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Economic Growth and Environmental Quality: A Study on Mineral-Rich Provinces in Indonesia

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ABSTRACT

Research Originality: This research focuses on Indonesia's mineral-rich provinces and offers originality through its comprehensive analysis of the bidirectional relationship between economic growth and environmental quality, using the Environmental Quality Index (EQI).

Research Objectives: This study examines the relationship between economic growth and environmental quality in the Mineral Economy Provinces of Indonesia.

Research Methods: The data used in this research is secondary data from 2015 to 2022. The analysis method employed is the simultaneous equation model using Two Stage Least Squares (2SLS).

Empirical Results: The results show that in model 1, economic growth is significantly influenced by exogenous variables such as the environmental quality index, energy consumption, revenue sharing funds, investment, and population. In model 2, environmental quality is significantly influenced by exogenous variables such as GDP, mining output, energy consumption, and forest. Good environmental quality can enhance economic growth. Conversely, increased Economic growth can degrade environmental quality.

Implications: The study's findings suggest that policymakers in Indonesia's mineral economy provinces should prioritize sustainable development to balance economic growth with environmental preservation.

Keywords:

economic growth; environmental quality index; mineral economy provinces; sustainable development; two stage least squares

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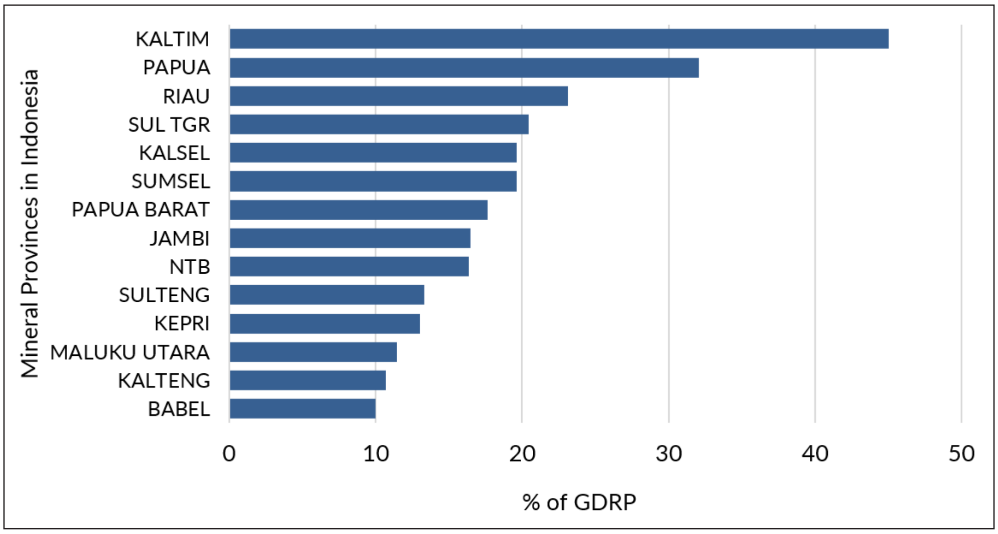
INTRODUCTION

Economic growth driven by the exploitation of mineral resources often has a negative impact on the environment (Huang et al., 2020). Indonesia heavily relies on the mining and quarrying sector, which ranked seventh in national GDP contribution in 2022 (BPS). While this sector supports the economy, such dependence makes it vulnerable to global commodity price fluctuations, affecting economic stability.

Although Indonesia has abundant natural resource wealth, the phenomenon of the Natural Resource Curse shows that countries with natural resource wealth often face challenges in achieving sustainable economic growth (Ridena et al., 2021). The "resource curse" concept suggests that countries rich in natural resources, such as minerals and oil, often face significant economic and political challenges, including unsustainable economic growth, corruption, and inequality (Auty, 1993).

A mineral economy is defined as an economy that generates at least 8% of its Gross Domestic Product (GDP) from the mining sector and derives at least 40% of its foreign exchange earnings from mineral exports. Several provinces in Indonesia have significantly contributed to their economies from the mineral sector. Some provinces in Indonesia with a mineral sector contribution above 8% to their GDP are called "mineral economy provinces". This term encompasses regions that have natural resources, particularly in the mining sector, which significantly impact the economy of those areas (see Figure 1).

