
ANALYSIS OF REGIONAL GROSS DOMESTIC PRODUCT PER CAPITA, POPULATION DENSITY, AND THE NUMBER OF MOTOR VEHICLES ON ENVIRONMENTAL QUALITY IN INDONESIA



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ABSTRACT

Environmental quality plays an essential role in maintaining sustainability amid a country's economic activities. In Indonesia, environmental quality can be influenced by national sectoral economic activities, population density, and the number of motor vehicles. This study aims to analyze the effects of regional gross domestic product (RGDP) per capita, population density, and the number of motor vehicles on environmental quality in Indonesia. The observation period of this research spans from 2012 to 2023, aiming to determine whether these variables exert a positive or negative effect on environmental quality in Indonesia. The data analysis method employed is a spatial panel multiple linear regression model. This study adopts both descriptive and inferential research designs. The data utilized are secondary data obtained from Statistics Indonesia (BPS) and the Ministry of Environment and Forestry of the Republic of Indonesia. The findings indicate that RGDP per capita (PDRBK) has a positive effect on the Environmental Quality Index (IKLH) in Indonesia during the 2012-2023 period. Conversely, population density has a negative effect on IKLH during the same period, and the number of motor vehicles also negatively affects IKLH in Indonesia between 2012 and 2023.

Keyword : Regional Gross Domestic Product per Capita, Population Density, Motor Vehicles, Environmental Quality

INTRODUCTION

Environmental conditions have become a very important global issue, especially in countries with developing economies, such as Indonesia (Ar'rida & Sopiana, 2023). This country is highly dependent on an economy based on natural resources, which often ignores the environmental impact of such economic activities. As a result, Indonesia experiences various environmental problems such as deforestation, air and water pollution, and ecosystem damage caused by excessive exploitation of natural resources. (Fadhilah et al., 2024) This environmental damage is one of the main challenges in achieving sustainable development, which requires countries to balance economic growth and the protection of environmental quality. This issue is becoming increasingly relevant because its impact is not limited to the environmental sector, but also affects human health, economic sustainability, and overall quality of life.

(De et al., 2022) Environmental damage can be seen from various indicators, including declining water quality, air pollution, and reduced forest cover, which plays an important role as a carbon sink and ecosystem protector. In Indonesia, this problem is often linked to production and consumption activities that do not take into account the sustainability of natural resources. For example, industrial activities that produce air pollution, illegal logging that reduces forest area, and industrial waste disposal that pollutes rivers all contribute to environmental damage. (Kustanto, 2020) This environmental damage often occurs due to improper management of natural resources, with little attention paid to environmental restoration and conservation. Therefore, the environmental degradation that occurs indicates a failure to implement development that takes into account the principles of sustainability.

(Latifa, 2025) The Environmental Quality Index (EQI) is one indicator that can be used to assess the level of environmental damage in a country. In Indonesia, the EQI measures three main indicators, namely water quality, air quality, and forest cover quality. Based on available data, during the period from 2018 to 2023, Indonesia experienced fluctuations in its environmental quality, as indicated by an average ELQI value of 66.15. This figure reflects that the quality of the environment in Indonesia is in an unstable condition, with alternating declines and improvements. This shows that despite efforts to improve environmental quality, environmental damage is still significant and requires more attention.

(Guo et al., 2020) One of the main causes of this environmental damage is the growing industrial activity. The industrial sector, especially those engaged in manufacturing and mining, contributes significantly to air pollution and greenhouse gas emissions, such as carbon dioxide (CO₂) and sulfur. Larger production processes require more energy and raw materials, which in turn increases pollution and damages air quality. (Ardini & Sirait, 2023) In addition, the transportation sector, especially motor vehicles, also contributes significantly to air pollution. The increase in the number of motor vehicles in Indonesia each year is one of the main causes of declining air quality. In 2019, motorcycles were the most numerous motor vehicles, followed by passenger cars and goods vehicles. Although the development of the transportation sector has had a positive impact on the economy by facilitating mobility, its negative impact on the environment needs to be addressed immediately (Noviandy et al., 2024).

