Carbon Emissions, Economic Growth, Forest, Agricultural Land and Air Pollution in Indonesia

Azwardi Azwardi*, Sukanto Sukanto, Alghifari Mahdi Igamo, Arika Kurniawan

Department of Economic and Development, Faculty of Economics, Sriwijaya University, Indonesia. *Email: azwardi@fe.unsri.ac.id

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ABSTRACT

This study specifically analyzes the effect of motor vehicle emissions, economic growth of forest area, and agricultural area on air pollution in 33 Indonesian Provinces during the year 2010-2017 using the panel data regression approach. The results showed that (1) Carbon emissions and agricultural area in all regions in Indonesia had a negative and significant effect on the air quality index (2) Based on the regions of Sumatra Island, Java Island, and Kalimantan Island, GDP had a positive and insignificant effect on air pollution (3) Forest area in all regions in Indonesia, as a whole, has a positive and significant effect on the air quality index.

Keywords: Air Pollution, Carbon Emissions, Economic Growth, Forests, Agriculture

JEL Classifications: Q50, Q53

1. INTRODUCTION

Air pollution is the biggest threat to global health (Alvarado et al., 2019; Wang et al., 2019; Martinez et al., 2018; Cohen et al., 2017). The world health organization (WHO) estimates that there were 4.9 million of premature deaths that caused by ambient air pollution in 2017 (Health Effects Institute and Project, 2019). This condition continues to increase every year at an alarming rate around the world, especially in low and middle-income countries (Pinder et al., 2019; Gulia et al., 2020; Antoine et al., 2019). Over the last two decades, Indonesia has experienced very significant changes in its air quality during the period 1998 to 2016; Indonesia is one of the twenty most polluted countries in the world (Greenstone and Fan, 2019). National air quality in 2018 is classified as good with a value of 84.74. As many as 32 provinces experienced a decrease in air quality index (AQI) except DKI Jakarta and South Sulawesi which experienced an increase of 13.07 points and 4.90 points respectively (Ministry of Environment and Forestry, 2018).

The main cause of increasing air pollution is the number of motorized vehicles (Wang et al., 2019) which significantly impacts motor vehicle pollution causing 8.9 million deaths globally (Burnett et al., 2018). Indonesia tends to experience a decrease in air quality in several areas due to increased usage of transportation, this is evidenced by an increase in particles ($\text{PM}_{10}$ and $\text{PM}_{2.5}$) and ozone oxidant (O3) (Ministry of Environment and Forestry, 2018). Jakarta is the main contributor to motor vehicle pollution, namely 35 percent of $\text{PM}_{2.5}$ in all cities in Indonesia in 2008-2009 (Greenstone and Fan, 2019). According to WHO, the impact of PM exposure causes an increased risk of respiratory disease, cancer, irritation and phenomena, and even death, in addition to these health problems it will have an impact on visibility and environmental damage (Samet et al., 2000; Puett et al., 2014). People who live near highways have a higher risk of exposure to air pollution and its side effects on health (Krzyzanowski et al., 2005; Venn et al., 2000).

Increasing usage of agricultural land will lead to poorer environmental quality, this condition is related to agricultural activities such as the use of many chemicals in the agricultural process, the types of plants that are modified (genetically) and the types of land (peat) used will cause environmental conditions,
namely climate change, deforestation, pollutants and genetic pollution (Agbogidi, 2011; Onu and Ikehi, 2016). In line with that, the negative impact of agricultural activities especially agricultural land use, such as forest conversion will cause degradation of soil quality, soil pollution, aquifer and surface water (Phairuang et al., 2019). The relationship between the agrarian sector and air pollution is bilateral in nature, the cause of air pollution, namely agricultural activities related to deforestation, exploitation of natural plant resources such as forestry (Olsen et al., 2020, Phairuang et al., 2019). Clearing forests for use as plantations or agro-industry has a significant impact on increasing air pollution (Phairuang et al., 2019; Rosales-Rueda and Triyana, 2018) one of the impacts of using forests as plantations or agro-industry is forest fires (Phairuang et al., 2019; Rosales-Rueda and Triyana, 2018; Chaiyo and Garivait, 2014) the impact of causing a decline in health and causing various respiratory diseases (Cheong et al., 2019).

