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The Effects of Environmental, Economic, and Demographic Factors on the Environmental Quality Index in Indonesia

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Abstract

This study aims to identify the effect of environmental expenditure, agricultural sector GRDP, industrial sector GRDP, foreign investment, population density, and human development index on the environmental quality index in 34 provinces in Indonesia from 2016 to 2023. This study uses panel data comprising time-series data for the period 2016–2023 and cross-sectional data for 34 provinces in Indonesia. The analysis method used in this study employs a dynamic panel data approach with the GMM (Generalized Method of Moments) model. Based on the GMM (Generalized Method of Moments) estimation results, the Foreign Investment and Human Development Index has a significant positive effect. In contrast, Environmental Expenditure, industrial-sector GRDP, and population density have significant negative effects on the Environmental Quality Index. Meanwhile, the agricultural sector GRDP has no effect and is not significant for the Environmental Quality Index.

Keywords: Environmental Quality Index, Environmental Expenditure, Generalized Method of Moments, Gross Domestic Regional Product, Population

JEL Classification: H61, O15, O44, Q01

1. Introduction

1.1 Introduce the Problem

Humans and other living creatures are highly dependent on the surrounding environment. Humans and the natural environment share a very close relationship. Both exert significant mutual influence on one another. The natural environment's influence on humans tends to be more passive, whereas human influence on the natural environment is more active. Thus, if the environmental quality in each region is good, the people living in that environment will fare well, and vice versa (Rizal, 2017). As an indicator for assessing the environment in Indonesia, the EQI combines the Environmental Quality Index (EQI) and the Environmental Performance Index (EPI) concepts. The EQI can also be used to evaluate the performance of environmental quality improvement programs and as a source of information to support decision-making processes regarding environmental protection and management.

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The interconnection between the environment and the economy has become a growing issue in regional studies. The challenge of achieving inclusive economic growth in Indonesia, as evidenced by data, will face challenges from various influencing factors, such as the government's role through mitigation budgets, sectoral economies, investments, and the demographic dividend. If not managed properly, these factors could pose significant challenges to human development quality. A high-quality environment is characterized by the condition of its environmental aspects, emphasizing interaction, mutual dependence, harmony, and resilience through diversity.

1.2 Explore Importance of the Problem

All environmental elements or components that perform their functions efficiently (Utility), accessible information regarding environmental conditions for the advancement of scientific knowledge, and conditions that support cultivation for the achievement of specific sustainability indicators.

Figure 1. Graph of the Environmental Quality Index in Indonesia 2016–2023

Figure 1 shows that the national EQI has shown a positive trend from 2018 to 2023, although the national EQI figure in 2017 was 66.46 and dropped to 65.14 in 2018, a decline that certainly warrants the government's attention to address improvements in the sectors and factors influencing it. Consequently, the figure increased to 72.54 by 2023.

Over the 2016–2023 period, we can observe the state of the environment during President Joko Widodo's decade-long administration, which prioritized investment to drive economic growth. Investment, which serves as the lifeblood of the Jokowi administration, was subsequently implemented through economic policy packages. During the first term of Jokowi's administration alone, 16 economic policy packages were issued. These packages were designed

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to streamline investment licensing in Indonesia, which has long been a major bottleneck for investment. (Saputro & Taufiequrrohman, 2021).

The government's role, particularly through government spending to drive the economy and improve environmental quality, is crucial. One of the government's strategies, through the Ministry of Environment and Forestry (KLHK), in addressing climate change is to promote multi-stakeholder collaboration to strengthen community-based adaptation and mitigation capacities at the grassroots level through the implementation of the Climate Village Program (ProKlim). ProKlim is a national climate change movement at the community-based grassroots level in Indonesia, with a target of reaching 20,000 villages by 2024 (Suska et al., 2024). Additionally, the government may use this budget allocation to implement environment-based budgeting in accordance with Article 45(1) of Law No. 32 of 2009 on Environmental Protection and Management to fund environmental protection and management activities as well as environmentally sustainable development programs (Puspitasari & Yuliawan, 2023). Green budgeting can also be interpreted as environmental funding policy and constitutes part of the government's accountability in environmental management (Hariyati, 2020).

1.3 Describe Relevant Scholarship

In addition to the government's role, economic development, followed by production activities, namely the processing of inputs or production factors into outputs, is considered to impact the environment. Increased economic growth driven by production and consumption activities is assessed to have negative impacts on the environment. The environment in Indonesia, as a country with an agrarian economy, is a spatial unit of organisms, objects, forces, conditions, and living organisms, including humans and their behaviors, that influence nature itself, the sustainability of life, and the well-being of humans and other living organisms. (Oktavilia et al., 2021).

