



**DETERMINANT FACTORS OF AIR QUALITY: EMPIRICAL STUDY IN
JAVA ISLAND**

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Abstract

Air pollution is one of several environmental problems faced by several countries in the world, including Indonesia. Air pollution caused many environmental problems such as global warming and climate change. Air pollution increased due to human activity and economic development. Economic activities such as industry, infrastructure development to community mobility can affect air quality in an area. The study aimed to analyze the impact of income per capita, transportation, and population on the air quality of six provinces in Java Island. This study obtained data from the National Statistic Central Bureau and the Ministry of Forestry websites from the year 2013-to 2019. This study was using a quantitative method through the regression model with panel data to achieve the research's goals. The result showed that the variable of income per capita has negative effects on air quality. The variable of income per capita is described by the economic activity of people in Java Island. The results of this study indicate that the economic activities of people in Java Island still have a negative impact on the environment, especially on the air quality. The opposite result was obtained from transportation and population variables that have a positive effect on air quality in the six provinces in Java Island from 2013 to 2019.

Keywords: Air Quality; Income per Capita; Transportation; Population

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INTRODUCTION

Sustainable development is a national development that maintains the sustainability and ability of ecosystems. In the process of sustainable development, it is always striving to observe the sustainability of environmental use. Sustainable development is an effort to sync and integrate essential aspects of a country such as the economy, social culture, and environment (Keraf, 2020). At the base of this concept of sustainable development is a plan for vanguard development in the process to maximize the benefits of human and natural resources by combining them in the development process.

For a country, the application of the concept of sustainable development is not as easily as expected. Development that integrates economies with environmental sustainability in the face of global problems such as poverty, inequality, or natural disasters. What some have said is that integrating economic development with environmental quality will not be easy for policymakers in every country, especially in developing countries like Indonesia. Like other developing countries, Indonesia is also facing problems in many areas such as social, economic, and environmental issues. It takes strong commitment from policymakers to societies to change the conventional pattern of development that relies too much on the availability of natural resources to the

sustainable economic development pattern (Rahadian, 2016).

Economic development will need to be implemented optimally to help increase national or regional incomes (GDP) continuously and can impact on other aspects such as social, economic, and technological. In the process, economic development always runs in step to environmental quality. Economic development that focuses too much on economic growth often ignores environmental sustainability aspects. Economic development should take care of the environment in each activity because sustainable development not only focus on economic aspects but also on other aspects such as cultural and environmental society. Therefore, only economic growth will not be enough to boost the economy of a country, and it will require environmentally sustainable development (Todaro, 2006).

Economic development has always been followed by improved economic growth. Economic growth is the process of increasing GDP per capita over the years. This increase may be said to be successful when standards of living have been pointed toward better results from increasing income per capita and increasing the real wages of a country. About the quality of the environment, some studies show that economic growth has a negative impact on the quality of the environment. Economic growth in the process of not taking care of nature can result in negative impact on

environmental conditions (Nikensari et al., 2019).

As explained earlier, economic growth can have a negative impact on the quality of the environment (Measey, 2010). This is because increasing economic growth will also increase public mobility. Increasing public mobility will increase the number of vehicles owned by the community. The number of vehicles used by the community will affect environmental quality, especially air quality. Aside from economic growth and the increase in transportation, the quality of the environment, in particular the air in an area, is affected by the large population in that area.

Large populations in one area where not managed properly will bring a lot of problems, especially environmental quality. According to the research of Nikensari et al, (2016), the number of populations affects CO_2 emissions. This shows that too much of the population in one area can have a negative impact on the environment, especially the air quality due to the waste landfill that occurred because of human activity and industrialization.

The Air Quality Index is calculated from the five components of the polluter as oxidants or ozone in the surface, particulates, carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2). However, The Environmental Quality Index data uses only two parameters, namely NO_2 and SO_2 , to calculate air quality index. The NO_2

parameters measure the emissions of gasoline fuel vehicles, and SO_2 measure the emission of diesel vehicles, solar vehicles and other sulfur-containing fuel (Idris, 2015).

