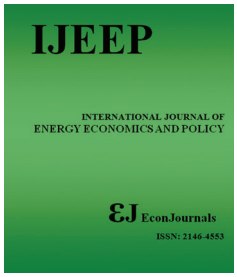

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Industrialization and Consumption of Fossil Energy are the Main Determinants of Environmental Degradation in Water Catchment Areas in Indonesia

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ABSTRACT

Economic growth is the main goal of the global economy. However, increasing economic growth often results in increased CO_2 emissions and encourages environmental degradation. This study analyzes the impact of industrialization, consumption of fossil energy, economic growth, and population activities on CO_2 emissions in upland water catchment areas. Data analysis using panel data regression, in a span of 20 years. The results of the study show that economic factors, namely industrialization and consumption of fossil energy, are the main determinants of increasing CO_2 emissions. Meanwhile, social aspects such as education, waste generation, and population have no effect on CO_2 emissions.

Keywords: CO_2 Emissions, Economic Growth, Fossil Energy, Industrialization
JEL Classifications: O44, Q43, Q56

1. INTRODUCTION

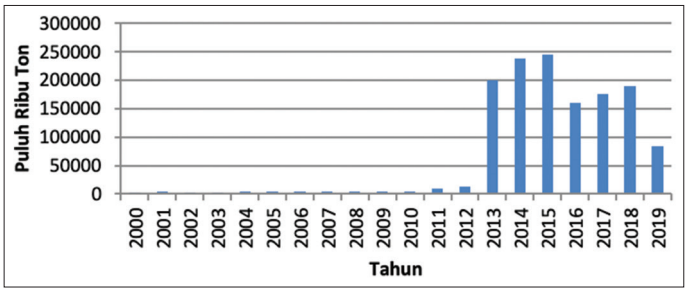
Massive economic development has a positive impact on people's welfare, but also has a negative impact, namely the decline in environmental quality. Environmental degradation due to air pollution, water pollution, and soil pollution has become a global issue. Global warming as a result of rising concentrations of carbon dioxide (CO_2) and other gases in the atmosphere has driven climate change.

Global warming is one of the global issues that is increasingly being echoed by various countries. Greenhouse gases, especially CO_2, are the cause. The incessant economic development with industrialization and consumption of fossil energy in various regions has pushed up CO_2 emissions and decreased environmental quality in the regions (Fadholah et al., 2017).

Sustainable or sustainable economic development must have a balance between economic growth on the one hand and the preservation of natural resources or the environment on the other (Todaro and Smith, 2009). Sustainable economic development is an effort to improve the welfare of the population by taking into account the environmental impact. Increasing the welfare of the population does not have to be followed by a decrease in environmental quality, such as polluted water sources, deforestation, and air pollution due to various types of pollutants.

Indonesia is one of the largest CO_2 emitters in the world. Based on data as shown in Figure 1, CO_2 emissions in Indonesia have spread to the regional level with agricultural concentrations. CO_2 emissions in the regions, especially highland areas as water catchments in Central Java Province, tend to increase. This is partly due to the existence of industrialization activities in various fields, which causes the consumption of fossil energy to increase. The largest contributor to CO_2 emissions in various regions comes from the fossil energy sector, industrial activities, and inorganic waste that is not managed properly. The data in Figure 1 below shows CO_2 emissions in the six study areas that tend to increase.

Figure 1: CO2 Emissions study area year 2000–2019. Source: Department of environment and forestry, central java, 2000–2020



Source: Department of environment and forestry, central java, 2000–2020

The industrial sector has become the main driving factor for economic growth. Industrialization as the engine of economic development is increasingly massive in various regions. Energy consumption, especially fossil energy as an industrial input, is increasingly expanding in an effort to maintain economic growth. Energy consumption, especially fossil energy, tends to increase with increasing economic activity, thereby increasing CO_2 emissions. The increasing use of fossil energy in many areas is not only carried out by medium and large industries, but also small industries, to home industries. Li and Chunshan (2021) stated that the use of fossil energy is one of the main sources of environmental degradation by increasing the level of CO_2 emissions.

