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THE EFFECT OF AGRICULTURE, MANUFACTURING AND TRANSPORTATION ON ENVIRONMENTAL QUALITY IN INDONESIAN SELECTED PROVINCES

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Abstract: The study is aimed to analyse the impact of agriculture, manufacturing, and transportation on environmental quality in Indonesia. Analysis of the data was performed using the Partial Least Square-Structural Equation Model (PLS-SEM) with Warp-PLS software 6.0 version. The finding showed that manufacturing and transportation activities negatively and significantly impact environmental quality, while the effect of agricultural activities on environmental quality is positive and significant. The manufacturing industry growth triggers more liquid waste that leads to water pollution, more energy used that increases air pollution, and more industrial areas that cause the land cover to be reduced. The increase in road transportation caused more air pollution. In contrast, low energy consumption, controlled use of chemical fertilisers and pesticides, and the prohibition of forest clearing for agriculture activities positively impacted environmental quality. The study implies that the government needs to encourage manufacturing companies to have wastewater treatment plant. To reduce dependence on fossil energy, the government needs to encourage the manufacturing and transportation sectors to use more renewable energy and prevent the reduction in the land cover area on Java Island. The government can divert investment targets to other islands.

Keywords: Agriculture, manufacturing, transportation, environmental, sustainability.

Introduction

Although academics concur that economic activities reflected by economic growth have a positive impact on human well-being (Sacks *et al.,* 2010) and reduced poverty (Balisacan *et al.,* 2003; Ivanic & Martin, 2018; Suryahadi *et al.,* 2012), several studies have pointed out that the more rapidly growing economic activities exacerbate environmental contamination (Alvarado & Toledo, 2016; Begum *et al.,* 2015). Jorgenson (2014) showed that the effect of economic development on the carbon intensity of well-being varies by region, and the effect changes through time. Analysis shows that economic development has become less sustainable for countries in Africa, Asia and South and Central America through time. Meanwhile, for most high-income countries in North America, Europe and Oceania, economic growth continues to increase the carbon intensity of human well-being. The findings demonstrated that these countries continue to use large amounts of fossil fuels and other inputs to benefit the welfare of their population. According to Lansing & Maran (1969), a high-quality environment provides welfare and satisfaction to its inhabitants through characteristics that may be physical, social, or symbolic (Kamp *et al.*, 2003).

The Hague Environment Council (1996) defines environmental quality as the quality of the parts that construct an area, such as nature, open space, infrastructure, the built environment, physical environmental facilities, and natural resources (Kamp *et al*., 2003). Bostenaru *et al.* (2016) revealed that environmental quality is an important element in human well-being because the quality of the physical environment fundamentally influences the quality of life. The quality of human health is leveraged by the quality of the environment (Nowak *et al.*, 2014). Mcmichael *et al.* (2006) revealed that drastic environmental changes could reduce the quality of human health through climate change. Water, air, land, forests, and access to green space are basic human needs (Pretty *et al*., 2005). The quality of water, air, forest and land, which continues to decline, affects not only human health but also threatens human survival in the future (Udeigwe *et al*., 2015). Some studies indicated the threat of food shortages due to water, air and soil pollution (Lu *et al*., 2015; Sun *et al.,* 2017; Wei *et al*., 2014).

The decline in environmental quality is generally associated with the increased levels of air pollution, water pollution, and soil pollution. Previous studies indicated that the increasing levels of air pollutants such as carbon dioxide (CO_2), nitrogen dioxide (NO_2), methane (CH_4), sulphur dioxide (SO_2) and particulate matters (PM) are caused by many factors such as excessive of fossil fuels use (Afroz *et al.,* 2003; Aneja *et al*., 2009; Cole *et al.,* 2008; Haryanto, 2018; Santosa *et al*., 2008), deforestation and land use (Werf *et al*., 2009), and chemical fertilisers use (Aneja *et al*., 2009). Increasing levels of CO_2, NO_2, SO_2, CH_4 and PM triggers more greenhouse gas emissions (Fearnside, 2000). Meanwhile, the increasing levels of water pollutants such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and dissolved oxygen (DO), soil salinity, nitrate, phosphorus, ammonia and heavy metals are triggered by excessive use of chemical fertilisers and pesticides and poor quality of sanitation (Alam *et al.,* 2011; Amira *et al.,* 2019; Cole *et al*., 2008; Dsikowitzky *et al*., 2018; Parris, 2011; Rajput *et al*., 2017; Riani *et al.,* 2018; Savci, 2012).

The decrease in environmental quality is also identified with decreased land cover quality due to land-use change. Land cover is defined as the layer of soils and biomass, including natural vegetation, crops and human structure covering the land surface (Verburg *et al.,* 2000). Differences in land use result in different environmental pressures on plants and animals, impacting water quality, climate, ecosystems of goods and services, economic welfare, and human health (Gutman *et al.*, 2004).

