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Economic, Environment, and Social Welfare in the Mineral Economy Provinces of Eastern Indonesia

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Abstract

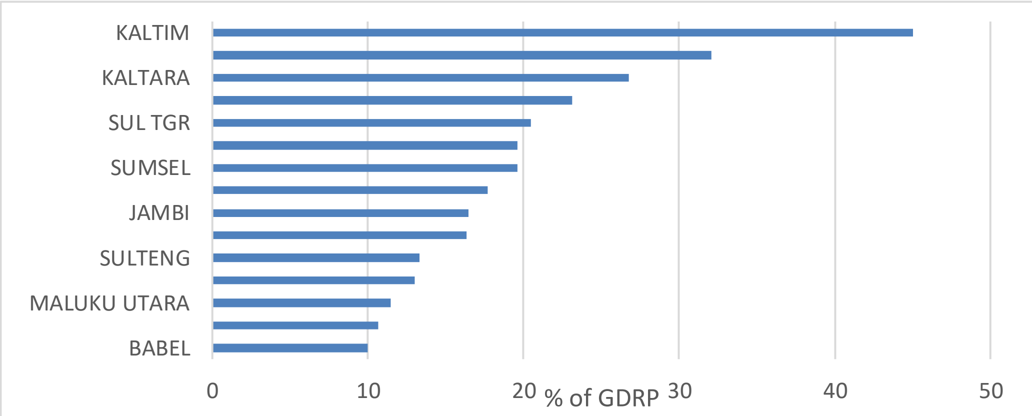
This study explores the relationships between economic growth, environmental quality, and social welfare in the mineral economy provinces of Eastern Indonesia, which are heavily dependent on the mining sector. Using simultaneous equation models and secondary data from 2015–2022. Empirical results show There is a bidirectional causal relationship between EQI and HDI, suggesting that improvements in environmental quality enhance human development, and higher human development levels contribute to better environmental quality. Additionally, a unidirectional causal relationship from EQI to GDP indicates that improvements in environmental quality can lead to economic growth, but economic growth alone does not necessarily lead to improvements in environmental quality.

INTRODUCTION

The provinces in Eastern Indonesia store abundant mineral wealth that drives national economic growth. However, the massive exploitation of these resources carries serious environmental and social impacts (Miller et al., 2018); (Carvalho, 2017). The high dependence on the mining sector has a significant impact on economic growth, but it also poses major challenges related to environmental degradation and the social welfare of local communities. The main challenge is how to optimize the economic growth of this sector without sacrificing environmental quality and social welfare (Lorek & Spangenberg, 2014); (Abdul et al., 2020). The future of the mineral economy in Eastern Indonesia is highly dependent on policies and commitments to sustainable development that prospers the people and preserves nature, in line with the achievement of the Sustainable Development Goals (SDGs) such as poverty reduction, good health, quality education, decent work, economic growth, and action on climate change (Barbier & Burgess, 2017).

In Indonesia, there are 15 provinces with a mineral sector that contributes more than 8 percent to GDP (Figure 1). Provinces in Eastern Indonesia such as Papua, West Papua, Southeast Sulawesi, Central Sulawesi, and North Maluku were chosen as the focus of the research because they are the main centres of mining activities in the region. The region is rich in mineral resources such as gold, nickel, and copper which are significant drivers of regional economic growth (Erb et al., 2020). Mining activities in Eastern Indonesia bring complex environmental and social challenges. Papua and West Papua have large gold and copper reserves, but mining activities are often linked to widespread deforestation and serious environmental degradation, negatively impacting biodiversity and indigenous peoples' livelihoods (Gaveau et al., 2021). Southeast Sulawesi and Central Sulawesi, as major producers of nickel important to the global industry, particularly electric vehicle batteries, face serious impacts on local ecosystems, including water and soil pollution and threats to local public health (Kadir, 2020). With abundant mineral reserves, North Maluku also faces the challenge of environmental pollution and socio-economic injustice, where the economic benefits of mining tend to be uneven and are more felt by outsiders than residents, creating social inequality. (Far, 2022).