Economic growth is always closely related to the exploitation of natural resources and the environment. Through economic development in all fields, economic growth tends to increase, although it fluctuates. This is due to changes in the production of goods and services and inefficiencies in industrial activities. An economy that grows efficiently is considered to be able to reduce the impact on environmental degradation (Sheng et al., 2021). For developing countries, it is important to investigate the environmental impacts caused by rapid economic growth through massive energy consumption (Uddin, 2014). environmental damage (Arista, 2019).

Meanwhile, the population as a production factor continues to increase in number, although it has not been followed by the availability of facilities and infrastructure, as well as public facilities such as adequate waste disposal sites. So that there is a lot of waste that cannot be controlled and continues to increase, especially inorganic waste which has a bad impact on the environment, and encourages an increase in greenhouse gases. Plastic waste, for example, which relies on the extraction of fossil fuels will continue to generate greenhouse gases until the waste decomposes (Zheng and Suh, 2019).

Based on the above background, economic activities that are not followed by environmental balance are thought to have an effect on increasing CO_2 emissions in the region. Therefore, further research is needed to formulate the right strategy so that CO_2 emissions are reduced in a sustainable manner so that environmental quality can be maintained.

2. LITERATUR REVIEW

Natural resources are factors of production in economic activities. Understanding of resources is not limited as an input factor, because the production process will also produce output which then becomes an input factor for the continuity and availability of natural resources (Fauzi, 2006). According to Yusgiantoro (2000) natural resources can be divided into two, namely renewable natural resources and non-renewable resources.

The use of natural resources in the production process that continues to increase has an impact on increasing carbon dioxide (CO_2) gas. Akpan and Akpan (2012) state that since the 1850s the global use of fossil fuels (coal, oil and gas) has increased sharply to dominate the world's energy consumption and supply. The research of Sheinbaum et al. (2012) states that in Mexico in the period 1990–2008 there were several important changes in the structural effect that could reduce emissions in 10 sub-sectors of the manufacturing industry. The energy intensity and carbon index tested had negative effects on all subsectors with the exception of cement and some other subsectors. Total energy use continues to show an increase due to production activities that continue to grow and industrial products that continue to drain energy in meeting the demands of a growing population (Shamsuzzaman et al., 2021).

There is an interrelated relationship between economic development and the environment. The Environmental Kuznets Curve (EKC) explains the relationship between economic development and environmental quality (Shaharir and Alinor, 2013).

At a time when per capita income is still low, steps to reduce environmental damage are not carried out by humans, because it is better to use their limited income to meet basic consumption needs. When a certain level of income has been reached, individuals begin to consider the trade-off between environmental quality and consumption. In this condition the rate of environmental damage begins to slow down. The third condition, after a certain point, spending on reducing environmental damage dominates individuals to prefer improve environmental quality compared to subsequent consumption. In the end, the quality of the environment began to improve along with economic growth.

Chen's (2007) study in China found that the relationship between environmental damage and per capita income is in the form of a U-curve. Bartz and Kelly's (2004) study of the relationship between welfare and environmental degradation concluded that welfare affects environmental degradation in a pattern as shown by the Environmental Kuznet Curve (EKC).

Garbage is solid waste consisting of organic and inorganic substances which are considered useless so that it needs to be managed so that it is not harmful to the environment and can provide protection for development investment (SNI 19-2454-2002). The amount of waste that results from the activities of living things in a certain period of time is called waste generation. Waste generation is the amount or amount of waste in gravimetric units of weight (kilograms) or volume (liters) volumetric (Tchobanoglous et al., 1993). The effect of waste generation on environmental

degradation can be caused by an increase in population, with increasing demand for plastic because the material is cheap and light to carry out daily activities (Ford et al., 2022).

Rapid industrial growth has resulted in increased retention of carbon and other greenhouse gases over time (Martines, 2005). Industry requires high fossil energy to support its business activities. According to Stolyarova (2013), industry causes carbon and greenhouse gas emissions to increase because industrial activities cause the conversion of forest functions and the use of fossil energy. Fossil energy in the form of oil, natural gas, and coal is a source of air pollution.