Economic performance cannot be separated from environmental conditions, starting with the industrial and agricultural sectors, which in 2023 ranked at the top as the pillars of Indonesia's economic performance. Both sectors have undergone rapid changes and developments that impact the quality of the environment. For example, industrial land clearing with uncontrolled burning causes forest fires and air pollution; illegal logging leads to the loss of watershed areas; and the disposal of industrial waste also causes pollution and hinders the utilization of aquatic ecosystems. (Prasetyo Wibowo & Kurniawati, 2024). Additionally, these two sectors were also selected as representatives: urban areas, which are home to many capital-intensive and labor-intensive industries, and rural areas, which typically focus on land use in the agricultural sector, an area that must also prioritize environmental conservation and quality of life.

A country's economic performance is also influenced by foreign direct investment; in this context, every country requires investment as an effort to achieve momentum and ensure a balanced growth trajectory. For instance, domestic technology, innovation, and capital investment may be insufficient to achieve the higher growth trajectory preferred by developing countries. (Krishnankutty et al., 2023). FDI plays a crucial role in both developed and developing

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countries. In practice, Foreign Direct Investment (FDI) plays a significant role in Indonesia's economic growth. However, environmental issues are equally important concerns. Increased economic activity will inevitably place greater pressure on the environment. Economic activities require natural resources and generate waste that can harm the environment. (Diwid Prasetyawati, 2019).

The role of the government and a healthy economy is, of course, underpinned by the contributions of every individual living in each region. These contributions are reflected in human capital resources, particularly in terms of population size, which is projected to increase steadily each year. As estimated in Indonesia's Long-Term National Development Plan (RPJPN), the population is expected to reach approximately 300 million by 2045, though the growth rate is projected to slow. As the population grows, the expansion of residential areas will inevitably increase population density. Higher population density in a region will also lead to environmental issues related to household waste, sanitation, and so on (Yani et al., 2023).

This indicates that the annual increase in population density across Indonesia must be addressed if not balanced by improvements in human development, as reflected by the average Human Development Index (HDI) values across regions. High levels of education and health determine the capacity to absorb and manage sources of economic growth, whether in terms of technology or institutional frameworks, which are crucial for improving the well-being of the population itself, all of which ultimately lead to action. (Kartika & Purwiyanta, 2024).

Countries in the development phase are often situated on the left side of the Environmental Kuznets Curve (EKC). At this stage, the primary focus is often on economic progress and poverty alleviation. Environmental conditions in the countries studied in this research, particularly in the Asia-Pacific region, largely exhibit characteristics of the early phase of the Environmental Kuznets Curve (EKC). This condition is often achieved through industrialization and the intensive use of natural resources. Consequently, as per capita wealth increases, environmental quality often deteriorates. On the other hand, industrialized countries show many signs indicating that they have passed the inflection point on the Environmental Kuznets Curve, thus being on the right side of the curve. OECD countries have agreed to increase government spending on energy research and development to reduce greenhouse gas emissions. This indicates that industrialized nations possess the capacity and commitment to invest in clean technologies and implement stricter environmental regulations, thereby positioning themselves advantageously on EKC, where economic progress aligns with improved environmental quality (Ahmed et al., 2022).

1.4 State Hypotheses and Their Correspondence to Research Design

Thus, this study provides an overview of environmental conditions across 34 Indonesian provinces by examining the government's role through Environmental Function Expenditures, economic performance as indicated by the Regional Gross Domestic Product (RGDP) in the Agriculture sector and RGDP in the Industry sector, Foreign Direct Investment (FDI) as a driver

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of economic growth, and demographic factors such as Population Density and human capital development indicators via the Human Development Index (HDI).

2. Method

2.1 Identify Subsections

The approach used in this study is quantitative, utilizing secondary data. The data sources include the Central Statistics Agency (BPS), the Ministry of Finance, and the Ministry of Environment and Forestry (KLHK). Secondary data refers to data collected by statistical agencies and released or made available to the public for data usage. Information regarding the variables used in this study, along with their sources, is provided in the following table.

