Economic Activities, Energy Consumption, and Environmental Quality in Indonesia towards a Green Economy

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Abstract. This study aimed to analyze the determinants that affect Environmental Quality in Indonesia. The independent variables in this study were Gross Domestic Product, Population, and Energy Consumption. Meanwhile, the dependent variable in this study was the Environmental Quality Index (EQI). The data utilized in this study were time series data from 2009 to 2021 in Indonesia and were analyzed using multiple linear regression analysis. The results of this study show that the Gross Domestic Product (GDP) variable exerts a negative and significant effect on the Environmental Quality Index in Indonesia, while the population variable exerts a positive and significant effect on the Environmental Quality Index in Indonesia. However, the energy consumption variable exerts a negative and insignificant effect on the Environmental Quality Index in Indonesia. The negative effect of GDP is because GDP output produced through economic activities always causes environmental damage. Furthermore, the positive effect of the population is because the dominant population in Indonesia already understands the importance of environmental preservation, as evidenced by a large number of organizations or communities engaged in environmental preservation. This forms the basis for the population having a positive effect on Environmental Quality in Indonesia. Whereas, the negative insignificant effect of energy consumption is because the measurement of energy consumption is more likely to be associated with CO2 emissions than with the Environmental Quality Index in Indonesia.

Keywords: Gross Domestic Product, Population, Energy Consumption, Environmental Quality Index.

1 Introduction

Swift growth of the economy typically results in a decline in environmental quality. Economic growth necessitates heightened production of goods and services to fulfill the societal demands both locally and globally. However, this growth also precipitates a depletion of natural resources—and environmental damage, notably through pollution. Pollution is part of the negative externalities that result from the production of

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goods and services. In almost every economic activity, the technology for producing goods and services, and consumption patterns produce pollution [1]. Ideally, economic growth can be demand-driven, resulting in better changes in economic sectors, for example, in the agricultural sector, thereby causing an increase in intensity in the agricultural sector, which has an effect on output growth in the agricultural [2].

Rapid economic growth often goes hand in hand with environmental damage. Economic growth necessitates heightened production of goods and services to fulfill the societal demands both locally and globally. However, this growth also causes a decrease in natural resources—and environmental damage. Indonesia's economic growth, as seen from the economic structure, proves the theory of stages of economic growth according to Friedrich List and WW Rostow.

The economic structure in Indonesia is experiencing a shift from agriculture to industry and from industry to the service sector. There was rapid growth and development of the manufacturing industry in the 1980s. Meanwhile, the contribution of agricultural productivity has been decreasing since the 1970s until now. This is suspected through the five-year development plan (REPELITA) which was launched in 1969. The New Order regime, which studied the mistakes of the previous regime, attempted to stabilize food supplies through the green revolution to achieve rice self-sufficiency. The results of the ELD Study (2015) reveal that global land degradation has caused economic losses of US$ 10.6 trillion per year or the equivalent of 17% of world Gross Domestic Product (GDP). The implications of these economic losses are certainly quite serious because they will threaten food security, causing the loss of ecosystem functions that are important for survival and affecting poverty.

As per the Ministry of Environment and Forestry, environmental development achievements are measured using the Environmental Quality Index (EQI). EQI serves as an index for environmental management and is a common reference for all parties in measuring management performance and environmental protection performance. In calculating the Environmental Quality Index (EQI), three main components are used, namely: Water Quality Index (WQI), Air Quality Index (AQI), and Land Cover Quality Index (LCQI).

Table 1. Environmental Quality Index in Indonesia from 2016 to 2020

Year	Environmental Quality Index (EQI)	Target Environmental Quality Index (EQI)
2016	66.3	64
2017	66.46	63.3
2018	65.15	64
2019	66.15	65
2020	70.27	66.5

Sources: Ministry of Environment and Forestry, 2022 [3].

Table 1 shows that the Environmental Quality Index (EQI) experienced fluctuations from 2016 to 2020, with a significant increase of 70.27, up 3.27 points from 2019. The lowest Environmental Quality Index (EQI) was in 2018 at 65.15. The Min-

istry of Environment and Forestry categorizes the values of the Environmental Quality Index (EQI). Even though the realization exceeds the target planned in the RPJMN, it still falls within the "medium" range. The EQI value range of 90-100 is categorized as "very good," 70-90 is categorized as "good," 50-70 is categorized as "medium," 25-50 is categorized as "bad," and a value of less than 25 is categorized as "very bad."

Rapid population growth has serious consequences for the balance of natural resources. Every human being has various needs, spanning from fundamental to supplementary. While human needs are numerous and unlimited, essential needs can only be fulfilled when natural resource reserves remain abundant and adequate. The population in an area will cause the available space for movement to become narrower as humans are integral components of ecosystems and utilize their environment for sustenance. This phenomenon is also expounded upon by [4]. The growth in population contributes to the escalation of damage in every biological ecosystem.