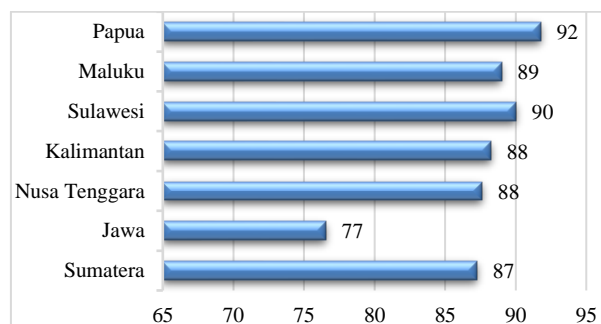


Figure 1. Average Island Air Quality Index in Indonesia 2016-2019

Based on the data above, we can see the average air quality of seven large islands in Indonesia during 2016-2019. During this period, the land with the lowest air quality was Java, which is 77 (enough category). This indicates that the air quality of Java is the most polluted of all other islands in Indonesia. High population density and mobility are affected by environmental conditions, particularly the air quality of Java, through vehicle pollution, industrial activity, and behavior that does not care about the environment. About 99% of the air, we breathe is oxygen gas and nitrogen. Very few other gases are inhaled. Some studies result that the gas is identified as a contaminant gas. This pollutant gas comes from vehicle smoke, industrial waste, power plants, cleaning fluids, and residues that are closely related to human activity (Karunia, 2013).

The World Meteorological Organization (WMO, 2017) explains that the

pollution problem is important to resolve. Air pollution if continuing will cause global warming. The continued increase in air pollution over the years is due to the use of fossil fuels (coal, transportation, manufacturing activities, oil and gas) and consumption of goods or services directly related to economic growth.

The research was conducted on the island of Java for 7 years from 2013-2019. As we know, the island of Java has six provinces, namely DKI Jakarta, Banten, West Java, East Java, Central Java, and Yogyakarta. The island of Java is categorized as the island that has a most populous population in Indonesia. But Java give the largest contribution to gross domestic product (GDP), especially in 2019. The variables used in the research are income per capita, transportation and population. This study has differences compared to previous studies. The novelty of this research is found in the use of transportation variables in the form of data on the number of motorized vehicles. As far as researchers know, this variable has never been used to analyze its relationship with air quality on the island of Java with air quality index data quoted from the Ministry of Environment and Forestry Indonesia.

LITERATURE REVIEW

Many studies of environmental quality are done by researchers, including Nikensari et al (2019). The study done by Nikensari et al (2019) aims to validate the hypothesis of the Environmental Kuznet Curve (EKC) in Asia's high-and middle-income countries and to analyze the different effects of income per capita, population, energy consumption on CO_2 emissions before and after the MDGs uses a panel data analysis. The conclusion from the study is that before MDGs (2000), income per capita, energy consumption, and populations in high-income countries contributed to the increase in CO_2 emissions, but after the implementation of MDGs gave positive impact on the quality of the environment, whereas increasing income per capita accompanied with decreasing of CO_2 emissions. Meanwhile in low - and middle-income countries, at the beginning of MDGs, shows that CO_2 emissions levels were high when income per capita was still low. Then, after the implementation of MGDs, increasing income per capita still contributes to increasing CO_2 emissions.

Idris (2015) conducted research to find out whether the Environmental Kuznet Curve (EKC) hypothesis on the relationship between economic growth and environmental damage in Indonesia. The research was done by using data panel analysis. The result of this study is the kuznets curve hypothesis about the relationship between economic growth and

environmental quality in Indonesia shaped like the letter U (not reverse U). Results from this test prove that the first increase in GDP per capita was followed by some drop in environmental quality.

Kusumawardani & Dewi (2020) in their research entitled "The effect of income inequality on carbon dioxide emissions: A case study of Indonesia". The study was conducted to see how income inequality affects emissions in 1975-2017. Additionally, the study also uses such variables as income per capita, the ratio of dependence, and urbanization. The results tested by using the analysis of the ARDL (Autoregressive Distributed Lag) show income inequality, urbanization and dependency rates negatively affect the environmental and income per capita variable form an EKC curve.

Air Pollution

Air pollution is one of the environmental problems faced by many countries in the world, including Indonesia. This air quality tends to worsen, especially in some urban areas of Indonesia. Over the last few decades, based on the results of monitoring on the parameters of the particulate and oxidants/ozone (O_3), which is where both of these parameters tend to increase over the years. This increase can affect the ecosystems and human health is that of increasing population and the need for transportation and energy.