Afroz *et al*. (2003) and Haryanto (2018) confirmed that industrial emission, land transportation, and open burning sources are the main cause of air pollution. Industrial, transportation and agricultural sectors dependence on fossil fuels triggered the growth of SO_2, NO_2 and CO_2 emissions in the atmosphere (Aneja *et al*., 2009; Cole *et al*., 2008; Haryanto, 2018). Moyen (2020) found that the effect of agricultural and manufacturing GDP growth on environmental degradation is higher in countries that consume more energy. The findings imply that energy use has a significant effect on the level of CO_2, methane (CH_4), and $PM_{2.5}$. A study by Cole & Elliott (2003), which evaluated factors that influence pollution intensity proxied by SO_2, soot and dust, showed that energy use and human capital incidence are positive functions and significant determinants of pollution intensity. Santosa *et al*. (2008) revealed that after the 1998 economic crisis, air pollution in Indonesia was caused by the large consumption of fossil fuels by the industrial and transportation sectors. The impact of agricultural activities on CO_2 emissions is found in Gokmenoglu & Taspinar (2018) study. Wang *et al.* (2007) argued that extensive use of fossil energy in China led to the increasing of sulphur oxides (SO_2), nitrogen oxides (NO_2) and carbon dioxide (CO_2). Other evidence from five (5) countries of the Association of Southeast Asian Nations (ASEAN), the United States and Pakistan suggested that the intensity of energy used by the transportation sector caused the acceleration of carbon emissions as well as SO_2 emissions in the atmosphere (Ali *et al*., 2019; Baloch, 2018; Chandran & Foon, 2013). Saleem *et al.* (2018) found a positive relationship among air-railways transportation, per capita income, and CO_2 emission. Observations by Aneja *et al.* (2009) implied that manufacturing processes, synthetic fertilisers, and utilisation of agricultural machinery by industry caused air pollution.

Matta *et al.* (2014) revealed two sources of water pollution, point source and non-point source. Water pollution from point sources includes factories, wastewater treatment facilities and septic systems. Meanwhile, pollution from non-point sources includes fertilisers, chemicals, fields, construction sites and mines. Whilst Long *et al.* (2006) revealed that industrialisation, population growth, and urbanisation are the components that most contribute to land-use change on a global scale (Driprabowo *et al.*, 2014). Another component is inappropriate agricultural practices that lead to deforestation, loss of biodiversity, soil erosion and soil quality (Alemu, 2015). The impact of agriculture activity on land use and land cover change was observed by Bishaw (2001) and Moutinho and Schwartzman (2005). The studies found that an extension programme (expansion of agricultural areas), which transforms forest areas into agricultural land, causes deforestation. In other studies, deforestation is associated with an increase in greenhouse gas emissions (Laurance, 1999; Moutinho & Schwartzman, 2005), reduced soil quality (Bishaw, 2001), reduced water and air quality (Reddington *et al.*, 2015), and loss of biodiversity (Pandit *et al.*, 2007).

This study was conducted to investigate the effect of agricultural, manufacturing and transportation sector activities on environmental quality. This study differs from previous studies because it uses an environmental quality index consisting of water quality index, air quality index, and land cover quality index as indicators of environmental quality. Using more comprehensive indicators, it is expected that it can provide a complete picture of environmental quality. Previous studies have focused on one environmental indicator, such as air pollution. The impact of air pollution was observed from the development of the financial sector (Shahbaz *et al.,* 2013), trade liberalisation (Oktavilia & Firmansyah, 2016; Robbi *et al.*, 2020), Foreign Direct Investment (FDI) (Brucal *et al.,* 2017), energy consumption (Alam *et al.*, 2016; Nugraha & Osman, 2019) and urbanisation, vehicle numbers and industrialisation (Baloch, 2018; Santosa *et al*., 2008; Sukarno *et al.,* 2016). Other researchers focus on water pollution generated by high population density, industrial and agricultural sectors (Sikder *et al.*, 2013) and sewerage systems (Kido *et al*., 2009).

This study was conducted in Indonesia. According to the World Bank (2019), Indonesia has 270,265,568 people. The large population growth triggers greater demand for products and services, which encourages more industrial growth, agriculture practices and transportation facilities. The manufacturing contribution on the Gross Domestic Product (GDP) is about 20% from 2013 to 2017, while the contribution of the agricultural sector and transportation sector is about 13% and 4.5%, respectively. In contrast, a study by Moyen (2020) showed that GDP growth from the manufacturing and agricultural sectors negatively affects environmental quality. Indonesia's environmental quality index (Table 1) was included in the "fair good" category with an index value of 65.39 on average, consisting of an Air Quality Index (AQI) of 82.64 (very good), Water Quality Index (WQI) 57.78 (deficient), and Land Cover Quality Index (LCQI) 58.15 (deficient) (The Ministry of Environment and Forestry).