Energy is one of the main needs in various sectors, both in consumption activities and in production activities. Chontanawat et al. (2006) stated that energy plays an important role in promoting an economic system on the demand side and supply side. On the demand side, energy is an important product for consumers, this can be seen in the consumer's decision to buy so that the quality is maximized. On the supply side, energy is an important factor in production activities in addition to labor, capital and materials. The use of fossil energy had decreased during the first and second world wars, which then increased again in 1950 and 1970 when fossil energy in the form of oil and gas became the dominant energy source for production purposes. Until now and in the future, this energy source has become a commodity in world trade activities followed by coal as an energy source in the field of electrification such as electricity and various electronic devices which began to develop rapidly in 1975 and beyond (Bach, 1980).

Population plays an important role in economic development. The population as an important human resource in the production process to support economic growth and provide goods and services for a larger market. However, excessive population is defined as human activities that are too dense to cause excessive CO_2 emissions (Rahman et al., 2020). The increase in population will affect the behavior/lifestyle and consumption patterns of the people. According to Arbulú et al. (2015), the higher the education level of the population, the significantly higher the commitment to care for the environment. Chen (2010) also argues that universities will produce more graduates with environmentally conscious behavior. Education about the environment began to be obtained by high school students from the curriculum that was included as an additional subject (Zeeshan et al., 2021). Study Cordero et al. (2020) to groups of students providing confidence about the existence of good awareness about environmental conditions.

3. METHODS

This study uses a quantitative descriptive approach to test hypotheses about the influence of economic and social factors on environmental quality in the upland areas of water catchment areas in Central Java. The research area covers Kebumen Regency, Purworejo Regency, Wonosobo Regency, Magelang Regency, Temanggung Regency, and Magelang City.

The independent variables that determine environmental quality consist of: economic growth, industrialization, consumption of fossil energy, waste generation, quality of human resources, and population. The dependent variable is CO_2 emissions. Secondary data comes from the Central Bureau of Statistics and the Department of Environment and Forestry.

Quantitative analysis uses a panel data regression model, which is a combination of time series data and corss section data (Gujarati and Porter, 2020). Time series data for a period of 20 years (2000–2019), while cross section data covers six research areas. The panel data regression model is formulated in the following equation:

$$Emi_{it} = \alpha_0 + \beta_1 Was_{it} + \beta_2 Eco_{it} + \beta_3 Ind_{it} + \beta_4 Edu_{it} + \beta_5 Eng_{it} + \beta_6 Pop_{it} + e \quad (1)$$

$$LogEmi_{it} = \alpha_0 + \beta_1 logWas_{it} + \beta_2 Eco_{it} + \beta_3\ logInd_{it} + \beta_4\ logEdu_{it} + \beta_5\ logEng_{it} + \beta_6 logPop_{it} + e \quad (2)$$

Information:
Emi: CO_2 Emission;
Was: Waste;
Eco: Economic growth;
Ind: Industrialization;
Edu: Average length of school;
Eng: Energy consumption;
Pop: Total population;
α: Constant;
$\beta_{(1,2,3,4,5,6)}$: Regression coefficient
i: Research area;
t: Time;
e: Error term.

4. RESULTS AND DISCUSSION

The research area covers six highland and water catchment areas in Central Java Province. In the archaeological history of Indonesia, this area was the place where the ancient Javanese civilization of the Syailendra dynasty developed. Borobudur Temple is located in this area. Most of the Gross Regional Domestic Product (GDP) is still contributed by the agricultural sector, because the six research areas rely on the agricultural sector as the main support for the economy. The majority of the population works in the agricultural sector and industrial workers. The description of the population, area, and GRDP in the study area is as follows:

Based on the data from Table 1, Gross regional domestic product (GRDP), the largest population and area is in Magelang Regency. Magelang City is the area with the least population, the narrowest area and the smallest GRDP.