Figure 1. Mineral Province in Indonesia with the contribution of the Mining and Quarrying Sector to GDP above 8% in 2022



Source: Central Statistics Agency, 2022, Data Processed

Planning to address these issues requires comprehensive insights and effective solutions. A profound approach is needed to ensure that economic growth goes hand in hand with environmental preservation and improved social welfare. Several previous studies have examined the economic impact of the mining sector and its implications on the environment and social welfare, but they are often still fragmented and lack the simultaneous integration of all three aspects. (Mancini & Sala, 2018); (Edraki et al., 2014). Therefore, an analytical model is needed that can comprehensively capture the relationship between these three aspects to support better and sustainable decision-making. This is important in achieving the SDGs, where the balance between economic growth, environmental conservation, and improving social welfare is the main key. (United Nations, 2017). Better integration will help develop policies that not only focus on short-term economic benefits but also consider long-term impacts on the environment and society.

Previous research has shown that the exploitation of natural resources in the mining sector can significantly increase people's income and living standards. (Singh & Singh, 2016); (Barbosa & Monteiro, 2019). However, uncontrolled exploitation leads to severe environmental degradation, such as water pollution, deforestation, and ecosystem damage (Brown et al., 2019). Another study highlights that people living around mining areas often face health risks and reduced quality of life due to pollution and loss of access to clean natural resources (Okereafor et al., 2020); (Goltz & Barnwal, 2018). However, there are still few studies that focus on the simultaneous interaction between economic growth, environmental quality, and social welfare.

Related research shows that the environmental impacts of mining can be devastating, including water pollution that is harmful to public health (Lu et al., 2015) and deforestation that causes biodiversity loss. (Siqueira-gay et al., 2020). The economic impact is also studied by several studies that show an increase in regional GDP but it is often accompanied by income distribution inequities. (Loayza & Rigolini, 2016); (Fleming et al., 2015); (Loayza & Rigolini, 2016). Poor environmental quality can affect the Human Development Index (HDI), which measures the dimensions of health and decent living standards. (Hickel, 2020). Several studies also show that there are limitations in the implementation of effective policies to manage the environmental impact of mining (Miller et al., 2018).

Therefore, this study intends to fill the gap by exploring the relationship between economic growth, environmental quality, and social welfare in the mineral economy provinces of Eastern Indonesia. Using simultaneous equation models and secondary data from 2015 to 2022, the study provides in-depth insights into the complex interactions between economic growth, environmental quality, and social well-being. The simultaneous equation method was chosen because of its ability to analyze the reciprocal relationships between these variables simultaneously, which is important for understanding the dynamics that occur and their impact on sustainable development. Through a comprehensive analysis, this research is expected to make a significant contribution to environmental conservation, social welfare improvement, and sustainable economic growth.

RESEARCH 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, Human Development Index, GDP, investment, population, mining output, population density, poverty, sanitation, and energy consumption. This study uses the two-stage least squares analysis (TSLS). There are three equations in which carbon dioxide emissions, GDP, and social welfare are the endogenous variables. The three-equation system is as follows:

$$GDP_{it} = \beta_1 + \beta_2 EQI_{it} + \beta_3 HDI_{it} + \beta_4 RSF_{it} + \beta_5 INV_{it} + \beta_6 POP_{it} + e_{it} \quad (1)$$

$$HDI_{it} = \beta_7 + \beta_8 EQI_{it} + \beta_9 GDP_{it} + \beta_{10} MNG_{it} + \beta_{11} POV_{it} + \beta_{12} SAN_{it} + e_{it} \quad (2)$$

$$EQI_{it} = \beta_{13} + \beta_{14} GDP_{it} + \beta_{15} HDI_{it} + \beta_{16} MNG_{it} + \beta_{17} PD_{it} + \beta_{18} EC_{it} + e_{it} \quad (3)$$

Description :
EQI = Environmental Quality Index; GDP = Gross Domestic Product; HDI = Human Development Index; RSF = Revenue Sharing Fund; INV= Investment; POP = Population; Mng = GDP mining; PD = Population density; POV = Poverty; San = Sanitation; EC = Energy Consumption; β0,…β18 = Estimation Parameters; and *e*= Standard Error.

The previous equations (Equations 1, 2, and 3) 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:

$$GDP_{it} = \pi_{10} + \pi_{11} RSF_{it} + \pi_{12} INV_{it} + \pi_{13} POP_{it} + \pi_{14} MNG_{it} + \pi_{15} POV_{it} + \pi_{16} SAN_{it} + \pi_{17} PD_{it} + \pi_{18} EC_{it} + e_{it} \quad (4)$$

$$HDI_{it} = \pi_{20} + \pi_{21} RSF_{it} + \pi_{22} INV_{it} + \pi_{23} POP_{it} + \pi_{24} MNG_{it} + \pi_{25} POV_{it} + \pi_{26} SAN_{it} + \pi_{27} PD_{it} + \pi_{28} EC_{it} + e_{it} \quad (5)$$

$$EQI_{it} = \pi_{30} + \pi_{31} RSF_{it} + \pi_{32} INV_{it} + \pi_{33} POP_{it} + \pi_{34} MNG_{it} + \pi_{35} POV_{it} + \pi_{36} SAN_{it} + \pi_{37} PD_{it} + \pi_{38} EC_{it} + e_{it} \quad (6)$$

Order Condition

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.