The two main parameters are NO_2 and SO_2 used to calculate air quality indexes. The NO_2 parameters represent emissions from gasoline - fueled vehicles, while the SO_2 parameters represent those from industry and diesel engines that use sulfur diesel and other fuels. This indicator is calculated by comparing the annual average with the standard direction of the European Union (EU). The European Union (EU) directive defines the quality standards of the World Health Organization (WHO). Air pollution is a bad condition for the environment and can have a negative impact on health, and economic variables can be used to measure environmental quality in Indonesia (Gilbert, 2017).

Income Per Capita

Income per capita represents the average income of all population of a region or a country. The income per capita is earned by dividing the income of a particular year by the population of the country (Nikensaris et al., 2019). Income per capita value is used to determine the average income per person in a particular region or country where this is usually done to assess people's living standards and quality of life. Income per capita indicates the average income of each productive age society (work age) by macroeconomic indicators. Income per capita is used to measure the value of all goods and services that output from an economic activity. Income per capita is routinely

calculated each year as one of the economic indicators used to measure population prosperity. Some of the uses of per capita income in addition to calculating the level of prosperity of one country is also a data for comparing the living standards of one country with another. Each country may each year review the income per capita status within the national or national sphere and decide whether the income per capita in the region or national is in the low (below), moderate or high category. The data is also used as a model for economic policy formulations.

Transportation

Transportation is either a transfer of goods or human beings from origin place to destination (Nasution, 2014). Good transportation systems are one of the keys to both economic development and civic development and the growth of the industrial sector. The continuity of a good transportation system would increase people's productivity, as a good transportation system would make easier public mobility. The good of public mobility will have a positive impact on the rate of economic growth and development. In the process of economic development, this transportation has an important role. The economic growth is divided into four areas of production, transactions, distribution, and consumption. The existence of transportation has an important role, especially in terms of distribution. Transportation can provide a

good transition to the economic process. Data of transportation variable in the study is to use the number of motor vehicles as data the number of motorized vehicles was cited from BPS (Badan Pusat Statistik) for seven years, from 2013-2019.

Population

The population is a group of people who have settled in an area for 6 months or more and those who live less than 6 months but intend to stay there. This population continues to settle and grow over the years, population growth is change in population from period to period within a region influenced by three major demographic components of fertility (birth), mortality, and migration. About the environment, a problem associated with the population is one of the things that become a source of environmental problem. The growing number of people without proportional to the increasing quality of the population could have a negative impact on the country or the area. Increasing population growth could lead to many problems, especially regarding the fulfillment of the needs such as the need for a primer or social life of the community. The impact of rapid and uncontrolled population growth affects not only those things but also other things, including the environment. Setyadharma et al (2021) in his research says that the population has a positive effect on CO_2 emissions, which means CO_2 will continue to increase as the population increases.

The difference between this research and previous research is the use of research variables. As far as the researcher's knowledge, the use of the transportation variable with data on the number of motorized vehicles in the province of Java Island has never been used to analyze its relationship to air quality on the island of Java with air quality index data quoted from the Ministry of Environment and Forestry websites.

RESEARCH METHODS

This study is one type of quantitative research. Quantitative research is defined as research in which data is in the form of numbers or qualitative data that numbered (Sugiyono, 2012). Studies on air quality on the island of Java use the kind of quantitative research to analyze the relationship between independent variables consisting of income per capita, transportation, and populations with dependent variables of air quality. The data were analyzed using Eviews 9.

This study aims to analyze the relationship between income per capita, transportation and population to air quality in Java in 2013-2019. The data used in the study is that air quality data is a dependent variable quoted from the website of Ministry of Environment and Forestry. Then, per capita income, transportation and population as independent variables are quoted from National Statistic Central Bureau.