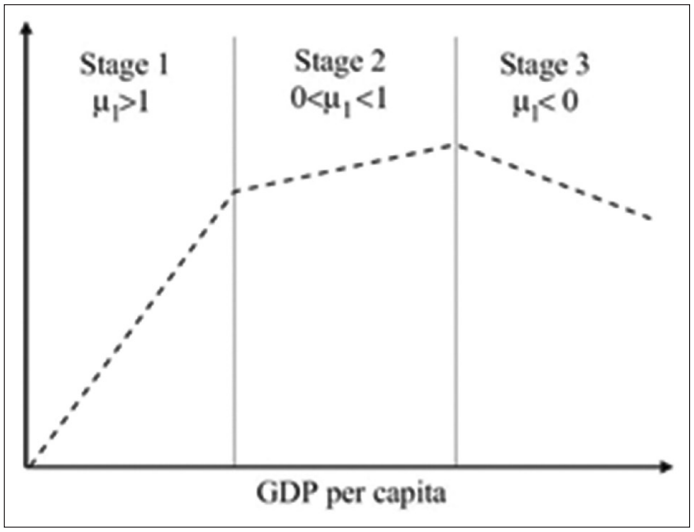
The topography of the six research areas is at an altitude of 500–2,250 meters above sea level. Based on the topographical conditions, this research area is a highland area so it is suitable for plantations, agriculture, and is a water catchment. However, over the last two decades, various business fields have gradually industrialized. The location and position of the six research areas can be seen in Figure 2, given a red line.

Table 1: Total population, area, and GRDP year 2019

No	Daerah penelitian	Population (people)	Large (km^2)	GRDP (milyar Rp)
1	Kebumen regency	1.197.982	1211.74	19.825
2	Purworejo regency	718.316	1091.49	13.353
3	Wonosobo regency	790.504	981.41	13.793
4	Magelang regency	1.290.591	1102.93	23.253
5	Temanggung regency	772.018	837.71	15 214
6	Magelang city	122.111	16.06	6.473

Badan pusat statistik central java province, 2020

Figure 2: Environment kuznet curve. Source: Shaharir and Alinor, 2013



Global warming is one of the global issues that is increasingly being echoed by various parties. The effect of greenhouse gases, especially from CO_2 gas, is the main cause (Fadholah et al., 2017). During the study period, CO_2 emissions in the study area tended to increase. This is due to the massive industrial activity in various fields which causes energy consumption to increase sharply. The largest contributor to CO_2 emissions comes from the consumption of fossil energy due to industrialization, and the amount of waste that is not managed properly.

Data processing of CO_2 emission determinant variables used panel data regression model, to determine the appropriate analysis model used Chow test. The test results show that the Fix Effect model is more appropriate for estimating panel data.

Based on the results of the Chow test in Table 2, it is shown that the probability value of the resulting Chi-square Cross-section is 0.0000. This shows that the probability value is <5% (0.05), so it can be seen that the fixed effect model is more appropriate to use than the common or random effect model. The estimation results are shown in Table 3 below.

Based on the estimation results as shown in Table 3, the following regression equation is written:

$$\text{Log(Emi)} = -173640.2 - 367.4993\ \text{Log(Was)} + 2058.330\ \text{(Eco)} + 55842.08\ \text{Log(Ind)} + 239331.9\ \text{Log(Edu)} + 7494.443\ \text{Log(Eng)} - 25981.82\ \text{Log(Pop)} + e \quad (3)$$

Table 2: Chow test result

Effects test	Statistic	d.f.	Prob.
Cross-section F	6.876252	(5,107)	0.0000
Cross-section Chi-square	33.157136	5	0.0000

Secondary data processed with E views 10, 2022

Table 3: Panel data regression results with fixed effect approach

Variable	Coefficient	SE	t-statistic	Prob.
C	–173640.2	1321662.	–0.131380	0.8957
Log (Was)	–367.4993	4127.742	–0.089032	0.9292
(Eco)	2058.330	3434.916	0.599237	0.5503
Log (Ind)	55842.08	22705.63	2.459393	0.0155*
Log (Edu)	239331.9	174319.1	1.372953	0.1726
Log (Eng)	7494.443	4367.319	1.716028	0.0891*
Log (Pop)	–25981.82	232084.3	–0.111950	0.9111
R-squared	0.400843			
Adj R-squared	0.339248			
F statistic	6.507662			
Prob F statistic	0.000000			