(Ilham, 2021) Meanwhile, the agricultural sector, which is an important part of the Indonesian economy, is also not immune to negative environmental impacts. Unsustainable agricultural practices, such as the use of chemical pesticides and excessive fertilization, have resulted in soil degradation, water pollution, and reduced air quality (Kendani & Febriani, 2025). The reduction in forest cover due to land conversion for agriculture is also a factor contributing to environmental damage. Therefore, it is important to develop organic and integrated farming that takes environmental sustainability into account. Agribusiness systems based on the principles of sustainability can reduce the use of chemicals and increase agricultural efficiency and productivity without damaging the environment.

(Wan et al., 2024) Sustainable agricultural development can have a positive impact on the economy while protecting the quality of the environment. In addition, the development of infrastructure that supports organic farming and environmentally friendly agro-industry systems must also be a priority for the government. Sustainable agricultural development can improve the quality of the environment while increasing the income of farmers and the agribusiness sector.

In this case, the relationship between economic growth and environmental quality is a complex issue that must be understood in greater depth. Several studies show that rapid economic growth, if not accompanied by sustainable development policies, can cause significant environmental degradation (Mahfudh et al., 2024). For example, the growing transportation sector, especially with the increase in the number of motor vehicles, contributes significantly to air pollution. However, there are also studies that show that certain sectors, such as agriculture and agro-industry, can develop sustainably and have a positive impact on environmental quality if managed properly.

Therefore, research on the relationship between gross regional domestic product (GRDP) per capita, population density, and the number of motor vehicles with environmental quality in Indonesia is highly relevant. This study aims to analyze how economic factors such as GRDP, population density, and the transportation sector can affect environmental quality in Indonesia. The results of this study are expected to provide a clearer picture of how sustainable development policies can be implemented to improve environmental quality while maintaining economic growth. Thus, the government and society can work together to achieve sustainable development and preserve environmental quality for future generations.

REVIEW OF LITERATURE

Sustainable Development

Sustainable development is a concept that balances social, economic, and environmental dimensions to ensure a decent life for current generations without compromising future generations. (Maryanti, 2021) Despite its noble goals, the implementation of sustainable development is often hampered by ideological conflicts, differences in interests, and challenges from developed countries that control development policies in developing countries.

Scope of Economic Development

Economic development is a process of change in the social and economic structure that aims to improve the welfare of society through sustainable economic growth. This includes shifting economic sectors, improving the welfare of the poor, and using more efficient and environmentally friendly technologies. (Saputri & Pratama, 2022) Economic development needs to be supported by policies that take into account the balance between growth and environmental sustainability.

Economic Growth Theory

Economic growth, according to Todaro (2014), is a continuous process of increasing production capacity in the economy. (Hamzah et al., 2023) The main factors in economic growth are capital accumulation, population growth, and technological progress. Economic growth can be measured by an increase in per capita income in the long term, which reflects the prosperity of a country.

The Environment and Its Degradation

The environment is a space that encompasses all objects, forces, conditions, and living things that affect human life and other living things. (Gunawan et al., 2022) Environmental degradation occurs as a result of excessive exploitation of natural resources, which can reduce the quality of human life and cause ecological damage that impacts the economy. This damage

occurs through air, water, and soil pollution, as well as deforestation, which can reduce the carrying capacity of nature.

The Relationship Between Economic Development and the Environment

(Wagino et al., 2024) Economic development is not only determined by capital, labor, and technology, but also by the quality of the environment. Environmental damage can reduce production capacity and diminish a country's prosperity. The Environmental Kuznets Curve model shows that in the early stages of economic development, environmental degradation increases, but with further progress and environmentally friendly technology, environmental quality can be improved.

Population Density and Motor Vehicles

Population density affects economic activity, but it can also cause social and environmental problems, such as resource shortages and traffic congestion. (Wafiq & Suryanto, 2021) The increasing number of motor vehicles in Indonesia worsens air quality and causes pollution, which affects public health. In addition, traffic congestion increases energy waste and raises socioeconomic costs.

RESEARCH METHOD

This study is a quantitative descriptive study that aims to describe the condition of the problem based on numerical data. The analysis used is spatial panel data, which combines time series data (2012-2023) and cross-sectional data from 33 provinces in Indonesia. This study was conducted in Medan City, North Sumatra Province, during the period 2024-2025 and focused on analyzing the influence of per capita GRDP, population density, and the number of motor vehicles on the quality of life in Indonesia.