Table 1: Indonesia Environmental Index

Year	AQI	WQI	LCQI	Environmental Index
2013	80.17	51.82	59.01	63.2
2014	80.54	52.19	59.01	63.42
2015	83.84	65.86	58.3	68.23
2016	81.61	60.38	57.83	65.73
2017	87.03	58.68	56.88	66.46

Source: The Ministry of Environment and Forestry

This study was conducted to analyse the impact of agricultural, manufacturing, and transportation sector activities on the environmental quality in 6 provinces in Java Island by referring to the above phenomena. There are several reasons why Java Island was selected as a unit analysis: (1) approximately 58% of Indonesia's population lives in Java Island, (2) the growth of vehicles is far higher than the other islands; more than 52% of the total national vehicles are on the island of Java, (3) Java is the centre of the manufacturing industry in Indonesia, 82% of the manufacturing industry operates in the Java Island, the manufacturing industry is the largest contributor in the formation of the national Gross Domestic Product (GDP). The study of Afroz *et al.* (2003) showed that higher pollution was found in areas where more industry was growing. Another study revealed agglomeration of manufacturing in a city exacerbates environmental pollution (Cheng, 2016), (4) Java is a producer of agricultural products, (5) Java is the largest contributor in the formation of the national GDP which is 57%, and (6) the environmental quality index of 6 provinces on Java Island tend to be lower than the other provinces (Appendix 1).

The significances of the study is applying the environmental quality index that comprises of the air quality index, water quality index, and land cover index as an indicator of environmental quality. This indicator is more comprehensive compared to previous studies that focused only on CO_2 emission. Another significance, examining the effect of agriculture, manufacture, and transportation sectors on environmental quality simultaneously are infrequently found in Indonesia context.

Materials and Methods

Sample

The sample of the study is 6 provinces, Jakarta, West Java, Central Java, Yogyakarta, East Java, and Banten (Figure 1). This study used secondary data. The income contribution of agriculture, manufacturing, and transportation sector on Gross Domestic Regional Product (GDRP) data that was obtained from the Statistical Central Agency and the Environmental Quality Index data of six provinces gathered from the Ministry of Environment and Forestry. The study used panel/pooled data that consist of cross-sectional data from 6 provinces and 8 years (from 2010 to 2017) data series. Because of this study focus on three sectors (agriculture, manufacturing, and transportation), the total data used is 144 data.

The International Energy Agency (2018) stated that there are seven groups of energy users and emitters of carbon from energy combustion, including industry, transportation, housing and agriculture/forestry, and commercial and private services (Nugraha & Osman, 2019). This study focused on the agricultural, manufacturing and transportation sectors for three reasons: (1) the agricultural and manufacturing sectors are the main pillars of the Indonesian economy (Prastiyo, 2020). Appendix 2 shows the contribution of the agricultural sector to the GDP at an average of 13% per year (2013 to 2017), the contribution of the manufacturing sector is higher at 20% per year on average (2013 to 2017), while the contribution of the manufacturing sector is lower than the previous two sectors, at 4.5% per year on average. (2) In terms of energy consumption, the manufacturing and transportation sectors consumed more than 50% of total final energy. The percentages of energy used by the manufacturing and construction sectors for four years are 40.9% (2014), 36.5% (2015), 36.2% (2016), and 31.6% (2017). Although the percentage tends to decline, it is still higher compared to other sectors. On the other hand, the trend of the transportation sector in using energy tends to increase over the four years (2014 to 2017). In 2014, the amount of energy consumed was 1,154,560 terajoules (23.3%). The following year, it increased to 1,308,584 terajoules (28.85%), and in 2017, it increased to 1,367,147 terajoules (30.3%) compared to 2016, which amounted to 1,336,531 terajoules (28.1%) (Statistical Central Agency, 2017a). The increase in the amount of energy consumed has an impact on the growth of emissions. In 2012, the greenhouse gas emissions produced

Figure 1: The Map of Java Island
Source: researchgate.net

by Indonesia was 1.9 billion tonnes, which is almost double compared to the 1990s when the amount was 1.1 billion tonnes (Dutu, 2016). (3) The rate of deforestation caused by forest clearing for industry and agriculture continues to increase.