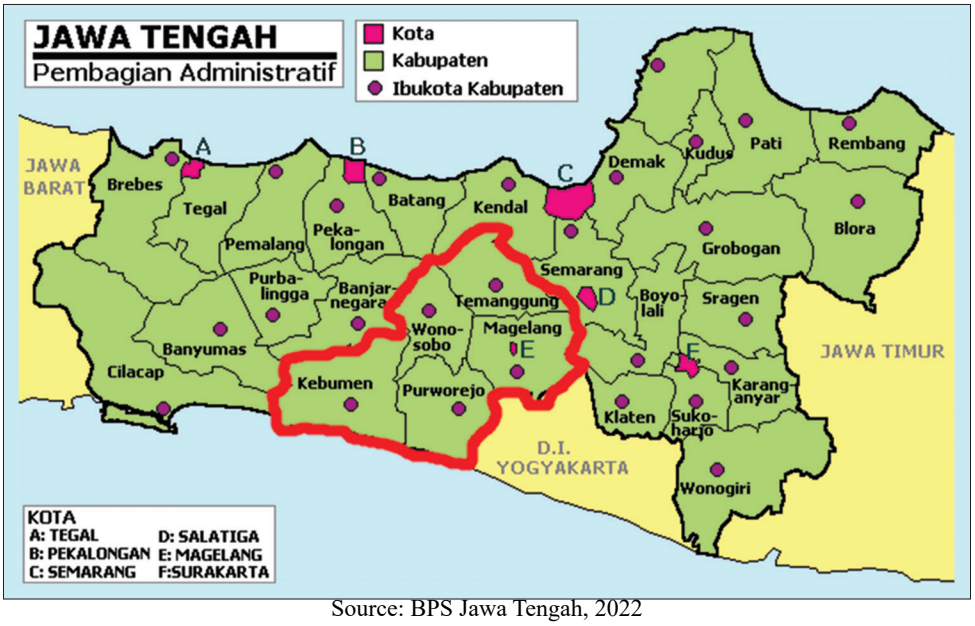
Secondary data processed with EViews 10, 2022. *Signifikan α=5%

The results of the F test show that all variables simultaneously affect CO_2 emissions in the six research areas for the period 2000–2019.

Based on the estimation results, it shows that waste generation has no effect on CO_2 emissions. Garbage generation tends to increase but is still well managed by residents and local governments. Every day there are officers from the local government who transport residents' waste to the final disposal site. In addition, most of the waste is from households and is organic waste. Research results Kiswandayani et al. (2016) stated that waste generation and CO_2 emissions have a negative effect. Landfilling can produce tons of methane gas (CH_4), and composting is beneficial for the environment.

Subsequent research findings show that economic growth has a positive value to CO_2 emissions, but it is not statistically significant. Positive economic growth will increase CO_2 emissions. In the research area, economic growth tends to increase every year, although it fluctuates. Fluctuations in economic growth have become one of the main factors for environmental degradation (Li and Chunshan, 2021). But the impact of economic growth on the environment also depends on the efficiency of economic activity through the type of technology used in producing goods/services. Changes in the production of goods and services and inefficiencies in the processing of industrial activities are the causes. In addition, it is also supported by increased production of various types of

Figure 3: Research Area Position



Source: BPS Jawa Tengah, 2022

output with technology and activities to support economic growth. The results of this study are in line with research by Lin and Xu (2017) which shows that economic growth leads to an increase in CO_2 emissions in the short term, but is conducive to reducing CO_2 emissions in the long term, due to differences in fixed asset investment and export trade.