The variables used consist of independent variables, namely per capita GRDP, population density, and number of motor vehicles, as well as dependent variables, namely the Environmental Quality Index (IKLH). The data used is secondary data obtained from the Central Statistics Agency and the Indonesian Ministry of Environment and Forestry. The operational definitions for these variables include GRDP per capita calculated on a constant price basis, population density calculated as the ratio of population to land area, and number of motor vehicles based on the total number of vehicles.

Data analysis was performed using spatial panel data regression with Eviews12 software. Inferential tests were used to test the effect of independent variables on environmental quality, selecting the best regression model through Chow, Hausman, and Breusch-Pagan tests (Irawan, 2023). Assumption testing, including residual normality, multicollinearity, and homoscedasticity, was also conducted to ensure the suitability of the regression model used.

RESULTS AND DISCUSSION

Overview of the Environment in Indonesia from 2012 to 2023

Sustainable development aims to maintain environmental balance by preventing damage caused by economic development activities. Environmental degradation is a global concern, including in Indonesia.

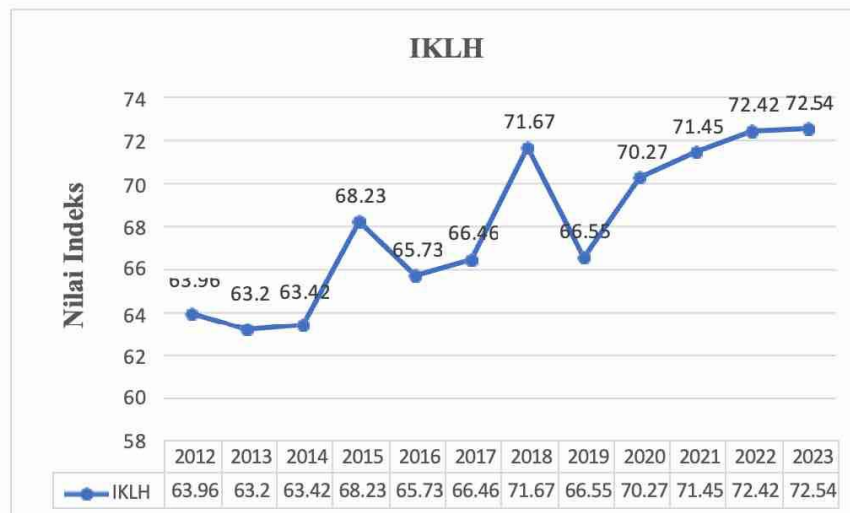


Figure 1.

Overview of the Environment in Indonesia

Source: Processed Data (Ministry of Environment and Forestry)

Based on data from the Ministry of Environment and Forestry, nationally, Indonesia's environmental quality showed an improvement in 2023 compared to 2012. Despite this increase, fluctuations were still evident during this period, with the Environmental Quality Index (IKLH) continuing to change. In 2023, the IKLH was recorded at 72.54, an increase from 63.96 in 2012, although it remained in the fluctuating category.

The level of environmental degradation is closely related to its decline in quality. Despite an increase at the national level, the quality of the environment in Indonesia has fluctuated significantly across provinces. Figures 2 and 3 show a comparison of environmental quality at the provincial level, with some areas experiencing a decline that can be seen from the change in color of the environmental quality status indicator. In 2023, two provinces with alert environmental quality are DKI Jakarta and DI Yogyakarta, while three provinces show very poor environmental quality, namely West Java, Banten, and Bali. The province with the highest environmental quality status in 2023 is West Papua with an IKLH score of 84.51. In 2023, Indonesia's IKLH score is in the alert category with a score of 72.54.

Water Quality (IKA)

Water quality is one of the important parameters in measuring environmental quality in Indonesia. The table below shows water quality indicators from 2020 to 2023, covering various parameters used to measure water quality, such as TSS, DO, BOD, COD, T-P, Fecal Coli, and Total Coli.

Table 1.