Figure 1. Provinces in Indonesia with Mining and Quarrying Sector Contribution to GDRP above 8%



Source: Authors' calculation from Central Bureau of Statistics (BPS) Indonesia

Fourteen provinces in Indonesia are classified as Mineral Economy Provinces, as the mineral sector's contribution to their GDP exceeds 8% (see Figure 1). Referring to the resource curse hypothesis above, regions that rely on mineral resources face challenges in managing the sustainability of their economy and environment. The mining sector in Indonesia faces serious challenges related to sustainable environmental management (Marimuthu et al., 2021). This challenge is crucial for Indonesia in achieving the Sustainable

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Development Goals (SDGs), which emphasize the importance of maintaining a balance between economic development and environmental conservation (Fatimah et al., 2020).

To understand the relationship between economic growth and EQI, previous research has identified various interrelated factors. A study by Malik (2021) on economic growth and its impact on the environment in Turkey concluded a positive causal relationship between economic growth and energy consumption. High energy consumption is required for economic growth, but this increase in energy consumption also contributes to higher CO2 emissions, ultimately leading to environmental degradation. For instance, Bouznit et al. (2023) in Algeria found that increased economic growth leads to higher energy consumption and, in turn, higher CO2 emissions.

The findings of these studies vary depending on the country under analysis. For instance, Acheampong (2018) examined the relationship between energy consumption, economic growth, and carbon emissions in 116 countries. Globally, energy consumption raises GDP, which eventually increases pollution. However, economic growth in Latin America and the Caribbean does not lead to increased pollution. Likewise, energy consumption negatively impacts carbon emissions in Africa, Latin America, and the Caribbean.

Studies by Khan et al. (2021) and Ghorashi and Rad (2017) identified a bidirectional relationship between economic growth and environmental degradation. In contrast, (Lateef et al., 2021) found a unidirectional relationship. Lateef et al. (2021) researched the causal impact of carbon emissions in SAARC (South Asian Association for Regional Cooperation) countries on foreign direct investment (FDI), economic growth, and other economic factors. The results showed a unidirectional relationship between carbon emissions and economic growth.

While there are similarities in the variables examined, this research distinguishes itself through its choice of subjects, study period, and variable variations. The primary aim of this approach is to provide a more thorough and nuanced understanding of the phenomenon under investigation. Additionally, environmental studies often use CO2 gas emissions as a measurement, other indicators such as water pollution, deforestation, habitat destruction, and biodiversity loss are also important (Ahmad et al., 2020; Lateef et al., 2021; Soukiazis et al., 2017). Consequently, selecting the Environmental Quality Index can provide a more comprehensive view of the complex environmental challenges. This method offers a richer perspective than focusing on a single indicator like CO2 emissions alone.

Based on the arguments above, this research is exciting. It deserves to be studied more deeply to uncover the intricate relationship between economic growth, environmental quality, and the mining sector's role in Indonesia. Given the mineral sector's significant contribution to several provinces' GDP, understanding the implications of this dependence on both the economy and the environment is crucial. This study aims to address the gaps in the existing literature by focusing specifically on the Indonesian context, where the dynamics of the resource curse, environmental degradation, and economic development are particularly pronounced.

This research explores the complex relationship between economic growth, environmental quality, and the mining sector in Indonesia, focusing on provinces where the mineral sector significantly contributes to GDP. By employing the Environmental Quality Index (EQI) and a simultaneous equation model using Two Stage Least Squares (2SLS), the study will analyze the bidirectional relationship between economic growth and environmental quality, considering factors like Revenue Sharing Fund, investment, population, GDRP mining, forest area, and energy consumption. The research seeks to fill gaps in the existing literature and provide valuable insights for policymakers, helping to balance economic growth and environmental sustainability in Indonesia's resource-rich regions, ultimately supporting the country's efforts to achieve its Sustainable Development Goals (SDGs).

METHODS

The data in this article uses secondary data obtained from the Indonesian Central Bureau of Statistics and the Ministry of Environment for the period 2015–2022 in Indonesia. The data include the Environmental Quality Index, GDRP, investment, population, mining output, forest, revenue sharing fund and energy consumption. This study employs two-stage least squares (TSLS) analysis to address several issues commonly encountered in regression models, such as heteroscedasticity, multicollinearity, auto-correlation, and endogeneity of economic and environmental. Unlike single equation models, simultaneous equation models, including TSLS, consider the interactions between multiple equations, allowing for a more comprehensive analysis. There are two equations in which, GDRP and EQI are the endogenous variables. The two-equation system is as follows:

$$Y_{it} = \beta_0 + \beta_1 EQI_{it} + \beta_2 EC_{it} + \beta_3 RSF_{it} + \beta_4 Pop_{it} + \beta_5 Inv_{it} + e_2 \quad (1)$$

$$EQI_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 EC_{it} + \alpha_3 Mng_{it} + \alpha_4 Fr_{it} + e_1 \quad (2)$$

Description:

EQI = Environmental Quality Index; Y = Gross Domestic Regional Product; RSF = Revenue Sharing Fund; INV= Investment; POP = Population; Mng = GDRP mining; FR = Forest; EC = Energy Consumption.