Operational Variables

This study was designed to analyse the impact of the agriculture, manufacturing, and transportation sectors on environmental quality. The variables of study consists of independent variable and dependent variable. The independent variable of study includes agriculture, manufacturing, and transportation sectors. The income contribution of each sector in forming a Gross Domestic Regional Product (GDRP) is used an indicator. Its contribution is expressed in constant prices. The dependent variable is environmental quality, the Environmental Quality Index Index (EQI) is used as an indicator of environmental quality. The EQI value resulted from sum of the air quality index, water quality index, and land cover quality index. Referring to the Ministry of Environment and Forestry, the water quality index is resulted from monitoring the river water quality. Monitoring is carried out based on parameters including Total Suspended Solid (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphate, Faecal Coli, and Total Coliform. The air quality index is resulted from monitoring transportation, residential, industrial, and commercial areas in 150 districts /cities. The monitoring is focused on air quality parameters, sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). The land cover quality index is formed by the land cover index, forest performance index, land cover condition index, water body conservation index, and habitat condition index. The index value of land cover quality is influenced by several factors, including land clearing activities, forest and/or land fires, illegal logging, forest and/ or land rehabilitation activities, coastal area rehabilitation, post-mining land restoration activities, and restoration of hazardous and toxic waste of contaminated land (Indonesia Ministry of Environment and Forestry, 2018).

Data Analysis

The data was analysed using the Partial Least Square-Structural Equation Model (PLS-SEM), using Warp-PLS 6.0 software. According to Latan & Ghozali (2016), the evaluation of models in the Partial Least Square-Structural Equation Model (PLS-SEM) is carried out in two stages, namely measurement model evaluation and structural model evaluation. The measurement model evaluation or the outer model is carried out to assess the reliability and validity of the indicators forming the latent constructs. For constructs formed with reflexive indicators, the validity and reliability of each indicator can be seen from composite reliability indicators. The loading factor value of each indicator must have a value between 0.6 and 0.7 or by comparing the square root of the Average Variance Extracted (AVE) for each construct in the model, in which the value must be greater than the correlation between the constructs in the model (Latan & Ghozali, 2016). For variables formed with formative indicators, measurement model evaluation is performed by looking at the significance of the weight obtained from the resampling procedure. If the weight is significant ($P < 0.05$), the indicator meets the criteria of validity. In order to ensure that there is no correlation between indicators, the variance inflation factor (VIF) value should be <5 or <3.3 and the tolerance value >0.20 or >0.30. Structural model evaluation or the inner models aims to predict relationships between latent variables. The inner model was used for hypothesis testing. Path coefficient demonstrates the relationship between variables or constructs. Meanwhile, the p-value was used to determine the significance level of the relationship between variables or constructs.

The inner model value is looked at from the Adjusted R-squared (R^2) value, predictive relevance (predictive validity), and goodness of fit (GOF) for the overall model. The adjusted R^2 0.70 shows that the effect of the independent variable on the dependent variable is strong, 0.45 shows a moderate effect, and 0.25 indicates a weak effect. The effect size (f^2) value shows the magnitude effect of the exogenous variables to the endogenous variables. A value of f^2 0.02 indicates a small effect, 0.15 indicates a moderate effect, and 0.35 shows a large effect. The Q-squared (Q^2) or predictive relevance indicates that the model has predictive validity or otherwise. The predictive relevance value (Q^2) > 0 indicates that the model has predictive validity, $Q^2 < 0$ indicates the model does not have predictive validity. The Q-squared value of 0.02 indicates the model has a weak predictive validity, a value of 0.15 indicates a moderate predictive validity, and 0.35 shows a strong predictive validity. In addition to the two measures above, Warp-PLS version 5.0 and 6.0 also provide other model fit measures, such as average path coefficient (APC), average R-squared (ARS), and average adjusted R-squared (AARS) in which the p-value should be significant or a p-value ≤0.05, while the ideal value of Average full collinearity VIF (AFVIF) should fulfil ≤ 3.3 or ≤ 5.

Results and Discussions

Results

An outer model with a formative construct was used to show the validity of indicators in explaining the construct (variable). The validity and reliability of indicators can be seen from the significance value of the weight—the weight <0.05 (Latan & Ghozali, 2016). Table 2 indicates that the indicators of agriculture, manufacturing, and transportation (independent variable) have a significant value or weight or p-value <0.05, showing that the indicators used for these three variables meet the reliability criteria. The results also show that the relationship between the three independent variables (agriculture, manufacturing, transportation) is free from collinearity problems, indicated by the value of the variance inflation factor (VIF) <5.00.

The inner model (Table 2) illustrates that the agricultural sector in six provinces (Jakarta, West Java, Central Java, East Java, Yogyakarta, Banten) positively and significantly influences the environmental quality in Java. The significance can be seen in the path coefficient (β) + 0.806 with the p-value (ρ) <0.001. These findings indicate that every 1 rupiah increase in income from the agricultural sector increases the environmental quality index by 0.806. On the other hand, the manufacturing and transportation sectors negatively and significantly affect environmental quality. The negative effect can be seen from the path coefficient (β) −0.238 and −0.441 for manufacturing and transportation, respectively. The p-value (ρ) 0.037 <0.05 and p-value (ρ) <0.001 imply that the two independent variables significantly influence the dependent variable. The path coefficient (−)0.238 explains that the manufacturing sector negatively affects environmental quality. This result implies that 1 rupiah increase in income from the manufacturing sector reduces the environmental quality index by 0.238. The path coefficient (−)0.441 indicates that 1 rupiah increase in income from the transportation sector reduces the environmental quality index by 0.441.