Development of 7 Water Quality Indicators in Indonesia 2020 - 2023

Parameter	2020	2021	2022	2023
TSS (mg/l)	54.73	51.52	58.94	127.80
DO (mg/l)	5.82	6.02	5.74	5.82
BOD (mg/l)	6.29	8.32	5.50	6.69
COD (mg/l)	26.98	29.65	22.78	25.59
T-P (mg/l)	0.42	0.21	0.20	0.18
Fecal Coli (count/100 ml)	329,430.07	1,241,432.80	464,699.06	269,486.34
Total Coliforms (count/100 ml)	96,940.94	22,947,847.51	50,881,285.38	1,197,941.37

Source: Ministry of Environment and Forestry

TSS indicates the presence of solid particles suspended in water, which indicates poor river quality. In 2023, TSS experienced a sharp increase, indicating that river conditions in Indonesia have deteriorated due to increased soil erosion. TSS values in Banten, for example, increased by 2199.64%, indicating the impact of industrialization and domestic waste disposal, which has increased river damage.

Another parameter to consider is DO, which indicates the oxygen dissolved in water. The lower the DO, the poorer the water quality. In general, DO has declined, especially in 2022. In several provinces, such as Lampung and East Java, the decline in DO was caused by an increase in organic waste from household and industrial activities.

Table 2.
Water Quality Index (IKA) in Indonesia 2012-2023

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
IKA	54.58	51.82	52.19	65.86	60.38	58.68	72.77	52.62	53.53	53.33	53.88	54.59

Source: Ministry of Environment and Forestry

During the period 2012-2023, water quality in Indonesia fluctuated, with a downward trend. The average Indonesian water quality index (WQI) value during this period was 343.51, which falls into the "poor" water quality category. Water quality declined in 2013 with a WQI value of 51.82, down 5.06% compared to 2012, but improved in 2018 with a WQI value of 72.77. Despite this improvement, water quality remained in the poor category in almost all provinces. Figure 4 shows that many provinces in Indonesia have water quality that is classified as poor, very poor, or hazardous, with no provinces having good water quality.

Provinces with poor water quality include North Sumatra, South Sumatra, Lampung, and Bali. Meanwhile, provinces with very poor water quality include Aceh, Riau, Jambi, East Java, and Papua. Several provinces, such as DKI Jakarta, West Java, and Yogyakarta, are in the alert category.

Air Quality (IKU)

Air quality in Indonesia fluctuated between 2012 and 2023, with the largest decline occurring in 2012. However, Indonesia's air quality has improved overall, with an IKU value of 88.67 in 2023, up from 79.61 in 2012.

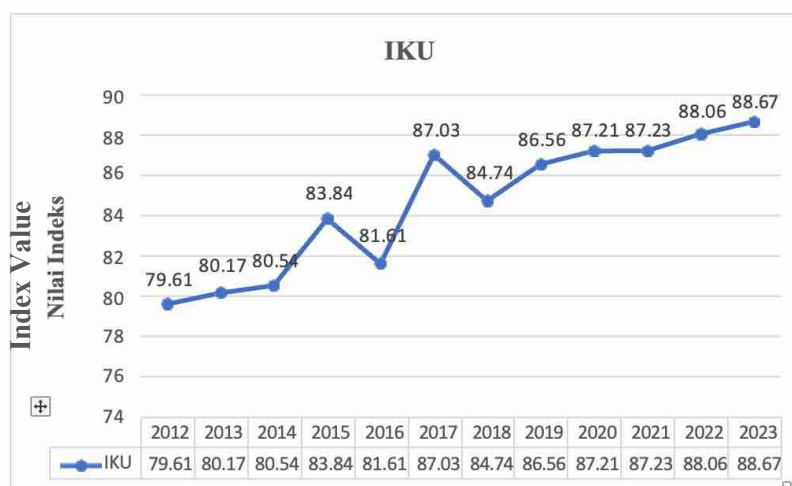


Figure 2.
Air Quality Index (AQI) in Indonesia from 2012 to 2023
Source: Ministry of Environment and Forestry

Air quality has improved, although there are still provinces with poor air quality, especially in the Java region. Air pollution is caused by emissions of sulfur dioxide (SO₂) and nitrogen dioxide (NO₂), which are produced by industrial activities and motor vehicles. DKI

Jakarta and West Java are recorded as provinces with poor air quality, while provinces in eastern Indonesia tend to have better air quality.