The key to reduce pollutants is by expanding land cover (Sun et al., 2016). Increasing land cover in urban areas can affect pollutant concentrations and will reduce the spread with an impact on energy demand and biogenic emissions in the surrounding area (Sun and Zhu, 2019; Xian et al., 2007; Nowak et al., 2000). The interaction of land cover on environmental quality, especially air quality, will have an environmental impact on the sustainable atmosphere (Vadrevu et al., 2017).

The relationship between economic growth and the environment is contradictory; generally the increasing of economic growth will cause environmental degradation in accordance with the Environmental Kuznets Curve (EKC) (Ali and Oliveira, 2018). Policies in developing countries have entered the stage clean economy while developing countries are still experiencing the impact of pollution simultaneously as a result of increasing economic growth (Andrée et al., 2019; Zheng et al., 2015)

2. LITERATURE REVIEW

The relationship between economic growth and the environment is questionable whether limited resources or increased income can improve environmental conditions (Griffin and Schiffel, 1972; Grossman et al., 1991; Panayotou, 1994). Economic progress has had a significant impact, especially on the increasing motorized vehicles which have an effect on air pollution (Greenstone and Fan, 2019; Burnett et al., 2018). In general, motorized vehicle emissions contribute greatly to urban air pollution worldwide (Health Effects Institute, 2010; Lyons et al., 2003). This linkage is discussed in the literature review in terms of transportation and air pollution. The main sources of air pollution are related to transportation, namely the number of motorized vehicles, traffic, and congestion (Brugge, 2019; Burnett et al., 2018). Exposure to air pollution caused by transportation traffic has a significant impact on health conditions (Burnett et al., 2018) and at an advanced stage will have an impact on children’s health (Frondelius et al., 2018). In response to it, the need for economic policies must be based on environmental policies (Bo, 2011; Crespo et al., 2017). One of the policies that can reduce pollution is to expand land cover (Sun et al., 2016).

The implications of economic growth for environmental policies are related to the interpretation of the U-shape model which confirms that developing or lower-middle-income countries must carry out strict regulations regarding land cover. It because economic growth is not sufficient to restore the condition of natural forests lost (Andrée et al., 2019; Crespo et al., 2017; Panayotou, 1993). In addition, there is a need for policies to increase trees, especially in urban areas, because most of the elimination of pollution occurs in rural areas that still have trees and forests (Nowak et al., 2014).

3. METHODS

This research is focused on analyzing the effect of motor vehicle emissions, forest area, and economic growth on air pollution in Indonesia. This study uses secondary data in the form of panel data, namely a combination of time series data and cross-section data in the period 2010-2017 of 33 provinces in Indonesia. The data source is obtained from the official website of the Ministry of Environment and the Indonesian Central Bureau of Statistics by taking data on indicators of developments in environmental conditions. The variables used can be seen in Table 1:

The analytical approach used is a panel data regression analysis model with the following specifications (Greene, 2012):

\[ Y_{it} = x_{it} \beta + z_{it}' \alpha + e_{it} \]

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There is a K regressor in \( x_{it} \) which is not included in the constant term. Heterogeneity or the individual effect \( z_{it}' \alpha \) where \( z_{it} \) contains the term and one individual or group variable. \( X \) is all individuals observed in the model it can be treated as an ordinary linear model and suitable for use in the OLS model. There are several types of models that can be estimated in panel data estimation. However, the most common is the model Pooled Least Square, Random Effects Model, Fixed Effects Model.