Table 1. Order Condition

	K	k	M	K-k>M-1	Result
Eq. GDP	8	5	3	3 > 2	Over identified
Eq. HDI	8	5	3	3 > 2	Over identified
Eq. EQI	8	5	3	3 > 2	Over identified

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 Least Squares (2SLS) method should be used.

Rank Condition

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 2. Rank Condition

C	GDP	EQI	HDI	RSF	INV	POP	MNG	POV	SAN	PD	EC
$-\beta_1$	1	$-\beta_2$	$-\beta_3$	$-\beta_4$	$-\beta_5$	$-\beta_6$	0	0	0	0	0
-β_7	$-\beta_9$	$-\beta_8$	1	0	0	0	$-\beta_{10}$	$-\beta_{11}$	$-\beta_{12}$	0	0
$-\beta_{13}$	$-\beta_{14}$	1	$-\beta_{15}$	0	0	0	$-\beta_{16}$	0	0	$-\beta_{17}$	$-\beta_8$

In the equation model (1), (2) and (3) a 2x2 matrix A, B, C is obtained with a non-zero determinant,

$$|A| = \begin{vmatrix} -\beta_{10} & -\beta_{11} \\ -\beta_{16} & 0 \end{vmatrix} \neq 0$$

$$|B| = \begin{vmatrix} -\beta_4 & -\beta_5 \\ 0 & 0 \end{vmatrix} \neq 0$$

$$|C| = \begin{vmatrix} -\beta_6 & 0 \\ 0 & \beta_{11} \end{vmatrix} \neq 0$$

Thus, the equation models (1), (2), and (3) meet the order condition and can be estimated using Two-Stage Least Squares (2SLS).

RESULT

Stationarity Test

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 are presented in Table 3 as follows.

Table 3. Stationarity Test

Variable	LLC		IPS		ADF		Stationarity
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	
EQI	-8.3283	0.000	60.549	0.000	43.297	0.000	**
GDP	-6.0016	0.000	40.103	0.001	29.567	0.000	***
RSF	-8.5753	0.000	73.340	0.000	41.420	0.000	***
EC	-6.4531	0.000	62.684	0.000	30.029	0.001	***
INV	-5.2499	0.000	68.242	0.000	27.968	0.002	***
HDI	-6.2292	0.000	32.970	0.000	30.272	0.001	***
MNG	-3.9738	0.000	61.045	0.000	18.820	0.043	***
PD	-5.1232	0.000	26.672	0.001	23.376	0.003	**
POP	-4.8148	0.000	63.301	0.000	22.160	0.014	***
POV	-3.8092	0.000	26.923	0.019	21.213	0.003	**
SAN	-8.7957	0.000	34.115	0.000	53.134	0.000	***

* = level
** = first difference
*** = second difference

Table 3 shows unit root testing. Statistically, all variables used in this study have been proven to be stationary (not containing unit roots).

Cointegration Test

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.

Table 4. Cointegration Test

	Panel ADF-Statistic	Prob.
Model 1 (GDP)	-2.553948	0.0053
Model 2 (HDI)	-2.314865	0.0103
Model 3 (EQI)	-2.704331	0.0034

Based on Table 4 of the cointegration test for the first model (GDP), 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 GDP model. Similarly, observations from the cointegration tests on the second model (HDI) and the third model (EQI) show that the obtained p-values also reject the null hypothesis at a 5% significance level. Therefore, it can be concluded that there is a long-term equilibrium relationship among the variables within the second and third models.

Exogeneity Test

The Hausman test evaluates whether the endogenous variables in the simultaneous equation model of GDP, HDI and EQI are truly endogenous or exogenous. Using the F-statistic from the Hausman test, if the F probability is less than 0.05 (significant at the 5% level), the null hypothesis is rejected, indicating that GDP, HDI and EQI are indeed endogenous variables.

