0 = constant,
β_1 dan β_2 = regression coefficient
ε_i = error term.

To ensure the validity of the regression model, classical assumption tests were conducted, including residual normality tests with the Shapiro-Wilk test, heteroscedasticity tests with the Breusch-Pagan test, multicollinearity tests with the Variance Inflation Factor (VIF), autocorrelation tests with the Durbin-Watson test, and model specification tests with the Ramsey RESET test. All data analysis was performed using DeepSeek V-3.1 software (DeepSeek Company, 2025), the selection of analysis tools was based on software that was compatible with the devices available during the work.

RESULTS AND DISCUSSION

Diagnostic Test Results Model

Table 1. Diagnostic Test Results

No	Assumptions	Test Method	Results	Conclusions
1	Residual Normality	Shapiro-Wilk	W = 0.957	Fulfilled
2	Homoscedasticity	Breusch-Pagan	$\chi 2$=1.13	Fulfilled
3	Multicollinearity	VIF	VIF = 1.82	Fulfilled
4	Non-Autocorrelation	Durbin-Watson	DW = 1.892	Fulfilled
5	Model Specifications	Ramsey RESET	F = 1.54	Fulfilled

Source: Results of data processing for 2025

Diagnostic tests indicate that the model meets all classical assumptions. The Shapiro-Wilk normality test results showed insignificant values, indicating normally distributed residuals. The Breusch-Pagan heteroscedasticity test was also insignificant, indicating no heteroscedasticity. A VIF value below 10 confirmed the absence of multicollinearity. The Durbin-Watson test indicated the absence of autocorrelation, and the Ramsey RESET test indicated that the model was correctly specified.

Table 2. Multivariate Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	104,4066	9,1767	11,377	0,0000

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Variable	Coefficient	Std. Error	t-Statistic	Prob.
GRDP	0,0000000815	0,000000022	3,705	0,00024
Population density	0,0000196	0,0000094	2,085	0,039

Source: Results of data processing for 2025

Based on Table 2, the regression model shows statistically significant results. The R-squared value of 0.4435 indicates that GRDP and population density are able to explain variations in environmental pollution across Indonesian provinces.
Analysis of the Effect of GRDP on Environmental Pollution. The analysis shows that GRDP has a positive and significant effect on environmental pollution. This finding is consistent with previous research that also found a positive relationship between economic growth and environmental degradation in Indonesia. These results support the early stages of the Environmental Kuznets Curve (EKC), where rapid economic growth during the early industrialization phase tends to be accompanied by increasing pressure on the environment.

Analysis of the Effect of Population Density on Environmental Pollution
The population density variable also showed a significant positive effect. This finding aligns with the theory that high population concentrations increase pressure on the environment through increased resource consumption and waste production. These results are consistent with research emphasizing the importance of considering demographic factors in environmental impact analyses.

The findings of this study provide empirical support for the validity of the Environmental Kuznets Curve (EKC) in the Indonesian context. The country is still in the early phase of the curve, where economic growth is positively correlated with increasing environmental pollution. This should be a serious concern for policymakers designing sustainable development strategies. The results of this study are in line with national-scale research by (Dinilhaq & Azhar, 2024), (Chamid & Damayanti, 2016), as well as research in Canada (Fofack et al., 2019) International Studies by (Borhan, Ridzuan, Subramaniam, Amin, et al., 2021) which focused on developing countries, as well as research in Algeria by (Cheikh, S., & Latifa, 2017) but contradict the results of research by (Susanti, 2018) and (Akbar Maulana Ramadhan, 2023) in connection with the results obtained, appropriate policies are needed to solve the environmental pollution problems that occur, supported by the results of research in East Java (Selly Febriana, Herman Cahyo Diartho, 2019) and studies in the Chinese region (Zhao et al., 2023)

Based on the analysis and discussion, it can be concluded that economic growth and population density have a significant influence on environmental pollution in Indonesia. These empirical findings confirm the validity of the Environmental Kuznets Curve hypothesis in the Indonesian context, where the country is still in the early stages of economic development, characterized by a positive correlation between economic growth and environmental degradation.
First, the GRDP variable shows a positive and significant influence on environmental pollution. Second, the population density variable also contributes to the increase in environmental pollution burden. Third, the model used has adequate explanatory power, although other factors beyond economic and demographic variables also influence environmental pollution.

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Research Limitations
This study's primary limitation lies in the use of cross-sectional data, which precludes analysis of long-term dynamics. Furthermore, the scope of the variables used is limited, as factors such as technology, environmental policy, and public awareness have not been fully incorporated into the model. The environmental pollution data used is also based on the number of polluted villages, which may not fully reflect the severity of the pollution.
The policy implications of this study emphasize the importance of an integrated approach to environmental management. The government needs to strengthen environmental regulations, encourage the adoption of environmentally friendly technologies, and increase the effectiveness of monitoring economic activities that have the potential to pollute the environment. Furthermore, spatial planning policies that consider environmental carrying capacity and control population growth in environmentally sensitive areas are crucial.

Directions for Further Research
Future research recommends using panel data with a longer observation period to more comprehensively capture the evolving relationship between economic growth and environmental pollution. Model development by incorporating institutional variables, technology, and environmental policy will also provide a deeper understanding of the mechanisms underlying the economic-environmental relationship in Indonesia.

CONCLUSION
This study investigates the impact of economic growth and population density on environmental pollution across 34 provinces in Indonesia. By employing a cross-sectional multivariate regression analysis on data from the Central Statistics Agency (BPS), this research provides empirical evidence regarding the relationship between economic development and environmental quality.
The findings reveal two key insights. First, Gross Regional Domestic Product (GRDP) has a positive and significant effect on environmental pollution. This indicates that, in the current stage of development, an increase in economic output is associated with a higher proportion of villages experiencing pollution. Second, population density also demonstrates a positive and significant influence, suggesting that higher concentrations of population exacerbate environmental pressure through increased consumption and waste generation.
Collectively, the independent variables explain approximately 44.35% of the variance in environmental pollution, indicating that while economic and demographic factors are crucial drivers, other variables not included in this model—such as technological adoption, environmental regulations, and industrial composition—also play substantial roles.
These results provide contemporary empirical support for the Environmental Kuznets Curve (EKC) hypothesis within the Indonesian context. The positive correlation between GRDP and pollution suggests that Indonesia is currently situated on the ascending segment of the EKC, where economic growth comes at the cost of environmental degradation.
In conclusion, this study affirms that economic growth and population density are significant determinants of environmental pollution in Indonesia. Therefore, it is imperative for policymakers to adopt an integrated approach that harmonizes economic objectives with environmental sustainability. This includes strengthening regulatory frameworks, promoting green technologies, and incorporating environmental carrying capacity into spatial planning to mitigate the adverse effects of development.

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