This model will use Natural Logarithms to get a higher level of significance (Gerdes, 2011; Croissant and Millo, 2008) so the model equation can be written as follows:

| No. | Variable | Unit | Symbol | Source |
|-----|----------|------|--------|--------|
| 1   | Air Quality | Index | IKU    | IKLH (Ministry of Environment) |
| 2   | Number of Motor Vehicles | Unit | JKM    | Indonesian Statistics (Central Statistics Agency) |
| 3   | Gross Regional Domestic Product | Million Rupiah | PDRB | Indonesian Statistics (Central Statistics Agency) |
| 4   | Forest Area | Thousand Acres | LH | Indonesian Statistics (Central Statistics Agency) |
| 5   | Plantation Area | Thousand Acres | LAP | Indonesian Statistics (Central Statistics Agency) |

Table 1: Research variables, data units, and data sources
Environmental conditions, this condition is a stage where a good economy is a threat to the environment (Meadows et al., 1972).

4.2. Analysis of Panel Regression
Statistical tests based on the Chow, Hausman and Breusch-Pagan Lagrange multiply (LM) tests which are classified by region in Table 3 which shows the variation of the model:

Table 4 shows the results of panel data regression estimation where panel A shows the Common Effect Model, Panel B Fixed Effect Model and Panel C the Random Effect model. Regionally, it shows that the number of motorized vehicles in all regions in Indonesia has a negative and significant effect on the air quality index, which means that any increase in the number of motorized vehicles will reduce air quality. These results are consistent with previous literature studies that the main sources of air pollution are related to transportation, namely the number of motorized vehicles, traffic and congestion (Brugge, 2019; Burnett et al., 2018; Health Effects Institute (HEI), 2010; Lyons et al., 2003).

Areas that are not an economic concentration or the region’s low GDP contribution to Indonesia’s gross regional domestic product (GRDP) such as Bali Island and Nusa Tenggara, Sulawesi, Maluku and Papua have negative coefficients, this shows that an increase in GDP will reduce air quality, consistent with the theory of Environmental Kuznet Curve (Kuznets, 1955). In line with it, air pollution has a profound impact on low-income areas resulting from increased economic growth (Andrée et al., 2019; Ali and Oliveira, 2018; Zheng et al., 2015).

Table 2: Descriptive statistic by region (2010-2017)

| Region                  | Vehicle | GDP   | Forestry | Agriculture Area |
|-------------------------|---------|-------|----------|------------------|
| Sumatra Island (n = 80) | Minimum | 52    | 28353    | 382              | 67    |
|                         | Maximum | 100   | 487531   | 9456             | 3167  |
|                         | Mean    | 88    | 184420   | 2540             | 1160  |
|                         | Std.Deviation | 10 | 134853 | 2028             | 890   |
| Java (n = 48)           | Minimum | 13    | 881155   | 0                | 17    |
|                         | Maximum | 115   | 20730267 | 117135           | 1361  |
|                         | Mean    | 48    | 9407229  | 19967            | 552   |
|                         | Std.Deviation | 23 | 5680953 | 20486            | 477   |
| Bali and Nusa Tenggara (n = 24) | Minimum | 77    | 908897   | 43847            | 2958  |
|                         | Maximum | 100   | 4931597  | 49128            | 1809  |
|                         | Mean    | 89    | 2345225  | 20965            | 988   |
|                         | Std.Deviation | 7  | 1330154 | 13396            | 692   |
| Kalimantan (n = 32)    | Minimum | 77    | 846469   | 56531            | 5887  |
|                         | Maximum | 100   | 2966407  | 469646           | 172163 | 15300 |
|                         | Mean    | 90    | 2045534  | 181079           | 37082  |
|                         | Std.Deviation | 6  | 627837 | 372833           | 5147  |
| Sulawesi (n = 48)      | Minimum | 77    | 846469   | 56531            | 5887  |
|                         | Maximum | 100   | 2966407  | 469646           | 172163 | 15300 |
|                         | Mean    | 90    | 2045534  | 181079           | 37082  |
|                         | Std.Deviation | 6  | 627837 | 372833           | 5147  |
| Maluku and Papua (n = 32) | Minimum | 28    | 39756    | 14984            | 2401  |
|                         | Maximum | 92    | 956547   | 148823           | 38363  | 42225 |
|                         | Mean    | 62    | 548234   | 12708            | 12850  |
|                         | Std. Deviation | 17 | 301089 | 7601             | 13252  |
Table 3: Diagnostics panel test