Forest Land Cover Quality

The decline in forest cover quality in Indonesia is an indication of significant environmental degradation. Deforestation, which occurs as a result of land clearing for plantations and industry, reduces the existing forest area.

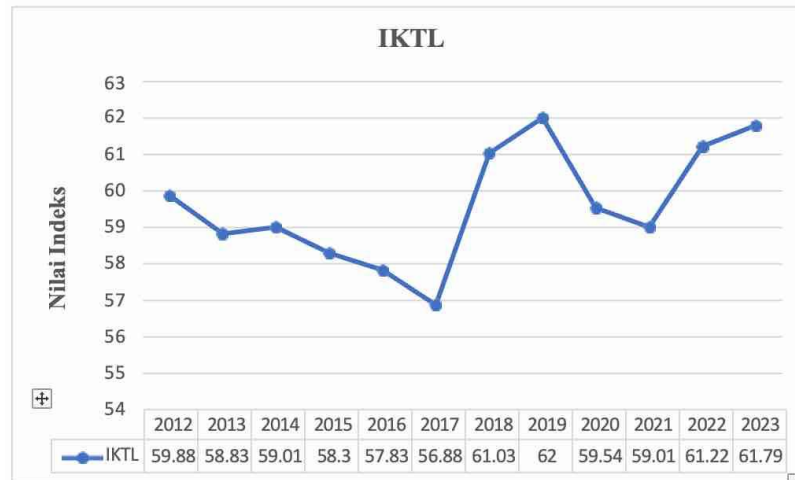


Figure 3.
Air Quality Index (AQI) in Indonesia from 2012 to 2023
 Source: Ministry of Environment and Forestry

The forest cover quality index shows fluctuations with varying decreases and increases throughout the period from 2012 to 2023. In general, the quality of Indonesia's forest cover is in the moderate category. The region most affected by deforestation is Kalimantan Island, which contributes 62% to national deforestation, followed by Sumatra Island with a contribution of 26%.

The Influence of Economic Development Factors

The estimation results show that every 1% increase in per capita GRDP will reduce environmental quality by 0.061763%. This is in line with the research by Hung and Shaw (2006), which reveals that an increase in per capita income is associated with a decline in environmental quality. These results are also consistent with the Environmental Kuznets Curve (EKC) hypothesis, which suggests that economic development in its early stages can worsen environmental quality, but in later stages, when the country becomes more developed, the impact tends to be positive.

Improvements in welfare are often associated with increased consumption of natural resources and pollution. Kristanto (2013) states that improvements in quality of life are often accompanied by increased consumption and pollution, which have a negative impact on environmental quality. Therefore, although economic development is important for improving welfare, it must be carried out with consideration for its impact on the environment.

Economic development that relies on natural resources must be carried out with consideration for environmental sustainability. Wise management of natural resources is necessary to prevent environmental degradation that could harm economic sustainability itself, as stipulated in Law No. 32 of 2009 concerning environmental management.

The Influence of Population Density Factors

Population density is an important factor that affects environmental degradation. Every 1% increase in population density reduces the quality of the environment by 0.071430%. Research shows that the higher the population density, the worse the quality of the

environment, especially water quality and CO emissions. This is in line with research by Alam et al. (2013) and Hardini (2013), which links population growth to pollution.

Increased population density puts pressure on natural resources, increases consumption, and worsens environmental quality, especially in densely populated areas such as Jakarta. This contributes to land degradation, erosion, and depletion of natural resources. Measures such as population redistribution are needed to reduce density in certain areas through means such as transmigration.

Environmental education is also necessary to raise public awareness of the importance of protecting the environment. Environmental education must be inclusive and accessible to all. Strategies to improve environmental education include institutional capacity building, improving the quality of human resources, and integrating local wisdom into the education curriculum.

The Influence of the Number of Motor Vehicles

The number of motor vehicles contributes significantly to environmental degradation. Estimates show that every 1% increase in the number of motor vehicles will reduce the quality of the environment by 0.043757%. This is in line with research by Sadullah et al. (2003) and Zainordin et al. (2014), which identified a positive relationship between traffic volume and increased air pollution, such as CO, SO₂, NO₂, and ozone. Motor vehicles emit air pollutants, negatively affecting environmental quality and increasing pollution.