With increasingly rapid population growth, there arises strong pressure on natural resources, such as the increasing demand for food, clean water, housing, and so on. Thus, this creates an imbalance between the supply of natural resources and human needs.

As per the conventions outlined by the United Nations Framework Convention on Climate Change (UNFCCC), “2018 saw unprecedented heatwaves, storms, and floods across the world, while greenhouse gas emissions continued to increase last year, with carbon dioxide concentrations in the atmosphere currently at the highest in the last three million years”[5]. Nevertheless, climate action lags far behind what needs to be done to slow the already dangerous rate of global warming, reflecting “failed environmental policies” by many governments. If there is no change in the rate of the increase in global temperatures by December 2040, we will reach a critical point, namely the point where we can no longer reverse the situation, and the rate of climate change will worsen, producing extreme hot or cold weather. That is the future of our children and grandchildren. Given the urgency and complexity of this problem, one big challenge for us is to determine our attitude and how to deal with this problem effectively.

Consumption in the energy sector constitutes the largest contributor to greenhouse gas emissions. In 2019, energy sector consumption contributed to emissions of 638.8 million tons of CO2, followed by forest use and other sectors. Given this circumstance, Indonesia still faces significant challenges in meeting its Nationally Determined Contribution (NDC) target, which represents its commitment to reducing greenhouse gas emissions as stipulated by the Paris Agreement. According to the NDC, Indonesia aims to decrease greenhouse gas emissions by 29% compared to the Business as Usual scenario by 2030 through domestic efforts alone, or by up to 41% with international support.

The change in GDP structure in Indonesia from Agriculture to Industry has brought unfavorable effects on the environment. How so? Waste or production processes conducted by industrial companies result in a significant metabolic strain on nature, whether in the form of pollution or other environmental damage, especially within the Industrial sector itself, the industry that is usually considered a middle to upper indus-

try--that transforms unfinished goods into semi-finished goods or semi-finished goods into raw materials. The industry's contribution to environmental damage usually produces waste referred to as B3 waste (hazardous and toxic materials). Every industry inevitably produces waste in its production process. This waste is the starting point for why environmental damage inevitably occurs--because the production process ignores environmental conditions and continues to reproduce the materials produced as an effort for economic growth and development. This is because the industrial sector is the largest contributor to a country's economic growth.

Sustainable development should be a necessity. This is based on the main considerations, covering aspects of benefits and costs. From the aspect of development benefits, it establishes the principles of sustainability. Apart from establishing benefits for the present, it also ensures the availability of sustainable resources in the long term. These resources are none other than those available on Earth, providing all human needs, both in terms of essentials and business. This is in line with the statement of David Brower, Executive Director of the legendary Sierra Club: "There is no business to be done on a dead planet."

Economic development designers view natural resources as nothing more than a "factor of production," utilizing these resources for development without acknowledging their inherent limitations. When nature is no longer able to regenerate itself within these constraints, environmental issues such as deforestation and forest depletion arise. This, in turn, contributes to the occurrence of natural disasters, affecting human survival. In economics, the resources employed by factories or companies in the production of goods and services encompass four essential factors: capital, labor, natural resources, and entrepreneurship. Meanwhile, ecologists and environmentalists view these natural resources as integral components of the "living system" on Earth. The differing views of "natural resources" in the context of markedly distinct and sometimes contradictory interpretations of "development" lead to contention between "economic development" and "environmental preservation."

Grossman and Krueger introduced the Environmental Kuznets Curve (EKC) in 1991, applying the Kuznet hypothesis to explore the relationship between economic growth and environmental quality. The EKC theory, characterized by an inverted-U curve, applies to several pollutants in regions with elevated income levels. The hypothesis illustrates that economic growth initially contributes to increased environmental degradation as countries focus on production without considering environmental aspects. However, further economic growth, supported by technological advancements and a shift to a service-based economy, has the potential to reduce environmental degradation [6].

The EKC theory posits that economic growth will initially exacerbate environmental degradation due to an emphasis on increasing production without adequate attention to environmental concerns. Continuous production processes result in environmental degradation, manifesting as land, water, and air pollution. At a certain point, economic growth prompts a realization of the critical importance of environmental quality. This turning point signifies that economic growth can lead to a reduction in environmental degradation [7]

The Environmental Kuznets Curve hypothesis, commonly referred to as the Environmental Kuznets Curve (EKC), actually identifies economic growth as a factor that determines changes in income distribution in the long term. The EKC was developed to study the relationship between economic growth and carbon dioxide. However, EKC studies on carbon dioxide are still controversial, as shown and proven by EKC in one study but not proven and observed in other studies. Studies that support the EKC hypothesis, such as that conducted by Shahbaz, et. al. testing EKC in Pakistan, show an inverted U-curve in the long run [8]. Conversely, studies that did not support the EKC hypothesis, such as that conducted by Basarir and Arman, revealed that the EKC hypothesis was not proven in the Gulf Cooperation Council (GCC) countries [9].