| Region                  | Chow | Hausman | LM     | Best Model |
|-------------------------|------|---------|--------|------------|
| Sumatera                | 3.179 (0.0030) | 20.99 (0.000) | 51.39 (0.000) | FEM        |
| Java                    | 3.412 (0.021)  | 13.64 (0.008)  | 3.795 (0.0514) | FEM        |
| Bali and Nusa Tenggara | 4.027 (0.0371) | 0.000 (1.000)  | 2.818 (0.0932) | FEM        |
| Kalimantan              | 1.21 (0.3253)  | 10.661 (0.0306) | 16.658 (0.000) | FEM        |
| Sulawesi                | 1.919 (0.117)  | 8.887 (0.064)  | 54.44 (0.000)  | CEM        |
| Maluku and Papua        | 2.080 (0.194)  | 2.9714 (0.5626) | 0.523 (0.4694) | REM        |

Table 4: Air pollution indicator

Panel A: Common effect model by region

| Region                  | C      | Vehicle | GDP     | Forestry | Agriculture Area | Adj |
|-------------------------|--------|---------|---------|----------|-----------------|-----|
| Sumatera                | 2.078** (0.00) | 0.0596* (0.06) | -0.0797*** (3.17) | -0.0275 (0.21) | -0.0051 (0.21) | 0.23 |
| Java                    | 4.253** (2.62)  | 0.102 (1.68)  | -0.125 (0.62)  | 0.007 (0.05)  | 0.016 (0.25)  | 0.21 |
| Bali and Nusa Tenggara | 8.35** (12.08) | -0.021*** (7.79) | 0.13 (0.15)  | -0.087*** (17.58) | -0.058 (2.46) | 0.36 |
| Kalimantan              | 6.057*** (6.58) | -0.086 (0.65)  | -0.005 (0.56)  | 0.017 (0.23)  | -0.059 (0.38) | 0.21 |
| Sulawesi                | 4.89*** (66.2)  | -0.0168*** (4.33) | -0.011*** (4.106) | 0.003 (0.454) | -0.004 (1.57) | 0.06 |
| Maluku and Papua        | 5.286*** (25.8) | -0.036*** (2.80) | -0.084*** (2.500) | 0.075*** (2.87) | -0.019 (0.275) | 0.28 |

Panel B: Fixed effect model by region

| Region                  | C      | Vehicle | GDP     | Forestry | Agriculture Area | Adj |
|-------------------------|--------|---------|---------|----------|-----------------|-----|
| Sumatera                | 2.716*** (16.5) | -0.2046*** (2.8)  | 0.055 (0.51)  | 0.0778*** (4.2) | -0.00493*** (18.3) | 0.47 |
| Java                    | -486.24*** (7.01) | -0.295** (2.154) | 0.1796 (0.596) | 85.23*** (6.91) | -0.014 (0.415) | 0.36 |
| Bali and Nusa Tenggara | -21.69*** (2.07) | -0.119*** (2.95) | -0.356*** (2.67) | 5.046*** (3.85) | -0.113*** (3.86) | 0.48 |
| Kalimantan              | 5.90*** (6.55)  | -0.253*** (3.12) | 0.197 (1.48)  | 0.030 (0.454) | -0.0499 (0.763) | 0.42 |
| Sulawesi                | 6.074*** (7.22) | 0.052 (0.79)  | -0.2006 (0.344) | 0.009 (0.34)  | -0.0304*** (3.53) | 0.16 |
| Maluku and Papua        | 5.090*** (4.16) | 0.013 (0.237)  | -0.161 (0.2514) | 0.110* (1.912) | -0.002 (0.266) | 0.36 |