The adjusted R^2 value of 0.506 or 50.6% indicates the ability of the independent variable to explain variations in the dependent variable by 50.6%, and this value falls into the moderate category. The adjusted R^2 value of 50.6% implies that the agricultural, manufacturing and transportation sectors affect environmental quality by 50.6%, other variables outside the model influence the remaining 49.4%. The Q-squared is 0.545 indicates that the model has strong predictive relevance. This is because the Q-squared value > 0.35.

Table 2 highlights the path coefficient value of the agricultural, manufacturing and transportation sectors. The positive influence of the agricultural sector on environmental quality is very high compared to other sectors, amounting to 0.806. Table 2 also shows that the negative impact of the transportation sector on environmental quality is 0.441, higher than the negative impact of the manufacturing sector, 0.238. The findings indicate that the contribution of the transportation sector in reducing environmental quality is greater than that of the manufacturing sector.

Discussions

Agricultural Sector and Environmental Quality

The statistical output indicates that the agricultural sector positively and significantly influences environmental quality. The finding shows that there are several reasons why the

Table 2: Outer Model and Inner Model Output

Indicator Weight					
	Agriculture	**Manufacturing**	**Transportation**	**EQI**	**p-value**
Agriculture	1.000	0.000	0.000	0.000	<0.001
Manufacturing	0.000	1.000	0.000	0.000	<0.001
Transportation	0.000	0.000	1.000	0.000	<0.001
EQI	0.000	0.000	0.000	1.000	<0.001
Path Coefficient					
	Agriculture	**Manufacturing**	**Transportation**	**EQI**	
EQI	0.806	-0.238	-0.441		
p-value					
	Agriculture	**Manufacturing**	**Transportation**	**EQI**	
EQI	<0.001	0.037	<0.001		
	Agriculture	**Manufacturing**	**Transportation**	**EQI**	
R Squared				0.537	
Adjusted R^2				0.506	
Full Collin. VIF	4.347	4.208	2.137	2.161	
Q-Squared				0.545	

Source: Author 20201[1]

[1] Author 2020

agricultural sector does not have a negative impact on environmental quality, low energy use, no burning forests, controllable fertiziler and pesticides use, and reduced agriculture land.

As is mentioned, the environmental quality is proxied by the environmental quality index (air quality, water quality and land cover quality). The decreasing air quality is caused by air pollution from energy use (fossil fuels) and forest fires (Afroz *et al.,* 2003; Aneja *et al.,* 2009). Regarding energy use, the Environmental Statistics Report (2017) revealed that for 6 years (2011–2016), the amount of energy used by the agricultural sector was relatively small, only around 0.28% of the total national energy consumption. This relatively small energy consumed results in little environmental impact. Greenhouse gas emissions produced by the agricultural sector are 7% per year for 6 years, with annual details of 8.1% (2011), 7.77% (2012), 7.99% (2013), 6.27% (2014), 4.54% (2015), and 7.73% (2016) (Statistical Central Agency, 2017a). In terms of forest fire, Indonesian government delivered regulations that prohibit forest clearing for agriculture in the Java area, and the regulation effectively stops deforestation. Low energy use and no burning forests for agricultural land are potential reasons the agricultural sector does not negatively impact air quality on the Java island.

The impact of agriculture activities on water quality is not significant. A study by Kaswanto *et al.* (2012) in West Java concluded that chemical fertilisers and pesticides are relatively safe and do not cause river water contamination. However, they suggest that fertiliser use should be closely monitored. Referring to government standards for nitrogen and phosphorus contamination, Lubada *et al.* (2018) found that the water quality in the Cisadane River, West Java, is more contaminated with household waste. The impact of agricultural practices on river water quality has not been identified and needs further investigation. Permatasari *et al.* (2017) discovered water contamination in the Ciliwung River, Jakarta, due to land-use change in the watershed, from agricultural areas to urban land.