The previous equations (Equations 1 and 2) will be transformed into their reduced form. The purpose of the reduced form is to identify the endogenous and exogenous variables in the model to be analysed. The reduced form equations are obtained as follows:

$$Y_{it} = \pi_0 + \pi_1 Mng_{it} + \pi_2 Fr + \pi_3 EC_{it} + \pi_4 RSF_{it} + \pi_5 Pop_{it} + \pi_5 Inv_{it} + v_{it} \quad (3)$$

$$EQI_{it} = \pi_0 + \pi_1 RSF_{it} + \pi_2 Pop_{it} + \pi_3 Inv_{it} + \pi_4 EC_{it} + \pi_5 Mng_{it} + \pi_6 Fr_{it} + v_{it} \quad (4)$$

The order condition is a criterion used to determine whether an equation in a simultaneous equations model is identifiable. The order condition involves comparing the number of exogenous variables excluded from an equation to the total number of equations in the model.

Based on the identification test above, all of the equations are indicated to be overidentified. Therefore, to estimate the parameters of the given equations, the Two-Stage

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Least Squares (2SLS) method should be used. The rank condition is another important criterion used to determine whether an equation in a simultaneous equations model is identifiable. While the order condition is necessary for identification, it is not sufficient by itself. The rank condition provides a more stringent test to ensure that the model is identified.

Table 1. Order Condition Model 1 (Y) and 2 (EQI)

	K	k	M	K-k>M-1	Result
Eq. Y	6	4	2	2 > 1	Over identified
Eq. EQI	6	3	2	3 > 1	Over identified

Source: Author's Calculation Results

Table 2. Rank Condition

C	EQI	Y	EC	Mng	Fr	DBH	Pop	Inv
α_0	-1	α_1	α_2	α_3	α_4	0	0	0
β_0	β_1	-1	β_2	0	0	β_3	β_4	β_5

Source: Author's Calculation Results

In the equation model (1) and (2) a 2x2 matrix A and B is obtained with a non-zero determinant,

$$|A| = \begin{vmatrix} 0 & 0 \\ \beta_3 & \beta_4 \end{vmatrix} \neq 0$$

$$|B| = \begin{vmatrix} \alpha_3 & \alpha_4 \\ 0 & 0 \end{vmatrix} \neq 0$$

Thus, the equation models (1) and (2) meet the order condition and can be estimated using Two-Stage Least Squares (2SLS).

RESULTS AND DISCUSSION

The unit root testing for panel data on the variables in this research model was conducted using the Augmented Dickey-Fuller (ADF), Levin, Lin Chu (LLC), and Im Pesaran Shin (IPS) tests. The detailed results of the unit root testing shown in Table 3. Table 3 shows unit root testing. Statistically, all variables used in this study have been proven to be stationary (not containing unit roots).

Table 3. Stationarity Test

Variabel	LLC	IPS	ADF
Statistic	-71.0150	-10.9189	280.431
Probability	0.0000	0.0000	0.0062

Source: Author's Calculation Results

The purpose of the cointegration test in this study is to determine the long-term equilibrium between the variables in the model. The criterion for the cointegration test is that if the probability value is less than 0.05 or 0.1, it can be concluded that the null hypothesis is statistically rejected, which means that the variables are cointegrated.

Based on Table 4 of the cointegration test for the first model (Y), it shows that the p-value is less than 0.05. Therefore, it can be concluded that the null hypothesis is statistically rejected. This indicates that there is a long-term equilibrium relationship among the variables within the Y model. Similarly, observations from the cointegration tests on the second model (EQI) show that the obtained p-values also reject the null hypothesis. Therefore, it can be concluded that there is a long-term equilibrium relationship among the variables within the second and third models.

Table 4. Cointegration Test

	Panel PP-Statistic	Prob.	Panel ADF-Statistic	Prob.
Model 1 (Y)	-5.591498	0.0000	-4.186475	0.0000
Model 2 (EQI)	-7.473148	0.0000	-2.439704	0.0073

Source: Author's Calculation Results

The Hausman test evaluates whether the endogenous variables in the simultaneous equation model of Y and EQI are truly endogenous or exogenous. Using the F-statistic from the Hausman test, the null hypothesis is rejected, indicating that Y and EQI are indeed endogenous variables. The exogeneity test for the Y model and EQI model shows an F-test value 320.4403 and 24.10306. Therefore, the null hypothesis is rejected, indicating that Y and EQI is an endogenous variable in the simultaneous equation system.