Panel C: Random effect model by region

| Region                  | C      | Vehicle | GDP     | Forestry | Agriculture Area | Adj |
|-------------------------|--------|---------|---------|----------|-----------------|-----|
| Sumatera                | 2.1141*** (12.02) | 0.0512 (0.4)  | -0.0799*** (3.3) | -0.022 (0.54) | -0.0046*** (3.16) | 0.20 |
| Java                    | 4.253*** (3.65)  | 0.102*** (0.10) | -0.125 (0.77) | 0.007 (0.73) | 0.016 (0.38) | 0.05 |
| Bali and Nusa Tenggara | 7.103*** (3.65)  | -0.027 (0.203) | -0.138 (0.888) | -0.041 (0.954) | -0.1408 | -0.03 |
| Kalimantan              | 5.172*** (9.56)  | -0.197 (0.238) | 0.050 (0.487)  | 0.013 (0.63)  | -0.129 (0.617) | 0.13 |
| Sulawesi                | 4.973*** (18.82) | -0.030 (1.01)  | -0.014** (2.02) | 0.011 (0.357) | 0.005 (0.867) | 0.07 |
| Maluku and Papua        | 5.295*** (41.4)  | -0.036*** (9.12) | -0.073** (2.176) | 0.067** (2.359) | -0.027** (2.405) | 0.21 |

*0.1, **0.05, ***0.01

In contrast, areas that have the concentration of GRDP in Indonesia namely Sumatra, Java and Kalimantan, show positive coefficient results but the effect is not significant, which means that an increase in GDP does not directly affect the improvement of air quality. It is consistent with the results of Ali and Oliveira (2018) that economic growth has a positive effect but the effect is indirect but depends on the decomposition of economic growth itself. Hettige et al. (2000) explained that economic growth does not directly determine the quality of air pollution but is determined by three main factors, namely the contribution of industry to national output, the contribution of pollution and the intensity of pollution.

The impact of forestry in all regions in Indonesia, as a whole, has a positive and significant impact on air quality, meaning that any increase in forest area will improve air quality. The forest will directly reduce air pollution in all regions in Indonesia. The results of this study are consistent with Crespo et al. (2017), Sun et al. (2016) and Bo (2011) that policies to reduce pollution are to expand land cover by expanding natural forest areas, especially in the City of Jakarta as the main contributor to air pollution in Indonesia.

The coefficient value of agricultural area in all regions in Indonesia has a negative value, which means that agricultural area has a negative effect on air quality in Indonesia. This study is consistent with previous literature such as Olsen et al. (2020), Phairuang et al. (2019) Rosales-Rueda and Triyana (2018), Onu and Ikehi (2016) Agbogidi (2011) and Chaiyo and Garivait (2014) who found a significant impact on agricultural activities, especially land use such as agro-industry and forest exploitation will increase air pollution. There are two regions in Indonesia, namely Java and Kalimantan, where statistically agricultural areas do not have a significant impact on decreasing air quality. This condition is due to the small number of agricultural areas in the two areas, which causes an indirect effect on air quality.

5. CONCLUSION

This study analyzes the effect of motorized vehicle emissions, economic growth of forest area and agricultural area using panel regression in each region in Indonesia. In accordance to Brugge (2019), Burnett et al. (2018), Health Effects Institute (2010), Lyons et al. (2003) it can conclude that motor vehicle emissions will increase air pollution. Consistent with the theory (Kuznets,
1955), economic growth in low-income areas namely Bali and Nusa Tenggara, Sulawesi, Maluku and Papua islands, has a negative effect on air quality. In contrast to high-income regions such as Sumatra, Java and Kalimantan, it has a positive effect on improving air quality in Indonesia. In particular, forest areas in all regions in Indonesia have a positive impact in improving air quality in contrast to agricultural areas which have a negative impact on air quality in all regions in Indonesia.