The increase in motor vehicles is linked to the rapid growth of the transportation sector, but it also causes air pollution and environmental degradation. This transportation sector contributes to the consumption of natural resources, leading to deforestation and other environmental damage. Nevertheless, motor vehicles are important for supporting economic activities, particularly in the transportation sector, which has an impact on economic development and community welfare.

Motor vehicles, which require fossil fuels, produce harmful emissions. Therefore, it is important to improve vehicle efficiency and use environmentally friendly technologies to reduce negative impacts on the environment. In addition, the use of efficient mass transportation and environmentally friendly energy policies needs to be implemented to reduce environmental degradation.

Statistical Test Analysis of the Model

Table 3.
Data Analysis Result

No.	Variable	Coefficient	Sig. Value
1.	X ₁ {GRDP Per capita (PDRBK)}	0.003737	0.6893 > 0.05
2	X ₂ {Population Population (KP)}	-0.073323	0.0000 < 0.05
3.	X ₃ {Number Motorized (JKB)}	-0.004381	0.5782 > 0.05

Source: Processed Data

Summary of Model Estimates and the Influence of Factors on Environmental Quality

Based on the model estimation results, the variable of GRDP per capita (X₁) is not statistically significant for environmental quality with a significance value of 0.6893 (greater than 0.05). Conversely, population density (X₂) has a significant negative effect with a significance value of 0.0000, while the number of motor vehicles (X₃) also shows a significant effect with a significance value of 0.5782, although it has a positive effect. Simultaneously, these three variables have a significant effect on environmental quality, with an F sig. value of less than 0.05.

Kernel Testing

GWR was performed by trying several kernel functions, namely Adaptive Gaussian, Fixed Gaussian, Adaptive Bisquare, and Fixed Bisquare. Based on the Residual Sum of

Squares s (RSS) value, the best model was obtained with the Adaptive Gaussian kernel with a bandwidth of 10.25.

2023 GWR Estimation Results

The GWR model shows that the R-squared increased to 0.81, higher than the global regression model (OLS) which was only 0.53. The variable coefficients differed between provinces, indicating spatial heterogeneity. The KP variable has a significant negative effect in most provinces, consistent with the REM model results. The JKB variable shows varying effects, some of which are significantly negative and some of which are insignificant.

Global Regression Results

The global regression (OLS) results show a coefficient of determination (R-squared) value of 0.534, which means that the model can explain 53.4% of the variation in IKLH. Three independent variables, namely per capita GRDP (pdrbk), population density (kp), and number of motor vehicles (jkb), were used in the model.

GWR Results (Adaptive Gaussian Kernel)

In the GWR modeling stage, an adaptive Gaussian kernel was used. The optimal bandwidth selection results showed a bandwidth value of 10.25 with the smallest AICc value of 488.08. The GWR model produced an R-squared value of 0.808 and an Adjusted R-squared of 0.716, which means that the GWR model is better able to explain local IKLH variation than global regression.

Spatial Variation Test of Local Coefficients

The F test for local coefficients shows that the variables kp and jkb have negative Diff Criterion values and high F values, indicating significant spatial variation. Meanwhile, the variables pdrbk and intercept have positive Diff Criterion values, indicating no significant spatial variation.

Coefficient Distribution Map

The coefficient map visualization shows the local influence of each variable. For example, the negative influence of population density on IKLH is greater in densely populated provinces such as West Java and DKI Jakarta, while the positive influence of per capita GRDP is stronger in Kalimantan and Sumatra. GWR is used to capture spatial variations between independent variables (KB, KP, and PDRBK) and environmental quality (IKLH) in various regions of Indonesia, which cannot be captured by global regression. One important output of GWR is the t-statistic value, which shows the significance and direction of each variable's influence on IKLH in each province.