Table 5. Exogeneity Test

Model	Variabel	F-statistik	*Prob.*
Y	C IKLHF EC RSF INV POP	320.4403	0.000000***
IKLH	C PDRBF EC MNG PD	24.10306	0.000000***

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
Source: Author's Calculation Results

The identification analysis using the order condition and rank condition reveals that the structural equation models for economic and environmental factors are over-identified. This means that all these structural equation models can proceed using the two-stage least squares (TSLS) approach. The empirical results for the simultaneous equations model shown in Table 6. The results of Model 1 (Y) demonstrate a highly significant R-squared value of 0.919454, indicating that 91.94% of the variation in the economic

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growth (Y) can be explained by the exogenous variables: Environmental Quality Index (EQI), Revenue Sharing Fund (RSF), investment (INV), population (POP) and energy consumption (EC). This high explanatory highlights the strong interconnections between these factors and economic growth. Based on the t-statistic probabilities, it is evident that Y is significantly influenced by the environmental quality index (EQI), revenue sharing funds (RSF), population, and investment.

The estimation results of the EQI model are quite good, as indicated by the R-squared coefficient of 0.474388. This high R-squared value suggests that the variation in the independent variables in the model can explain 47.43% of the variation in the dependent variable. Based on the t-statistic probabilities, it is evident that EQI is significantly influenced by the economic growth (Y), GDP from mining (MNG), and forest (FR).

Table 6. Two-Stage Least Squares Estimation Result

	Model 1 (Y)	Model 2 (EQI)
Constant	4.972247***	121.8989***
Gross Domestic Regional Bruto (Y)		-5.855326**
Environmental Quality Index (EQI)	0.012694***	
Revenue Sharing Fund (RSF)	0.301265***	
Investment (INV)	0.472758***	
Population (POP)	0.192543***	
GDP mining (Mng)		-0.418888***
Energy Consumption (EC)	0.164624	3.197656
Forest		5.679621***
R^2	0.919454	0.474388

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
Source: Author's Calculation Results

The estimation results indicate that environmental quality in the Mineral Economy Provinces can drive economic growth, consistent with the findings of Acheampong (2018) and Ghorashi & Rad (2017). This condition is evident from the average EQI score, which increased from 71.17 in 2017 to 75.42 in 2022, alongside economic growth from 4.6 percent to 7.3 percent. Economic growth in this region is highly influenced by environmental sustainability because most of the Mineral Economy Provinces are not industrial areas, making the mining, agriculture, plantation, and tourism sectors the primary sources of regional income.

The estimation results show that energy consumption does not significantly impact economic growth; even though electricity consumption in the Mineral Economy Provinces has increased, economic growth remains fluctuating. This condition is mainly due to the infrastructure limitations in Indonesia's central and eastern regions, which restrict electricity consumption. Additionally, the economic structure of the Mineral Economy

Provinces is dominated by non-industrial sectors that require less electricity compared to industrial sectors, making electricity consumption a less crucial factor in determining economic growth.

Revenue Sharing Funds (RSF) have a positive impact on economic growth. This finding is consistent with the research by Omodero (2019). The average RSF in the Mineral Economy Provinces increased from 3.05 billion in 2017 to 7.57 billion in 2022, alongside a rise in average economic growth from 4.6 percent to 7.3 percent. Through RSF, local governments can finance infrastructure development such as roads, bridges, and other public facilities. This infrastructure boosts productivity and economic activity in the region, making effective management of RSF a critical factor in supporting regional economic development and contributing to increased Gross Domestic Regional Product (GDRP).

The results of the estimation indicate that investment can encourage economic growth (Omri et al., 2014; Abdouli & Hammami, 2020; Khan et al., 2019; Lateef et al., 2021; and Malik, 2021). Investment is a critical driver of economic growth as it boosts production capital, increasing the capacity for goods and services. Investment also creates jobs, providing employment opportunities that reduce poverty and improve living standards. Additionally, investment fosters technological innovation by funding research and development, creating new technologies and more efficient production processes. This technological advancement can further enhance productivity and sustainability, contributing to long-term economic growth and development.

The Mineral Economy Provinces have a relatively low population density, with the total population increasing from 48 million in 2017 to 56 million in 2022. In this model, the population variable significantly and positively impacts economic growth. This result is evident as the population in the Mineral Economy Provinces shows a yearly increasing trend, accompanied by economic growth. Population growth can boost economic growth, aligning with Adam Smith's classical growth theory, which suggests that an increasing population enhances the labor force. With more people working, total economic output rises, contributing to economic growth. According to Keynesian market demand theory, a growing population means a higher demand for goods and services, which stimulates increased production and investment.