The impact of agricultural activities on the decrease quality of the land cover is very small. In the condition of land cover in Java Island, agricultural land is converted into industrial and residential land in the lowlands, and new agricultural land clearing is carried out in the highlands (Verburg *et al*., 2000). However, the proportion of new agricultural land is relatively small. According to Agaton *et al.* (2016), land use/land cover change in the Upper Citarum watershed is caused by urbanisation and agriculture. From 1997 to 2005, there was an increase in agricultural land by 8%, and between 2005 and 2014, agricultural land increased by 2%. Along with the increasing population, it is predicted that agricultural land in this area will decrease by 3.13% in 2029 (Siswanto & Frances, 2019). The Statistical Central Agency report shows that the total land cover (forest and non-forest) for the six provinces in Java Island during 2014–2019 is constant. The total land cover for Jakarta, West Java, Central Java, Yogyakarta, East Java, and Banten are 65.3 hectares, 3698.6 hectares, 3456.6 hectares, 319.4 hectares, 4837.7 hectares and 939.2 hectares, respectively. Statistical Central Agency also reports that the forest cover of the provinces in Java Island is less than 30% of each province's total area. Jakarta Province has the lowest forest cover, namely 0.5% of its total area, while East Java Province is the largest forest cover province with 28.62% forest area. The small area of forest causes the land cover quality index in some provinces of Java Island to have a very poor status, even the alert status was attached to Jakarta and Surabaya.

Manufacturing Industry Sector and Environmental Quality

The output of the Warp-PLS software implies that manufacturing activities negatively influence environmental quality. Several things cause a negative impact—first, industrial growth followed by an increase in demand for energy. Socio-economic data shows that there has been an increase in the number of companies by 4000 units between 2000 (22,000) and 2015 (26,000), which are dominated by food, textile, and garment companies (Statistical Central Agency, 2017). In 5 years (2010–2015), it was reported that small and medium enterprises had also increased by 25%, from 2.7 million units (2010) to 3.6 million units (2015). The Statistical Central Agency report also shows that the average growth of medium and large industries is 5.85% per year (2010-2017), while the average percentage of energy consumed by the industrial sector, including manufacturing, is 38.60% per year (2010–2017), this is higher than the amount of energy consumed by other sectors. Dependence on fossil energy causes an increase in air pollutants, such as *carbon dioxide (CO_2), nitrogen dioxide (NO_2), particulate matters (PM), sulphur dioxide (SO_2)*. This finding supports the study of Afroz *et al*. (2003) and Santosa *et al*. (2008), air pollution was caused by the large consumption of fossil fuels. Increasing levels of CO_2, NO_2, SO_2, CH_4 and PM triggers more greenhouse gas emissions (Fearnside, 2000). The Ministry of Environment and Forestry reported that the energy sector generates greenhouse gas emissions (includes manufacturing industry) was 36.47% (2011), 35.03% (2012), 38.96% (2013), 31.93% (2014), 26.59% (2015), 40.83% (2016). The Research Energy and Clean Air Centre (2020) mentions that the increasing air pollution level in several provinces in Java, such as Jakarta, West Java, Banten and East Java, is because these locations have a power plant industry that uses fossil fuels. Emissions from energy combustion increase the levels of *nitrogen dioxide (NO_2), sulphur dioxide (SO_2),* and *particulate matter ($PM_{2.5}$)*. These emissions are also generated by sectors, such as cement, steel, glass, oil and gas refining, power, and energy (including coal-fired power plants), metals, petrochemicals, and plastics.

Second, the growth of the manufacturing industry causes water pollution. Water pollution is caused many manufacturing firms discharge the liquid waste directly into rivers and waterways without being processed first. The Statistical Central Agency report shows that levels of water pollutants such as *biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), total suspended solid (TSS), faecal coli,* and *total coliform* was found to exceed the water quality standards of rivers in Java Island (2010-2016)(Statistical Central Agency, 2017a). Central Statistics Agency data showed that during five years (2011-2015), BOD level was found above water quality standards. In 5 years, the average BOD content in Jakarta, West Java, Central Java, Yogyakarta, East Java and Banten was above the class 1 water quality standard. Meanwhile, the DO level was found to overshoot the water quality standard for Jakarta, West Java and Banten (2011-2015). In 2016, DO concentrations exceeding the quality standard were found in Jakarta, Yogyakarta, and East Java. The *Chemical Oxygen Demand (COD)* concentrations were also discovered to exceed the quality standard in 6 provinces, DKI Jakarta, West Java, Central Java, Yogyakarta, East Java and Banten (2011-2016). In 2014, the TSS level was found to outstrip the water quality standard in the Jakarta, Central Java and Banten rivers. In 2015 and 2016, TSS levels indicated above standard in the Jakarta, Central Java and Banten and East Java rivers. Faecal coli above the quality standard was found in all provinces (2016), for the previous two years (2015 and 2014) faecal coli exceeding the quality standard was found in four provinces: Jakarta, Central Java, Yogyakarta, and East Java.

The year 2015 reported that nearly 68% of the river was heavily polluted (Statistical Central Agency, 2018). It was also reported that water pollution was a serious problem on Java Island. The percentage of water pollution increased significantly over four years (from 2014 to 2018); the highest increase was in Jakarta at around 69.03% (from 20.33% to 89.36%). The same trend was also shown in West Java, Central Java, Yogyakarta, East Java and Banten. The increase in West Java was about 27.5% (from 18.97% to 49.27%), whereas, in Central Java, Yogyakarta, East Java and Banten, the increase in water pollution were 17.66%, 19.15%, 15.04% and 33.09%, respectively (Statistical Central Agency, 2018).