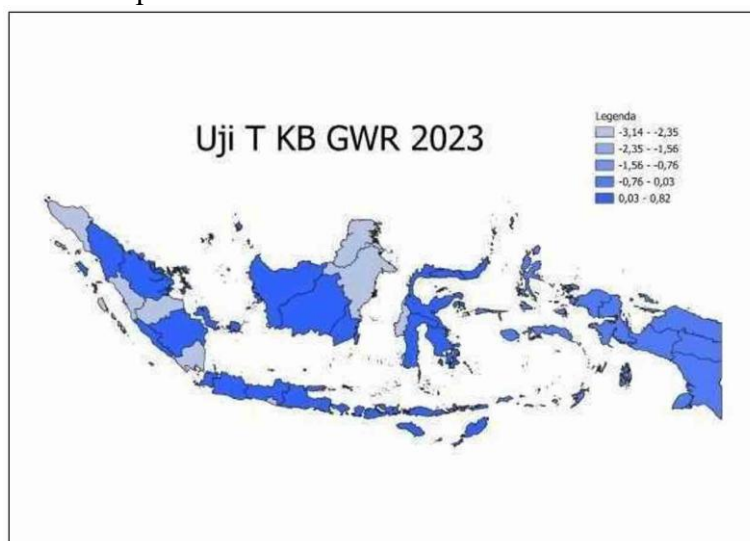


Figure 4.
T-Test Results for Motor Vehicle Variables GWR Results 2023

The first map shows the distribution of t-statistic values from the regression coefficient of motor vehicle numbers (KB) against IKLH. Blue indicates a significant positive effect, while gray indicates a negative effect. In provinces such as Central Java, South Kalimantan, and West Sumatra, positive t-values indicate that an increase in motor vehicle numbers correlates with a decline in environmental quality. Conversely, in regions such as Papua and North Kalimantan, negative t values or values close to zero indicate that motor vehicles are not a dominant factor in IKLH variation, possibly due to low motorization rates or extensive forest cover that offsets vehicle emissions.

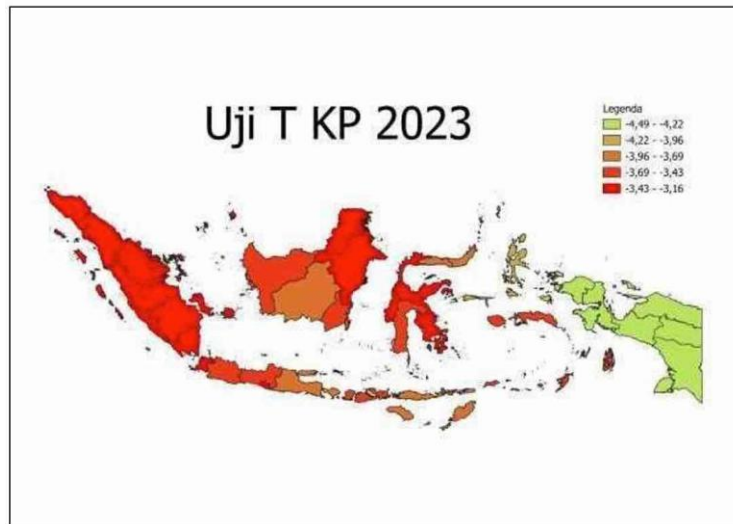


Figure 5.

T-test Results for the Population Density Variable in the 2023 GWR

The second map shows the effect of population density (PD) on IKLH. In provinces with high population density such as Java, Bali, and parts of Sumatra, the dark red color indicates a very negative t-value, indicating a significant negative effect on IKLH. This reflects that high population density increases pressure on environmental resources, worsens waste management, increases energy consumption, and reduces green open space. Conversely, in provinces with low population density such as Papua and Maluku, positive t values indicate that an increase in population density can contribute positively or neutrally to IKLH, as density has not yet exerted significant pressure on the environment.

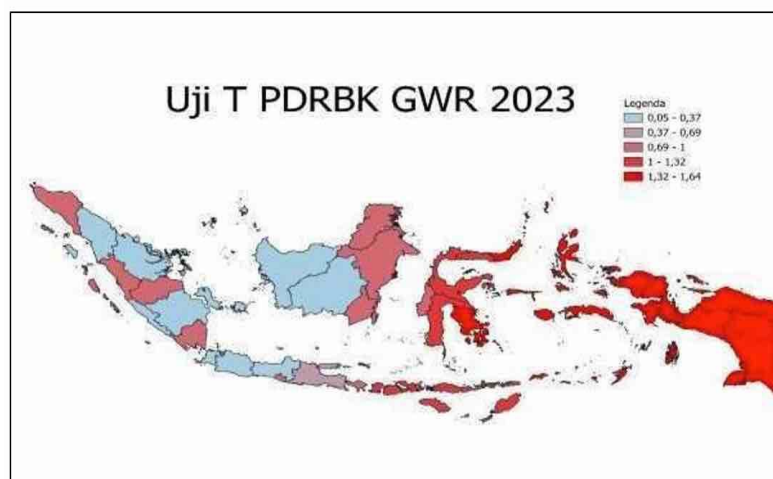


Figure 6.