The average economic growth in the Mineral Economy Provinces from 2017 to 2022 is 2.39% per year, with varying growth trends. In this model, the economic growth variable has a significant and negative impact, indicating that economic growth contributes to a decline in environmental quality. Economic growth contributes to the decline in environmental quality (Malik, 2021; Abdouli & Hammami, 2020; Khan et al., 2019; Lateef et al., 2021). According to the theory of externalities, one party's production or consumption activities can impose costs or harm on third parties who are not involved in those activities. For example, mining waste can contaminate local water sources and soil, negatively affecting drinking water quality and damaging aquatic ecosystems. The mining process, which produces dust and harmful gas emissions, can cause respiratory diseases among nearby communities.

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Theoretically, energy consumption negatively affects environmental quality, but in this model, energy consumption does not significantly impact environmental quality. Previous studies, such as those by Azlina et al. (2014) and Salahuddin et al. (2015), have found similar results, indicating that electricity consumption in developing countries and GCC nations does not significantly affect environmental degradation or CO2 emissions. In the Mineral Economy Provinces, increased electricity consumption only sometimes has a negative effect on environmental quality due to relatively low electricity consumption, extensive forest areas, and few coal-fired power plants (PLTUs), which help maintain good air quality.

Mining in the Mineral Economy Province contributes to a decline in the environmental quality of the Mineral Economy Province. These findings are consistent with the research of Jurakulov (2023), Jamin et al. (2023), and Li et al. (2024), which examined the relationship between mining and environmental degradation. Mining often requires extensive land clearing, leading to habitat loss for flora and fauna. Waste, including heavy metals like mercury, arsenic, and cadmium, contaminates nearby water sources, damaging ecosystems. Additionally, mining generates dust and harmful gas emissions and causes severe soil degradation and erosion, rendering land infertile. Despite its economic benefits, mining substantially negatively impacts the environment and public health.

Indonesia's forest area is approximately 125.76 million hectares, covering 62.97% of the country's land area. Regression results indicate that forest area has a statistically positive effect on environmental quality. A reduction in forest area also leads to a decline in environmental quality. This result is evident as the forest area from 2017 to 2022 in the Mineral Economy Provinces did not experience significant changes, and the Environmental Quality Index (EQI) remained stable during this period. Forest area significantly impacts environmental quality because it is one of the indicators in the EQI, alongside air, water, and soil quality. Forests directly reduce air pollution, as noted in the study by (Azwardi et al., 2021) Azwardi et al. (2021), since forests act as carbon sinks and air pollutant filters, contributing to air quality. This condition is reflected in the Air Quality Index (AQI) in the Mineral Economy Provinces, which ranges from 80 to 90, indicating that air quality remains well-maintained.

CONCLUSION

This model significantly influences economic growth through the environmental quality index, revenue-sharing funds, investment, and population. All these factors substantially enhance economic growth as each plays a crucial role in driving economic activity and productivity. Sustainable environments prevent the depletion of natural resources crucial for the economy while revenue-sharing funds enable infrastructure development that enhances logistical efficiency and local economic capacity. Investment increases production capital, creates jobs, and promotes technological innovation, while population growth provides a more significant labor force and expands market demand.

In the environmental quality index (EQI) model, the Environmental Quality Index (EQI) is significantly influenced by Gross Regional Domestic Product (Y), mining output, and forest. Forest area enhances EQI by serving as a carbon sink, boosting biodiversity, controlling soil erosion, and regulating the hydrological cycle, all crucial for maintaining environmental quality. GDRB, while contributing to economic growth, often reduces EQI because rapid economic growth can lead to excessive natural resource exploitation, increased pollution, and environmental degradation. Mining output also lowers EQI because mining activities often result in deforestation, water and soil pollution, and harmful gas emissions that damage ecosystems and public health. Therefore, while GDRB and mining are essential for economic growth, they negatively impact environmental quality if not properly managed.

The research findings reveal that a good environment can boost economic growth, while economic growth can deteriorate environmental quality. Therefore, in the future, to enhance economic growth while maintaining the environment, the government needs to formulate sustainable policies, such as improving forests through reforestation programs and protecting forests from illegal activities. Moreover, sustainable mining practices and land restoration of former mining sites are crucial. Strict regulations and monitoring of environmental violations must be strengthened, with incentives for environmentally friendly practices and penalties for violators. Finally, investment in green technologies, such as renewable energy and energy efficiency, should be encouraged.

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