Previous studies stated that liquid waste is the main source of water pollution. The environment statistics mentioned that in 2016 more than 60% of liquid waste resulted from industrial liquid waste (43%) and domestic liquid waste (18%). The Statistical Central Agency report was confirmed by Amira *et al*. (2019), Kido *et al*. (2009), Sikder *et al*. (2013), and Sikder *et al.* (2012). Studies conducted in Jakarta, West Java, Central Java, and East Java show that the main causes of water pollution are industrial and household waste. Water pollution is caused by many manufacturing companies that do not have liquid waste treatment plant. This finding confirmed by Fadhilah *et al. (*2018); Sulthonuddin *et al*. (2019).

Third, industrial growth followed by increased demand for industrial areas. The increasing demand has resulted in many agricultural lands being converted into the industrial area. The land use change from agriculture area into industrial area reduced land cover quality. This finding support Alvarado and Toledo (2016). The Strategic Plan of the Ministry of Agriculture for 2015 to 2019 shows thereabouts 50,000–100,000 hectares of agricultural land have been converted into the non-agriculture area. Permatasari *et al.* (2016) showed that agricultural land shrinks by about 6% because the land is converted to use for industrial land, housing, roads, and others in Jombang, East Java. Another evidence revealed by Robbany *et al.* (2019), showed that the vegetation in the Metropolitan (Jakarta, Bogor, Tangerang, and Bekasi) area reduced significantly from 2001 to 2015; the reduction was around 8%, from 54% (2001) to 46% (2015); in the following years, it is expected to fall to 30%. Impact of land-use change caused environmental problems such as increased temperatures, river pollution, slope failure, and flooding (Rozimah & Khairulmaini, 2016), lack of green open areas (Putri & Sari, 2019), reduced biodiversity, loss of water reservoirs areas (Robbany *et al*., 2019), soil erosion and decreasing soil quality (Alemu, 2015), and water pollution (Permatasari *et al*., 2017).

Transportation Sector and Environmental Quality

The statistical finding implies that environmental quality negatively and significantly influenced by transportation. The negative impact of the transportation sector on environmental quality is because high energy consumption by land transportation. Sukarno *et al.* (2016) revealed that the transportation sector contributes dominantly (80%) to air pollution. This study supports Sodri & Garniwa (2016) claimed who concludes that there is a positive relationship between the growth of energy consumed by road transportation and the increase of CO_2 in Jakarta. Lestari *et al.* (2020) reported a similar finding. The finding implies that road transportations are the biggest contributor of NOx, CO and PM2.5 emission in Jakarta. Afroz *et al.* (2003) showed that land transportation contributes the most to air pollution, carbon dioxide (CO_2), methane (CH_4), carbon monoxide, hydrocarbon (HC), nitrogen dioxide (NO_2), particulate matter (PM), and sulphur dioxide (SO_2).

In 2012, the amount of energy consumed was 24.31%. The following year, it increased by almost 10% to 32.29% and energy consumption reached 42.12% in 2014. In 2015 and 2016, the amount of energy consumed decreased by 28.79% and 28.07%, respectively (Statistical Central Agency, 2017b). The surge in energy consumption in 2014 was triggered by public transportation-based online applications that provide ease of low-cost mobilisation and the spending styles of people that began to shift to e-commerce, which resulted in a surge in freight forwarding services. The average growth of vehicles in Java was 4.97 million per year (2012 to 2017). The number of vehicles in 2013 rose by 5,227,805 units compared to 2012. In 2014 the increase was 7,015,653 units; in 2015, it grew 4,363,584 units from 2014; in 2016, it rose by 3,903,575 units, and in 2017, the increase was 4,347,010 units from the previous year (Appendix 3). The average percentage of energy use per year by the transportation sector is 31.08% of the total national energy consumption (2012–2016).

Conclusion

The environmental degradation quality in Java, Indonesia, was influenced by the growth in economic activities, especially the manufacturing industry and transportation. The contrast evidence, agricultural sector activity has a positive impact on environmental quality. Although the growth of these three sectors has a major influence on economic growth, the study findings indicate that it requires appropriate policies from the government that synchronise the growth of the manufacturing, transportation, and agriculture sectors with environmental preservation. Evidence shows that the greater the fossil energy consumed, the higher the level of air pollution. In order to reduce the air pollution level, the use of renewable energy must be intensified. To reduce water pollution, the government needs to supervise and encourage the industrial sector to provide wastewater treatment plant. Meanwhile, to prevent the continuous decline in the land cover quality in Java Island, the government needs to divert investment targets to other islands.