Table 1. Variables

Variabel	Konsep	Satuan	Sumber
Environmental Quality Index	EQI (Environmental Quality Index) is an overview or initial indicator that provides a quick assessment of environmental conditions within a specific scope and period. By identifying environmental aspects that are not yet well- managed, existing resources can be allocated more appropriately, thereby resulting in more effective and efficient conditions.	Index	KLHK
Government Expenditure on Environmental Protection	Government expenditures disbursed by relevant agencies or local governments for the implementation of specific activities aimed at improving the welfare of the community or achieving specific targets.	Rupiah	DJPK
GRDP of the Agricultural Sector	The Gross Regional Domestic Product (GRDP) of the Agricultural Sector is based on the activities carried out by production units engaged in agriculture, forestry, and fisheries within a specific region over a given period.	Rupiah	BPS
GRDP of the Industrial Sector	The Gross Regional Domestic Product (GRDP) of the Industrial Sector is based on the activities processing raw or semi-finished materials into finished goods, whether carried out by large or small industries.	Rupiah	BPS
Foreign Direct Investment	Foreign investment refers to the placement of funds by foreign investors to conduct commercial activities within the territory of the Republic of Indonesia, whether through wholly foreign-owned capital or in collaboration with local investors.	USD	BKPM
Population Density	Population density indicates the number of people per square kilometer of area. The population density figure indicates the average number of people per square	Persons /Km^2	BPS

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Variabel	Konsep	Satuan	Sumber
	kilometer.		
Human Development Index	The Human Development Index (HDI) is a comparative indicator that assesses life expectancy, education, and living conditions in various countries. The Human Development Index (HDI) serves as an indicator to evaluate the quality of development and classifies countries as developed, developing, or least developed, as well as measuring the impact of economic policies on quality of life.	Index	BPS

2.2 Model and Methodology

The data analysis method applied in this study is dynamic panel data analysis. Panel data is a combination of time series and cross-sectional data; in short, panel data encompasses both space and time (Gujarati, 2004), hence the term "panel data." The panel data analysis method used in this study employs dynamic panel regression analysis. Dynamic panel data arise due to the presence of many dynamic economic relationships. These dynamic relationships are characterized by using lagged dependent variables as independent variables, which leads to endogeneity issues. If the model is estimated using static panel data analysis, biased and inconsistent predictors can be addressed using the GMM model (Fahmi Ginanjar et al., 2020).

The researcher uses the Generalized Method of Moments (GMM). The Generalized Method of Moments (GMM) itself is a general method for estimating parameters in statistical models used under conditions that are functions of model parameters and data. GMM estimation relies on theoretical relationships that must be satisfied by the parameters. At the same time, the sample estimates are chosen to minimize the distance between the theoretical values and the actual values (Arellano & Bond, 1991). The econometric model used is as follows:

$$\mathrm{l}(EQI_{i,t}) = \beta_1\,(l(EQI_{i,t-1}) - l(EQI_{i,t-2})) + \beta_2\,(l(GEEP_{i,t}) - l(\mathrm{GEEP}_{i,t-1})) + \beta_3\,(l(\mathrm{AGDRP}_{i,t}) - l(\mathrm{AGDRP}_{i,t-1})) + \beta_4\,(l(\mathrm{IGDRP}_{i,t}) - l(\mathrm{IGDRP}_{i,t-1})) + \beta_5\,(l(\mathrm{FDI}_{i,t}) - l(\mathrm{FDI}_{i,t-1})) + \beta_6\,(l(\mathrm{POP}_{i,t}) - l(\mathrm{POP}_{i,t-1})) + \beta_7\,(\mathrm{HDI}_{i,t} - \mathrm{HDI}_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t\text{-}1})$$

l(EQI) : Environment Quality Index (%)
$l(\mathrm{E}QI_{\mathrm{i,t\text{-}1}})$: Environment Quality Index from the previous year (%)
l(GEEP) : Government Expenditure on Environmental Protection (%)
l(AGRDP) : Agriculture Gross Regional Domestic Product (%)
l(IGRDP) : Industry Gross Regional Domestic Product (%)
l(FDI) : Natural Logarithm of Foreign Direct Investment (%)
l(POP) : Natural Logarithm of Population Density (%)

HDI : Human Development Index (Index)
$\beta\gamma$: Vector of predictor variable coefficients
ε : Error
i : Number of Observations
t : Time

3. Results

The analysis begins with POLS and Fixed Effect estimations to examine the initial estimation results and measure the effectiveness of the estimated effects of independent variables on the dependent variable. These estimations are also used to verify the validity of the instruments and ensure the absence of endogeneity.