Empirical analysis evidence in both low-income and high-income regions of Indonesia finds that motor vehicle emissions are a determining factor for declining air quality. It needs an environmental regulations and policies related to the concentration of motor vehicle emissions (Ouyang et al., 2019; Ali and Oliveira, 2018). Government can make intervention to raise the demand for national electric vehicles and public transportation, also reduce the use of private transportation especially for vehicles that have high vehicle emission levels (Baayoun et al., 2019; Connolly et al., 2019). In addition, motor vehicle emissions and conversion of agricultural land causes air pollution to increase (Olsen et al., 2020; Phairuang et al., 2019). Air pollution can be overcome by managing agricultural land and reducing agro-industrial activities (Phairuang et al., 2019; Török et al., 2016).

It empirically proves that forest area will reduce exposure to air pollution in Indonesia (de Mello et al., 2020) thus it need forest restoration as well as forest conservation and maintaining plant diversity (Lillo et al., 2019). Economically there is an inequality of income in every region in Indonesia, therefore to create a sustainable environment it need government intervention related to inequality (Lillo et al., 2019) and reduce income inequality in the Eastern Indonesia region also creating social sustainability such as poverty alleviation (Scherer et al., 2018; O’Neill et al., 2018).

REFERENCES

Agbogidi, O. (2011), Global climate change: A threat to food security and environmental conservation. British Journal of Environment and Climate Change, 1(3), 74-89.
Ali, S.H., De Oliveira, J.A.P. (2018), Pollution and economic development: An empirical research review. Environmental Research Letters, 13(12), 13-29.
Alvarado, M.J., McVey, A.E., Hegarty, J.D., Cross, E.S., Hasenkopf, C.A., Lynch, R., Kennelly, E.J., Onasch, T.A., Awe, Y., Sanchez-Triana, E., Kleinman, G. (2019), Evaluating the use of satellite observations to supplement ground-level air quality data in selected cities in low- and middle-income countries. Atmospheric Environment, 218(1), 117016.
Andrée, B., Johannes, P., Chamorrow, A., Spencera, P., Koomenb, E., Dogo, H. (2019), Revisiting the relation between economic growth and the environment; a global assessment of deforestation, pollution and carbon emission. Renewable and Sustainable Energy Reviews, 114(1), 109221.
Antoine, D., Rivers, N., Stadler, B. (2019), ECO/WKP 54 OECD Working Papers The Economic Cost of Air Pollution: Evidence From Europe.
Baaayoun, A., Itani, W., El Helou, J., Halabi, L., Medlej, S., El Malki, M., Moukhadder, A., Aboujoue, L.K., Kabakian, V., Mokalled, T., Shihadeh, A., Lakkis, I., Saliba, N.A. (2019), Emission inventory of key sources of air pollution in lebanon. Atmospheric Environment, 215(1), 116871.
Bo, S. (2011), A literature survey on environmental Kuznets Curve. Energy Procedia, 5, 1322-1325.
Brugge, D. (2019), On the need for better exposure assessment for air pollution with high spatial and temporal variation. International Journal of Environmental Research and Public Health, 16(9), 1594.
Burnett, R., Chen, H., Szyszko, 2018; O'Neill et al., 2018).
Cheong, K.H., Ngiam, N.J., Morgan, G.G., Pek, P.P., Tan, B.Y.Q., Lai, J.W., Koh, J.M., Ong, M.E.H., Ho, A.F.W. (2019), Acute health impacts of the southeast asian transboundary haze problem a review. International Journal of Environmental Research and Public Health, 16(18), 3286.