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Appendix 1

Table 3: Environmental Quality Index (EQI) of provinces in Indonesia

Province	Year			
	2014	2015	2016	2017
Nanggroe Aceh Darussalam	72.60	74.83	73.55	77.70
North Sumatera	61.53	69.37	66.47	69.77
West Sumatera	68.91	59.07	60.06	68.16
Riau	52.59	53.07	56.73	68.64
Jambi	62.04	61.85	64.01	64.98
South Sumatera	61.62	69.06	67.27	69.18
Bengkulu	66.76	76.92	72.43	70.18
Lampung	56.42	63.04	60.34	59.72
Bangka Belitung	60.21	71.26	66.88	67.85
Riau Islands	69.27	73.11	70.19	70.34
DKI Jakarta	36.88	43.79	38.69	35.78
West Java	45.06	63.49	51.87	50.26
Central Java	60.63	60.78	58.75	58.15
Yogyakarta	49.53	50.99	51.37	49.80
East Java	56.48	62.67	58.98	57.46
Banten	43.67	55.36	60.00	51.58
Bali	59.81	73.71	72.59	70.11
Nusa Tenggara Barat	69.39	58.82	56.53	56.99
Nusa Tenggara Timur	62.98	63.79	59.23	61.92
West Kalimantan	68.31	75.88	72.24	74.17
Central Kalimantan	70.37	74.09	74.71	71.47
South Kalimantan	57.51	57.47	59.07	69.38
East Kalimantan	74.00	81.15	76.85	75.65
North Sulawesi	65.69	66.27	67.07	70.81
South Sulawesi	64.07	67.01	68.78	73.24
Central Sulawesi	76.40	76.43	70.54	69.39
Southeast Sulawesi	72.14	75.18	75.24	70.86
Gorontalo	75.52	71.08	68.30	67.46
West Sulawesi	72.29	68.78	64.54	74.47
Maluku	74.79	76.33	71.66	75.12
North Maluku	77.22	75.97	72.46	74.55
West Papua	84.51	82.33	83.01	85.69
Papua	80.65	81.01	81.35	81.47
National Index	63.42	68.23	65.73	66.46

Source: Indonesia's Ministry of Environment and Forestry, 2014-2017[2]
Note: EQI > 80: Very good, 70< EQI < 80: Good, 60< EQI < 70: Fair good
50< EQI < 60: Deficient, 40< EQI < 50: Very poor, 30< EQI < 40: Alert

[2] Indonesia's Ministry of Environment and Forestry, 2014-2017

Appendix 3

Table 4: Gross Domestic Product (GDP) based on business fields contribution

Business Fields	Year (%)				
	2013	2014	2015	2016	2017
Agriculture, Forestry and Fisheries	13.36	13.34	13.49	13.45	13.14
Mining and Excavation	11.01	9.83	7.65	7.20	7.57
Manufacturing Industry	21.03	21.07	20.97	20.51	20.16
Supply of Electricity and Gas	1.03	1.09	1.14	1.15	1.19
Water Supply, Waste Management, Waste and Recycling	0.08	0.07	0.07	0.07	0.07
Construction	9.49	9.86	10.21	10.38	10.38
Wholesale and Retail Trade, Repair and Maintenance of Vehicles	13.21	13.43	13.31	13.19	13.01
Transportation and Warehousing	3.93	4.42	5.02	5.22	5.41
Accommodation and Food and Beverage Provision	3.03	3.04	2.96	2.92	2.85
Information and Communication	3.57	3.50	3.52	3.67	3.80
Financial Services and Insurance	3.88	3.86	4.03	4.20	4.20
Real Estate	2.77	2.79	2.84	2.81	2.79
Company Services	1.52	1.57	1.65	1.70	1.75
Government Administration, Defense and Social Security	3.90	3.83	3.91	3.86	3.70
Educational Services	3.22	3.23	3.37	3.37	3.29
Health Services and Social Activities	1.01	1.03	1.07	1.07	1.07
Other Services	1.47	1.55	1.65	1.71	1.76

Source: Central Statistical Bureau 2016,2017 and 2018[3]

Table 5: The growth of vehicles based on islands, from 2012-2017 (Unit)

Island	Year					
	2012	2013	2014	2015	2016	2017
Sumatera	23590794	26012352	27561913	29203673	31102700	34071726
Java	48125915	53353720	60369373	64732957	68636532	72983542
Bali-Nusa	6473434	6895138	7294341	7476 427	8180258	8790530
Kalimantan	7167013	8194335	8784293	9253331	9825201	10468288
Sulawesi	7743408	8292170	8751748	9217729	98651461	10271832
Papua & Maluku	1272760	1371254	1447592	1510068	1684927	1970751
Total	94373324	104118969	114209260	121394 185	129281079	138556669

Source: Central Statistical Bureau 2016 and 2017[4]

[3] Indonesia's Ministry of Environment and Forestry, 2014-2017

[4] Central Statistical Bureau 2016 and 2017