The EKC curve explains the stages that occur in the relationship between economic growth and environmental quality, delineated into three phases. The initial phase of the Kuznets inverted U-curve relationship encompasses the stages of economic growth transitioning from agriculture to industry, followed by a post-industrial phase characterized by a service-based economic system. Environmental degradation tends to escalate due to shifts in economic structure from rural to urban settings and from agriculture to industry, driven by the expansion of mass production and consumption. This trend then diminishes with a secondary shift in economic structure from energy-intensive heavy industry to technology-driven industry and services. During the early stages of industrialization, pollution proliferates rapidly as emphasis is placed on employment and income generation rather than environmental preservation. Within this framework, individuals who lack the financial means to afford environmental control and regulation also contribute to environmental damage.

2 Methodology

The scope of this study includes the effect of Gross Domestic Product, Population, and Energy Consumption on Environmental Quality in Indonesia from 2009 to 2021. This study utilized secondary data. Data collection was carried out in a time series from 2009 to 2021. The data sources in this study were the Central Statistics Agency, the Ministry of Environment and Forestry, Journals, and Books.

The data collection method employed in preparing this study was the library research method. Data collection was carried out by reviewing data, theories, journals, and books that discuss the same topic as this study. To examine the extent of the effect that the independent variables (Gross Domestic Product, Population, and Energy Consumption) have on environmental quality in Indonesia, this study employed multiple linear regression analysis with the EViews program. The objective of multiple regression analysis is to ascertain the direction of the relationship between the independent variable and the dependent variable—whether each independent variable is positively or negatively correlated—and to forecast the value of the dependent variable in the event of an increase or decrease in the value of the independent variable.

The equation model utilized is as follows:

$$Y = f(X1, X2, X3, X4) \quad (1)$$

This equation is then transformed into a multiple linear regression equation, resulting in the following equation:

$$Y = \beta 0 + \beta 1\, X1 + \beta 2\, X2 + \beta 3\, X3 + e \quad (2)$$

$$Y = Ln\beta 0 + \beta 1\, LnX1 + \beta 2\, LnX2 + \beta 3\, LnX3 \quad (3)$$

Where:
Y = Environmental Quality (Index Ratio)
β (1,2,3) = Independent variable coefficient
X1 = Gross Domestic Product (Rupiah)
X2 = Population (People)
X3 = Energy Consumption (Million Barrels)

Statistical tests were carried out to assess the level of significance between the independent variables—namely, Gross Domestic Product, Population, and Energy Consumption—and the dependent variable, namely, environmental quality. This was accomplished using the t-test (partial test), F-test (simultaneous test), and coefficient of determination (R^2).

The t-test was carried out to determine the effect of each independent variable on the dependent variable. The t-statistical test essentially indicates how much the effect of an independent variable individually contributes to explaining variations in the dependent variable.

The Correlation Coefficient Test (R^2) measures the level or strength of the linear relationship between two variables. The correlation coefficient serves as a gauge of the strength of a linear relationship. To ascertain the relationship between two variables, it suffices to examine the value of the correlation coefficient. In a perfect correlation, there is no need for hypothesis testing because the two variables exhibit a perfect linear relationship, signifying that variable X perfectly affects variable Y. If the correlation is equal to zero (0), there is no relationship between the two variables. The coefficient of determination (R^2) serves to assess the level of determination or the effect of the independent variable on the dependent variable, as indicated by the magnitude of the coefficient of determination (R^2), which ranges between 0 (zero) and 1 (one). If the coefficient of determination (R^2) is zero, it means that the independent variable does not determine the variation in the dependent variable at all. As the coefficient of determination (R^2) approaches one, it can be said that the independent variable increasingly determines the variation in the dependent variable.

3 Results and Discussion

Linear regression analysis was employed to estimate the extent of effect of the dependent variable on the independent variables. The dependent variable was economic growth (Y), and the independent variables were Gross Domestic Product (X1), Population (X2), and Energy Consumption (X3) for the period 2009-2021.

The estimation results using regression analysis with EViews can be observed in the following table.