Table 5. Exogeneity Test

Model	Variable	F-statistic	*Prob.*
GDP	C EQIF HDIF RSF INV POP	255.9608	0.000000***
HDI	C EQIF GDPF MNG POV SAN	312.2884	0.000000***
EQI	C GDPF HDIF MNG PD EC	5.579293	0.000740***

* = *significant at the α 10 percent*
** = *significant at the α 5 percent*
*** = *significant at the α 1 percent*

The homogeneity test for the GDP model, HDI model, and EQI model shows an F-test value of 255.9608, 312.2884, and 5.579293 with a probability less than α = 0.01. Therefore, the null hypothesis is rejected, indicating that GDP, HDI and EQI an endogenous variable in the simultaneous equation system.

Estimation Result

The identification analysis using the order condition and rank condition reveals that the structural equation models for economic, social, 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 can be seen in Table 6.

Table 6. Empirical results for simultaneous equations model

	Model 1 (GDP)	Model 2 (HDI)	Model 3 (EQI)
Constant	-1.127307	15.84042	9.686823
Gross Domestic Product (GDP)	-	3.157020	-7.868446
Human Development Index (HDI)	0.030634		0.790388*
Environmental Quality Index (EQI)	0.022697**	-0.177512**	
Revenue Sharing Fund (RSF)	0.478939***	-	
Investment (INV)	0.502747***	-	

Population (POP)	0.356230	-	
GDP mining (Mng)	-	1.273902	10.44278
Population density (PD)	-	-	-0.208268**
Poverty (POV)	-	-0.318217***	
Sanitation (SAN)	-	0.140492***	
Energy Consumption (EC)	-	-	-41.86898
R2	0.888508	0.951227	0.464274

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Based on the results of the table above, the regression equation can be formed as follows :

$$GDP_{it} = -1.127307 + 0.022697EQI_{it} + 0.030634HDI_{it} + 0.478939RSF_{it} + 0.502747INV_{it} + 0.356230POP_{it} + e_{it} \quad (7)$$

$$HDI_{it} = 15.84042 - 0.177512EQI_{it} + 3.157020GDP_{it} + 1.273902MNG_{it} - 0.318217POV_{it} + 0.140492SAN_{it} + e_{it} \quad (8)$$

$$EQI_{it} = 9.686823 - 7.868446GDP_{it} + 0.790388HDI_{it} + 10.44278MNG_{it} + -0.208268PD_{it} - 41.86898EC_{it} + e_{it} \quad (9)$$

The estimation results of the GDP model are quite good, as indicated by the R-squared coefficient of 0.888508. This high R-squared value suggests that the variation in the independent variables in the model can explain 88.85% of the variation in the dependent variable, indicating a strong fit for the model. Such a significant proportion implies that key factors have been successfully identified and incorporated into the model. Based on the t-statistic probabilities, it is evident that GDP is significantly positively influenced by the environmental quality index (EQI), revenue-sharing funds (RSF), and investment. These findings are consistent with the research conducted by (Acheampong, 2018; Ghorashi & Alavi Rad, 2017; Lateef et al., 2021; Omodero, 2019)

The results of Model 2 (HDI) demonstrate a highly significant R-squared value of 0.951227, indicating that 95.12% of the variation in the Human Development Index (HDI) can be explained by the exogenous variables: economic growth (GDP), environmental quality index (EQI), GDP from mining (MNG), poverty (POV), and sanitation (SAN). (Gulcemal, 2020; Sagara et al., 2022; Wei et al., 2023). This high explanatory power highlights the strong interconnections between these factors and social welfare.

In Model 3, it is observed that only the Human Development Index (HDI) and population density have a statistically significant impact on the environmental quality index. These results align with the studies by (Khan et al., 2021; Listiyani et al., 2021).

DISCUSSION

The Economy in Mineral Economy Provinces of Eastern Indonesia

The economy in the Mineral Economy Provinces of Eastern Indonesia is influenced by the environmental quality index, revenue-sharing funds, and investment. Improvement in environmental quality can enhance public health by reducing pollution-related illnesses and improving overall living conditions. This enhancement in public health can lead to greater labour productivity as a healthier workforce is more efficient and effective, which in turn supports and stimulates economic growth. Furthermore, revenue-sharing funds play a crucial role in enabling infrastructure development, which is essential for increasing logistical efficiency and boosting local economic capacity. Improved infrastructure, such as better roads, ports, and communication networks, can reduce transportation costs, shorten delivery times, and open up new markets for local businesses. Meanwhile, investment is a critical driver of economic growth as it boosts production capital, thereby increasing the capacity for goods and services. Investment also creates jobs, providing employment opportunities that can reduce poverty and improve living standards. Additionally, investment fosters technological innovation by funding research and development, leading to the creation of new technologies and more efficient production processes. This technological advancement can further enhance productivity and sustainability, contributing to long-term economic growth and development.