To answer the purpose of the research that has been mentioned earlier, the analysis

tool used in this research is regression panel data to identify the influence of per capita income, Transportation, and population on the quality of the air. Regression of panel data is a technique of research that combines the data of the cross-section with the data time series. The equation with panel data analysis in this study follows research conducted by S. Oktavilia et al. (2020), which uses panel data analysis to analyze the relationship between per capita income, the environmental effects of financial market development, foreign direct investment, and trade openness on CO₂ emissions. The following is the equation used to answer the purpose of this research:

$$\text{Log}(IKU)_{it} = \alpha + \beta_1 \text{Log}(PDBP)_{it} + \beta_2 \text{Log}(TRANS)_{it} + \beta_3 \text{Log}(POP)_{it} + \varepsilon_t \dots (1)$$

Where:

IKU_{it}	= Province air quality index in Java in year-t
α	= Constanta
$PDBP_{it}$	= Real GDP per capita Province in Java in year-t
$TRANS_{it}$	= Provincial Transportation in Java Island in year-t
POP_{it}	= The population of the province on the island of Java in year-t
$\beta_1, \beta_2, \beta_3$	= Regression coefficient
ε_t	= error-term

RESULTS AND DISCUSSION

Based on the results of the Chow test and Hausman test has been done, it is seen that the best model used in the panel data regression is that the Fixed Effect Model

(FEM). The results of calculations using the method of the best model is the FEM, show that the value of R-squared of 0.763266 at the output weighted, which means the variable income per capita, transportation, and the population can affect the dependent variable is the quality of the air by 76%. Then, by 24% influenced by other variables beyond the variables studied. It has the sense that independent variables cannot deliver a complete change in predicting air quality, as those of air quality are not affected only by income per capita variables, transportation, and population. Then, the value of Prob (F-statistic) from the results of panel data regression FEM is 0.000000, the value is smaller than $\alpha = 5\%$. The results show that all the independent variables are per capita income, Transportation and population together affect the dependent variable is the quality of the air.

Table 1. Results of Panel Data Regression FEM Method

Variabel	Koefisien	Std. Error	t-statistic	Prob.
-				
Log PDBP	0.240899	0.239443	-1.006079	0.3217
Log TRANS	0.068815**	0.030082	2.287558	0.0287
Log POP	2.593881**	1.151080	2.253431	0.0310
C	-19.62789**	8.827585	-2.223473	0.0331
R-squared	0.763266			
Prob(F statistic)	0.000000			

Note: **) significant coefficient at alpha level is less than 5%.

Source: Secondary data, processed 2021

Table 2. Result of Statistic Descriptive

	LOG IKU	LOG PDBP	LOG TRANS	LOG POP
Mean	4.285282	10.53029	15.97363	9.773049
Median	4.351239	10.29219	16.39937	9.939668
Maximum	4.506233	12.06634	16.88799	10.80602
Minimum	3.725934	9.954071	14.20305	8.187271
Std. Dev.	0.192503	0.650954	0.836892	0.913992
Skewness	-1.199991	1.561727	-0.669588	-0.489910
Kurtosis	3.591529	3.838978	1.848463	1.875259
Jarque-Bera	10.69219	18.30473	5.458996	3.893908
Probabilty	0.004767	0.000106	0.065252	0.142708
Sum	179.9819	442.2723	670.8924	410.4680
Sum Sq. Dev.	1.519350	17.37338	28.71590	34.25064
Observations	42	42	42	42

Per capita income is defined as the average total income of the population. Per capita income is often used to reflect the level of prosperity of a region or country. The high value of per capita income shows the higher level of prosperity of the people in the region. The results of this study show that the income per capita variable has a coefficient of -0.240899 with a significance level of variables, 0.3217 at $\alpha = 5\%$ or 0.05. This shows that the relationship is not unidirectional between the variables of income per capita and air quality. Per capita income is one of the few indicators that are commonly used to explain the level of welfare of society as a macro and also is a measuring instrument used to measure the rate of economic growth. The per capita income of 6 provinces in the Island of Java negatively affects the air quality and has no significant effect. These results explain if the increase in income per capita is not absolute will cause a drop in air quality in 6 provinces in the Island of Java.

The value of per capita income describes the economic activities carried out by the community (Jufrida et al., 2017). Community economic activities, in this case, such as the production activities of goods and services are carried out by the industry. The results of this study show that the economic activities carried out by the people in the province of Java have a negative effect on the environment by reducing the level of air quality.