Table 2. Regression Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-7953.644	2953.653	-2.692816	0.0247
PDB	-87.14717	37.90111	-2.299330	0.0471
Jumlah Penduduk	495.0868	188.0719	2.632433	0.0272
Konsumsi Energi	-32.92842	24.98551	-1.317901	0.2201

Source: Eviews Data Processed Results 12, 2023 (processed)

Based on Table 2., the following regression results are obtained:

Env. Quality

$$(Y) = -7953.644 - 87.14717\,LnX1 + 495.0868\,LnX2 - 32.92842\,LnX3$$

The equation above explains that the GDP and Energy Consumption variables have a negative relationship with environmental quality, while the population variable has a positive relationship with environmental quality. Here is the explanation:

1. The constant value is -7953.644, signifying that if the GDP, Population, and Energy Consumption variables remain constant or do not undergo changes, then environmental quality will increase or decrease by 7953.644%.
2. The coefficient value of variable X1 (GDP) is at a negative value of -87.14717, signifying that if GDP increases by 1%, while the other independent variables remain constant, environmental quality will decrease by -87.14717%.
3. The coefficient value of variable X2 (Population) is at a positive value of 495.0868, signifying that if the population increases by 1%, while the other independent variables remain constant, environmental quality will increase by 495.0868%.
4. The coefficient value of variable X3 (Energy Consumption) is at a negative value of -32.92842, signifying that if energy consumption increases by 1%, while the other independent variables remain constant, economic growth will decrease by -32.92842%.

Table 3. Results of the Coefficient of Determination (R-Square)

R-Squared	0.814058
Adjusted R-Squared	0.752077

Source: Eviews Data Processed Results 12, 2023 (processed)

The R^2 coefficient of determination test was conducted to assess the extent to which the independent variables, comprising GDP, population, and energy consumption, could explain changes in the dependent variable, namely Environmental Quality. Based on the output in Table 3, it is evident that there is an adjusted R-Squared value of 0.814058 (81.4%). This signifies that 81.4% of the variance in the dependent variable, economic growth, can be explained by the independent variables—GDP, population, and energy consumption—while the remaining 18.6% (100% - 81.4%) is affected by other variables outside the model.

The statistical t-test serves to assess the magnitude of effect and test the significance of each independent variable individually in explaining the dependent variable.

Table 3. T-Test results

Variablle	t-Statistics	Prov
C	-2.692816	0.0247
GDP	-2.299330	0.0471
Population	2.632433	0.0272
Energy Consumption	-1.317901	0.2201

Source: Eviews Data Processed Results 12, 2023 (processed)

Based on the estimation results in Table 3., the following are the statistical t-test results for each independent variable:

1. In Table 3, the probability value of GDP is 0.0471, with a significance level of α=0.05. The probability value of 0.0471 is less than 0.05. Consequently, H0 is rejected, and Ha is accepted. Thus, GDP exerts a negative and significant effect on environmental quality in Indonesia.
2. In Table 3, the probability value of Population is 0.0272, with a significance level of α=0.05. The probability value of 0.0272 is less than 0.05. Consequently, H0 is rejected, and Ha is accepted. Thus, the population exerts a positive and significant effect on environmental quality in Indonesia.
3. In Table 3, the probability value of Energy Consumption is 0.2201, with a significance level of α=0.05. The probability value of 0.2201 is greater than 0.05. Consequently, H0 is accepted, and Ha is rejected. Thus, energy consumption exerts no significant effect on environmental quality in Indonesia.

4 Conclusion

Drawing from the data analysis results regarding the effect of Gross Domestic Product, Population, and Energy Consumption on environmental quality in Indonesia, it can be concluded that:

1. GDP exerts a negative and significant effect on environmental quality in Indonesia. This indicates that if GDP increases, environmental quality will decrease and vice versa. The cause is that Indonesia's GDP is still predominantly driven by industrial sector activities. Therefore, specialized studies on the effect of the industrial sector on environmental degradation are needed so that the overall economic activities in Indonesia can align with the principles of a green economy.
2. The population exerts a positive and significant effect on environmental quality in Indonesia. This indicates that when the population increases, the quality of the living environment also increases and vice versa. These findings indicate that the increasing population is making society more aware of the importance of preserving the environment for the sustainability of future generations. This is rein-

forced by the fact that environmentally based organizations are on the rise. These findings also suggest that Indonesian society is ready to move towards a green economy.

3. Energy consumption exerts no significant effect on environmental quality in Indonesia. This indicates that environmental quality is not affected by increases or decreases in energy consumption. These findings indicate that the adaptation of the energy sector in Indonesia is progressing well because economic actors have an awareness of the importance of environmental preservation. Nevertheless, mitigation efforts in the energy sector still need to be promoted, considering that Indonesia is still reliant on the industrial sector, which is known to be closely associated with environmental degradation.

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