The results of the next study stated that industrialization had a positive and significant impact on CO_2 emissions. Industrialization has a significant effect on CO_2 emissions. Industrialization in the research area was very massive during the period 2000–2019 and tends to increase. This is due to the support of the government and the private sector in various regions and various sectors. As a result of increasing industrialization, there is an increase in the production of output produced, so that the purchasing power and consumption level of the people increase, but on the other hand CO_2 emissions also tend to increase. Industrialization has increased the output and income of the people. Increasing people's purchasing power of industrial output will increase the amount of waste. Since 1990, the industrial sector has grown by around 174% and is thought to be the largest contributor to greenhouse gases (Sheng et al., 2021). The industrial sector is the difference, how much the industry contributes to the level of CO_2 emissions. The research of Singh et al. (2017) shows that the process of industrialization activities is identical to an activity that has an impact on increasing CO_2 emissions in the world (Labiba and Pradoto, 2018). This study is also in line with research by Aye and Prosper (2017) which states that industrial activities, especially the manufacturing industry, have a positive and significant influence on air pollution. In addition, according to the Intergovernmental Panel on Climate Change (IPCC) there are five main sources of CO_2 emissions, namely industrial processes and product use, forestry exploitation, agriculture and land use, energy use, and waste (Islam et al., 2017).

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The results of the next study stated that fossil energy consumption had a positive and significant effect on CO_2 emissions. The estimation results of the study are also supported by the research of Kurniawati et al. (2021) which explains that energy consumption using LPG has a positive impact on CO_2 emissions. This study is also in line with the findings of Riyakad and Chiarakorn (2015) which state that LPG consumption has a positive and significant impact on CO_2 emissions. According to Mikayilov et al. (2018) economic growth along with inefficient energy consumption causes

a bad impact on the environment by increasing CO_2 emissions, and environmental damage will have negative effects on humans and nature itself. The study of Sasana and Aminata (2019), found that the total use of primary energy (PE) in Indonesia has a positive and significant effect on CO_2 emissions. The results show that increasing the use of primary energy significantly increases CO_2 emissions. Industrial intensification with fossil fuels in economic activities has a negative impact on environmental quality. This is an urgency for countries that depend on the world's fossil fuel energy (Gani, 2021).

The findings of the next study explained that the population had no effect on CO_2 emissions. The population tends to increase but is not accompanied by an increase in CO_2 emissions, because most of the population works in agriculture with simple technology and a narrow land area (0.25 Ha on average). So that the activities of farmers do not have an impact on CO_2 emissions. The estimation results of this study are supported by the research of Shaari et al. (2020) which states that the population has no effect on CO_2 emissions. This is also in line with the research by Mansoor and Baserat (2018), that the population has no effect on CO_2 emissions because the technological development of a country is still low, causing low CO_2 emissions. The relationship between population and environmental conditions has become an interrelated problem when it comes to influencing CO_2 emission levels (Yeh and Liao (2017). In the broad context of the study of gyms and Aminata in Indonesia (2019)), population has a positive effect on increasing CO_2 emissions.

5. CONCLUSION

Based on the results and analysis that has been carried out, the conclusions in this study are as follows: (1) Industrialization in all business fields has a positive and significant effect on CO_2 emissions. The development of industry will increase CO_2 emissions in upland water catchment areas because the pollutants produced are getting bigger. Consumption of fossil energy that continues to increase for industrial needs has a positive and significant effect on increasing CO_2 emissions. Industrialization with fossil energy inputs that continues to increase will increase CO_2 emissions. (2) The next finding is that waste generation has no effect on CO_2 emissions. Most of the waste generated in the research area is organic waste, and the rest can still be managed properly by the local government and the community. The number of population, and the level of education have no effect on the increase in CO_2 emissions because the average level of public education is still low. The same thing also happens to economic growth where this variable has no effect on CO_2 emissions. (3) Based on the conclusions above, the researcher provides suggestions to stakeholders as follows: (a) energy raw materials for industry and transportation use energy that is more environmentally friendly, namely renewable energy. (2) implementing a non-organic waste recycling program based on the 3R concept (Reduce, Reuse, Recycle). (3) implementing a minimal waste lifestyle, namely by refusing to use single-use plastic packaging, shopping without packaging, sorting waste from home, and recycling consumption waste into compost or craft products.

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