T-test Results for the PDRBK GWR 2023 Variable

The third map shows the variation in t-values of the per capita GRDP (PDRBK) coefficient against IKLH. Regions such as Papua, Central Sulawesi, and North Maluku, marked

in dark red, show high and positive t values, indicating that per capita economic growth in these areas is closely related to improvements in environmental quality, possibly due to investment in environmentally friendly sectors or improvements in sanitation and health infrastructure. Conversely, in regions such as West Java and South Sumatra, t values tend to be low or negative, indicating that per capita economic growth in these regions does not always have a positive impact on the environment, most likely because they still depend on environmentally damaging sectors such as heavy industry or mining.

Analysis Results

The GWR results show that there is spatial heterogeneity in the relationship between the s of the independent variables and environmental quality. This indicates that environmental policy solutions cannot be generalized across provinces.

- a. Per capita GRDP (pdrbk): Although positive on average, there are areas where the effect is negative, indicating that economic growth is not always followed by an improvement in environmental quality.
- b. Population Density (kp): Almost all provinces show a negative effect, but the intensity varies, indicating high environmental pressure from the population.
- c. Number of Motor Vehicles (jkb): Although the coefficient is small, it still shows a negative pattern consistent with the contribution of the transportation sector to environmental pollution.

Discussion

1. Based on the estimation results, it shows that per capita GDP affects the quality of the environment in Indonesia. This indicates that if GDP increases by one billion units, it will improve the quality of the environment in Indonesia.
2. The population density variable has a negative effect on the quality of the environment in Indonesia. This shows that population density (KP) reduces the quality of the environment in Indonesia.
3. The number of motor vehicles has a negative impact on the quality of the environment in Indonesia. This shows that the number of motor vehicles reduces the quality of the environment in Indonesia.

CONCLUSION

Based on the data analysis that has been conducted, it can be concluded that, partially, the variable of GDP per capita has a positive effect on the quality of the environment in Indonesia. This shows that economic growth, as reflected in the increase in GDP per capita, can have a positive impact and contribute to improving the quality of the environment. Conversely, population density and the number of motor vehicles have a negative effect on the quality of the environment. The higher the population density and number of motor vehicles, the greater the negative impact on environmental quality, such as a decline in air quality and an increase in pollution. These results reflect that a dense population tends to put greater pressure on natural resources and the environment, while motor vehicles, as one of the main sources of air pollution, further worsen environmental conditions. In addition, this analysis also shows that the factors that affect environmental quality in Indonesia vary between provinces. This indicates that environmental policy solutions cannot be applied uniformly, because each province has different conditions and challenges. Overall, the three main factors that affect environmental quality in Indonesia are GRDP per capita, population density, and the number of motor vehicles.

Suggestions

Based on the results of the estimation model, several suggestions for further research are, first, that environmental quality data should be collected using time series data and data pooling to overcome differences between provinces. The use of time series data makes it

possible to see the development of environmental quality over time, while data pooling can reduce significant differences between regions with different characteristics. Second, the role of the government in reviewing and updating policies related to environmental quality is very important. The government needs to involve various stakeholders, both from the public and private sectors, in designing more effective policies to reduce negative impacts on the environment. In addition, stricter enforcement of environmental laws must be carried out to ensure that existing policies are properly implemented in the field. Not only that, massive public awareness campaigns are also needed to increase awareness and concern for environmental preservation. The government needs to educate the public about the importance of maintaining environmental quality in order to reduce adverse impacts such as pollution and natural destruction. Finally, in the context of population density and transportation, it is important for the government to implement policies that can reduce motor vehicle emissions, such as developing environmentally friendly public transportation and introducing environmentally friendly technology in the transportation sector. With these measures, it is hoped that the quality of the environment in Indonesia can continue to improve and not experience further degradation.

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