Social Welfare in Mineral Economy Provinces of Eastern Indonesia

The estimation results reveal poor environmental conditions and poverty, negatively impact social welfare by increasing health issues, lowering life expectancy, and diminishing overall quality of life. Environmental degradation, such as pollution and deforestation, contributes to chronic diseases, water shortages, and food insecurity, further compromising community well-being. Poverty exacerbates these issues by limiting access to healthcare, education, and clean water, often forcing impoverished populations to live in environmentally hazardous areas, thus increasing their vulnerability to disease and disaster. Conversely, good sanitation significantly enhances public health and social welfare by reducing waterborne diseases, improving hygiene, and boosting overall health. Improved sanitation infrastructure not only leads to a cleaner environment but also provides economic benefits by reducing healthcare costs and enhancing productivity through the prevention of illness. Therefore, addressing economic, environmental, and social factors comprehensively is crucial for improving environmental quality and fostering human development, as highlighted by the results of Model 2.

Environmental Quality in Mineral Economy Provinces of Eastern Indonesia

The environmental conditions in the Mineral Economy Provinces of Eastern Indonesia are considered very good, as evidenced by an average environmental quality index (EQI) of 78.86 in these areas. Based on the estimation results population density negatively affects environmental quality by increasing resource consumption and waste production, which leads to environmental degradation, ecosystem damage, pollution, and loss of biodiversity. In contrast, the Human Development Index (HDI) positively influences environmental quality, as it encompasses higher levels of education, health, and living standards. Enhanced education raises awareness and knowledge about environmental issues, while improved health reduces pressure on natural resources. Additionally, higher income and living standards facilitate the adoption of environmentally friendly technologies and investments in sustainable infrastructure. Regions with high HDI also generally have better environmental policies and regulations, as well as greater community awareness and participation in environmental conservation efforts. Thus, increasing HDI contributes to a cleaner and healthier environment through behavioural changes, improved policies, and advanced technology.

The Relationships Between Economic Environment and Social Welfare in Mineral Economy Provinces of Eastern Indonesia

The relationships between GDP, HDI, and EQI based on the empirical results indicate a complex interplay of causality. Specifically, there exists a bidirectional causal relationship between the Environmental Quality Index (EQI) and the Human Development Index (HDI). This means that improvements in environmental quality can lead to enhancements in human development indicators, such as health, education, and living standards. Conversely, higher levels of human development can contribute to better environmental quality. Additionally, there is a unidirectional causal relationship between EQI to GDP, suggesting that improvements in environmental quality can lead to economic growth. However, the reverse does not hold, indicating that economic growth alone does not necessarily lead to improvements in environmental quality.

CONCLUSION

The empirical results indicate a complex interplay of causality between GDP, HDI, and EQI. There is a bidirectional causal relationship between EQI and HDI, suggesting that improvements in environmental quality enhance human development, and higher human development levels contribute to better environmental quality. Additionally, a unidirectional causal relationship from EQI to GDP indicates that improvements in environmental quality can lead to economic growth, but economic growth alone does not necessarily lead to improvements in environmental quality.

Economic Growth is significantly influenced by the Environmental Quality Index, Revenue Sharing Funds and Investment. Enhancing environmental quality improves public health and labour productivity, while revenue-sharing funds support essential infrastructure development, increasing logistical efficiency and local economic capacity. Investment drives economic growth by increasing production capacity, creating jobs, and fostering technological innovation.

Model 2, focused on social welfare. The Human Development Index is explained by factors such as Gross Domestic Product, Environmental Quality Index, GDP from mining, poverty, and sanitation. Poor environmental conditions and poverty affect social welfare by lowering life quality, while good sanitation significantly enhances public health and social welfare.

In Model 3, it is observed that only the Human Development Index and population density have statistically significant impacts on the Environmental Quality Index. Population density negatively affects environmental quality through increased resource consumption and waste production, leading to environmental degradation. Conversely, the Human Development Index positively influences environmental quality by higher education, health, and living standards, which promote environmental awareness and reduce pressure on natural resources.

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