Table 2. POLS and Fixed Effect

Variable	*POLS*			*Fixed-Effect*		
	Coefficient	*t*	*P > | t |*	*Coefficient*	*t*	*P > | t |*
ln_GEEP	*-0.0014767*	*-1.27*	*0.205*	*-0.0017568*	*-1.28*	*0.201*
ln_AGDRP	*0.0056155*	*1.31*	*0.192*	*0.038073*	*1.48*	*0.139*
ln_IGDRP	*-0.005026*	*-1.34*	*0.181*	*-0.0165847*	*-0.74*	*0.458*
ln_FDI	*-0.0000783*	*-0.03*	*0.977*	*0.0005318*	*0.09*	*0.928*
ln_POP	*-0.0165635****	*-3.98*	*0.000*	*-0.1827493*	*-1.82*	*0.070*
HDI	*0.0011778*	*0.93*	*0.355*	*0.0280199****	*4.31*	*0.000*
_cons	*- 4.6618272*	*6.93*	*0.000*	*1.175192***	*2.60*	*0.010*
Nb. of observation	*238*			*238*		
Nb. of cross-section	*34*			*34*		
F	*156.87****			*25.73****		
Prob > F	*0.0000*			*0.0000*		
R-squared	*0.8268*			*0.6629*		

*Legend: * p<0.05; ** p<0.01; *** p<0.001*

Source: STATA 14

The use of the GMM method is since estimates from POLS and Fixed Effects may be biased due to endogeneity issues. For example, increased government spending on the environment under poor environmental conditions may result in a non- significant negative relationship. Furthermore, poor environmental quality caused by economic expansion in pursuit of growth consistently increases government spending on the environment; this can also lead to reduced government oversight of economic activities that lower environmental quality standards. The expenditure on these variables introduces a bias that may cause endogeneity, as it affects the accuracy of all environmental quality parameter calculations.

Table 3. FD-GMM and Sys-GMM

Variable	*FD-GMM*			*Sys-GMM*		
	Coefficient	*z*	*P > | z |*	*Coefficient*	*z*	*P > | z |*
Envir L1.	*0.512182****	*21.80*	*0.000*	*0.5635642****	*32.64*	*0.000*
ln_GEEP	*-0.0011154***	*- 2.95*	*0.003*	*-0.0012241***	*- 3.22*	*0.001*
ln_AGDRP	*0.0632009****	*6.42*	*0.000*	*0.0076207*	*1.63*	*0.103*
ln_IGDRP	*0.0015653*	*0.35*	*0.727*	*-0.0175355****	*- 3.82*	*0.000*
ln_FDI	*-0.0037757**	*- 2.36*	*0.018*	*0.0048748***	*3.41*	*0.001*
ln_POP	*-0.0440355*	*- 0.82*	*0.414*	*-0.0344106****	*- 7.81*	*0.000*
HDI	*0.016513****	*8.95*	*0.000*	*0.018653****	*16.86*	*0.000*
_cons	*0.5451612**	*2.57*	*0.010*	*0.765194****	*18.12*	*0.000*
Arellano-Bond test						
AR(1) z	*-2.4397***			*-2.563***		
Prob > z	*0.0147*			*0.0104*		
AR(2) z	*-0.34812*			*-0.34685*		
Prob > z	*0.7277*			*0.7287*		
Sargan test chi^2	*26.92361*			*30.83571*		
Prob > chi^2	*0.1374*			*0.2344*		

*Legend: * p<0.05; ** p<0.01; *** p<0.001*
Source: STATA 14

Table 3 presents the estimation results using the FD-GMM and Sys-GMM methods, with the latter chosen due to its stronger statistical consistency and better data validity, thereby allowing for more effective interpretation of the results. The findings of this study indicate that environmental quality in the previous period has a significant positive impact on current environmental outcomes, suggesting a degree of resilience over time. One key finding regarding the government's contribution through environmental expenditures is that it has a negative influence on the environmental quality index in Indonesia. In the economic landscape, an increase in economic output value in the industrial sector, which typically represents regions with high economic growth and activity, and the agricultural sector, which remains a vital pillar supporting the economy in remote areas with limited economic access, was observed. The results of economic output measured by the GRDP of the industrial sector were found to have a significant negative impact on the environmental quality index in Indonesia. Meanwhile, the GRDP of the agricultural sector was found to have no impact on the environmental quality index in Indonesia.

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A key aspect in assessing economic activity is foreign direct investment, which demonstrates a positive and significant impact on the Environmental Quality Index (EQI). Regarding population density, the results indicate a negative and significant impact on the Environmental Quality Index. Conversely, demographic factors measured by the Human Development Index (HDI) were found to have a positive and significant impact on the Environmental Quality Index.

4. Discussion

Estimations using dynamic panel data with the selected Sys-GMM estimation method in this study indicate that, based on the results of the Sargan test and the Arellano-Bond test, the assumptions are consistent and the model's instrumental variables are valid, allowing the results to be concluded (Arellano & Bond, 1991; Fahmi Ginanjar et al., 2020).