The study has results that are in line and support the research of Sri Indah Nikensari, Sekar Destilawati and Siti Nurjanah (2019) which analyze the relationship between per capita income, energy consumption, and population in high- and middle-income countries in Asia before and after the implementation of the MDGs. The result of this study shows a negative relationship between income per capita to the emission CO_2 . As well as research conducted by Idris (2015) in his research shows the increase in per capita income at the beginning will initially be accompanied with the decreasing quality of the environment, but at a certain point increase per capita income will be followed by increase the quality of the environment.

Transportation is the activity of moving goods (loads) or passengers from one place to another. The results of this study indicate the transportation variable has a coefficient value of 0.068815 and a significance level of the variable of 0.0287 at $\alpha = 5\%$ or 0.05.

The value of the coefficient of the variable of transportation has a direct relationship with the quality of the air. Variable Transportation citing data from the Badan Pusat Statistik (BPS) for many motor vehicles in 6 provinces in the Island of Java. This study shows that the variable Transportation has a positive effect on air quality in 6 provinces in Java Island from 2013 to 2019. Variable Transportation also showed a significant effect.

This transportation variable describes the level of community mobility on the island of Java. The results of this study indicate that the level of community mobility on the island of Java has a positive influence on the environment, which in this case is the air quality on the island of Java. This result is in line with the government's efforts to implement sustainable transportation policies such as the construction of the MRT, LRT, and BRT as well as improvements to public transportation services such as the addition of train lines that provide comfort and confidence to the public to use public transportation instead of private vehicles.

This study is not in accordance with the study of Kusminingrum & Gunawan (2008) who conducted research to determine the level of air pollution due to motorized vehicles on the islands of Java and Bali. The results of the research show transportation are primarily in the short term and will have a negative impact on environmental quality as well as air quality. Then, Karnila (2019)

showed another conclusion using transportation factors, stating that transportation variables, particularly land transportation such as motorized vehicles, had no effect on the environmental quality index (IKLH) and had a non-unidirectional link. In her research, Karnila (2019) states that this association emerges because of the government's poor efforts to reduce air pollution levels.

A population is a group of individuals with the same characteristics who live in the same place. According to Wijaya (2014), the population is made up of several the same or similar creatures, and these creatures together inhabit a certain place. The results of this study show the population coefficient value of 2.593881, this value has a significance level of variables of 0.0310 at $\alpha = 5\%$ or 0.05. The value of this coefficient explains that the variable of the population has a direct relationship with the quality of the air. Variable of the population using data for many residents according to the province on the Island of Java. Population data is citing from the Badan Pusat Statistik (BPS). The influence of the population on the quality of the air 6 provinces in the Island of Java is positive and has a significant influence.

The population here describes the total population in the 6 provinces of the island of Java. The results of this study, which show the positive influence of the population on the level of air quality in Java, mean that

the current increase in the population does not cause a decrease in air quality in 6 provinces in Java. These results do not support the research conducted by Setyadharna et al (2021) which has a research objective to investigate the possibility of the existence of an inverted U-shape relationship between education and environmental degradation in seven ASEAN countries. The results of this research suggest that the increase in the population will cause an increase in the emission levels of CO₂.

Based on the results of the study, the researchers suggest the government to make and strengthen environmentally friendly policies, especially policies regarding the analysis of environmental impacts as one of the conditions for the establishment and management of an industry. The results of this study also show the positive impact of transportation variables on improving air quality on the island of Java. Here, the government needs to continue to implement sustainable transportation policies by adding mass transportation modes and the use of environmentally friendly fuels.

CONCLUSION

The results of the research show that there is an independent variable that has negative effects on air quality on the island of Java. The variable is income per capita, the impact per capita income on air quality indicates that economic growth on the island

of Java still has a negative impact on the environment. Economic growth reflects the economic activities using fossil fuels, such as in the industrial sector to power plants. And then, in transport variables and population populations, it shows a unidirectional result in air quality. In transport variables, the result is consistent with the commitment of governments during 2013-2019 on sustainable transport policies such as increased quality of public transportation to increased public transportation modes such as KRL, MRT, and BRT. The increased quality and additions of this mode of public transportation provided comfort and increased public interest in using public transportation. There are several things to be noted about the results of this study. A limited amount of data might cause bias in independent variable coefficients in the study. Hence, the results of this study require further research, other researchers may add variables and use larger data to research.

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