Preliminary results indicate that the previous year's environmental quality index had a positive and significant influence on the environmental quality index of the study year. These findings align with those of Ginanjar et al. (2025) and Prasetianto & Kustiwan (2023), who noted that environmental quality management constitutes a cumulative and long-term system and pattern; this also highlights the role of various sectors and stakeholders in driving positive environmental quality index outcomes, such as government programs and policies from previous periods having a tangible impact on current environmental conditions.

The environmental budget allocated by the government has a negative and significant effect on the environmental quality index, meaning that increasing the budget remains ineffective in improving environmental quality. These findings are consistent with the research by Patra Yuda & Idris (2022) and Mohammed et al. (2019). In practice, government spending in the environmental sector tends to be misdirected or inefficient. This raises concerns regarding budget inefficiency, a greater response to environmental damage, and a time lag in observing environmental impacts.

The agricultural sector's GRDP shows no influence on the environmental quality index. This result aligns with the research by Hania Cholily (2023) and Ramadhan (2023), which states that in the agricultural sector, any activity generating added value does not influence environmental quality; this may indicate that other influencing factors are at play, so the agricultural sector's GRDP does not affect the environmental quality index. The GRDP of the industrial sector has a negative impact on the environmental quality index, which aligns with the early-stage EKC theory, which states that when economic growth is driven to reach a certain peak in its trajectory, it hurts environmental quality. These results align with the research by Wafiq & Suryanto (2021) and are like the findings of Eleais et al. (2023), which explains that industrialization damages environmental quality by increasing CO2 emissions in China.

Foreign direct investment (FDI) is one of the factors positively influencing the environmental quality index in Indonesia, according to Diwid Prasetyawati. (2019), FDI plays a crucial role in both developed and developing countries. These findings align with the research by Ginanjar et al. (2025), which states that foreign direct investment has a beneficial and significant impact on

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the Environmental Quality Index. Another study conducted by Duodu et al. (2021), which analyzes the impact of FDI on environmental quality in Sub-Saharan African (SSA) countries, found that the long-term effects generated by FDI contribute to improving environmental quality. Demographic factors can be seen to influence the environmental quality index in Indonesia; in these results, population density has a negative and significant impact on environmental quality. This aligns with Malthusian theory, which states that exponential population growth places pressure on natural resources that grow more slowly, potentially leading to environmental degradation and a decline in quality of life. These results are consistent with studies by Ginting et al. (2023); Kartika & Purwiyanta (2024) and Kondolele et al. (2023). A study by Dimnwobi et al. (2021) states that population dynamics are a primary determinant of environmental degradation.

The Human Development Index has a positive and significant effect on the environmental quality index in Indonesia, consistent with Human Capital Theory, which states that investment in human capital through education, health, and skills will increase productivity and economic well-being. These results are also consistent with research by Esther & Agustina Suparyati (2023) and Haris et al. (2023), which found that the higher a community's education level, the greater the innovation and awareness to address environmental issues, thereby enhancing public understanding and behavior in preserving the environment. Research by Tesalonika & Sutjipto (2023) and Sugeng et al. (2024) indicates that improvements in the Human Development Index (HDI) play a crucial role in enhancing environmental quality.

5. Conclusion

This study identifies several factors that significantly support improvements in environmental quality (EQI) in Indonesia. Key findings indicate that increases in the Human Development Index (HDI) and Foreign Direct Investment (FDI) flows are positively correlated with EQI. This implies that a more developed and educated society, as well as foreign investment that may bring more environmentally friendly technologies, contributes to a healthier ecosystem. Furthermore, environmental conditions from the previous year also strongly determine current conditions, indicating a persistence effect where a good environment tends to remain good.

This study also highlights factors that burden the environment. The expansion of the industrial sector and increasing population density consistently indicate a decline in environmental quality, demonstrating the significant impact of industrial activities and population concentration. The most unexpected (contradictory) finding is that government spending on the environment has a negative correlation with the EQI. This situation suggests that resource allocation may be inefficient, misallocated, or responsive only after environmental damage has occurred.

The main conclusion of this study is that there is great complexity in the interactions between economic, social, and environmental issues. Although the agricultural sector does not have a significant impact, balancing sustainability and progress is crucial. The implications are clear: Indonesia requires more sophisticated policies to manage demographic impacts, ensure the

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effectiveness of environmental spending, and drive economic growth through industry. Policies must be able to balance the need for future ecological sustainability with development goals.

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