Cohen, A.J., Brauer, M., Burnett, T., Anderson, H.R., Frostad, J., Estep, K., Balakrishnan, K., Brunekreef, B., Dandona, L., Dandona, R., Feigin, V., Freedman, G., Hubbell, B., Jobling, A., Kan, H., Knibbs, L., Liu, Y., Martin, R., Morawska, L., Pope C.A., 3rd, Shin, H., Straif, K., Shaddick, G., Thomas, M., van Dingenen, R., van Donkelaar, A., Vos, T., Murray, C.J.L., Forouzanfar, M.H. (2017), Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the global burden of diseases study 2015. The Lancet, 389(10082), 1907-1918.
Connolly, R., Pierce, G., Gattacecca, J., Zhu, Y. (2019), Estimating morality impacts from vehicle emission reduction efforts: The tune in and tune up program in the san joaquin valley. Transportation Research Part D: Transport and Environment, 2019, 1-13.
Croissant, Y., Millo, G. (2008), Panel data econometrics in R: The plm package. Journal of Statistical Software, 27(2), 1-43.
Cuaresma, J. C., Danylo, O., Fritz, S., McCallum, I., Obersteiner, M., See, L., Walsh, B. (2017). Economic development and forest cover: evidence from satellite data. Scientific reports, 7(1), 1-8.
de Mello, N.G.R., Gulinck, H., Van den Broeck, P., Parra, C. (2020), Social-ecological sustainability of non-timber forest products: A review and theoretical considerations for future research. Forest Policy Econ, 112(1), 102109.
Frodelius, K., Oudin, A., Malmqvist, E. (2018), Traffic-related air pollution and child BMI a study of prenatal exposure to nitrogen oxides and body mass index in children at the age of four years in Malmö, Sweden. International Journal of Environmental Research and Public Health, 15(10), 2294.
Gerdes, C. (2011), Using shares’ vs. log of shares in fixed-effect estimations. Journal of Economics and Econometrics, 54(1), 1-6.
Greene, W.H. (2012), Econometric Analysis. 7th ed. New York: Prentice Hall.
Greenstone, M., Fan, Q. (2019), Indonesia’s Worsening Air Quality and its Impact on Life Expectancy. p1-10.
Griffin, J.M., Schiffel, D.D. (1972), Compatibles: Economic growth and environmental quality. Battelle Res Outlook, 4(2), 12-15.
Grossman, G.M., Krueger, A.B. (1991), Environmental Impacts of a North American Free Trade Agreement. Cambridge MA: National Bureau of Economic Research Working Paper 3914, NBER, p1-57.
Guila, S., Khanna, I., Shukla, K., Khare, M. (2020), Ambient air pollutant monitoring and analysis protocol for low and middle income countries: An element of comprehensive urban air quality management framework. Atmospheric Environment, 222, 117120.
Health Effects Institute, and the Institute for Health Metrics and Evaluation’s Global Burden of Disease Project. (2019), A Special
Report on Global Exposure to Air Pollution and its Disease Burden
what is the State of Global Air? Who is it for? How can i Explore
the Data? Boston, MA: Health Effects Institute.
HEI. (2010), Traffic-Related Air Pollution: A Critical Review of the
Literature on Emissions, Exposure, and Health Effects. Boston, MA:
Health Effects Institute.
Hettige, H., Mani, M., Wheeler, D. (2000), Industrial pollution in
economic development: The environmental Kuznets Curve revisited.
Journal of Development Economics, 62(2), 445-476.
Krzyzanowski, M., Kuna-Dibbert, B., Schneider, J. (2005), Health Effects
of Transport-Related Air Pollution. WHO Library Cataloguing
in Publication Data. Geneva: World Health Organization
Kuznets, S. (1955), Economic growth and income inequality simon. The
American Review, 45(1), 1-28.
Lillo, E.P., Fernando, E.S., Lillo, M.J.R. (2019), Plant diversity and
structure of forest habitat types on dinagat Island, Philippines. Journal
of Asia-Pacific Biodiversity, 12(1), 83-105.
Lyons, T.J., Kenworthy, J.R., Moy, C., dos Santos, F. (2003), An
international urban air pollution model for the transportation sector.
Transportation Research Part D: Transport and Environment, 8(3),
159-167.
Martinez, G.S., Spadaro, J.V., Chapizanis, D., Kendrovski, V.,
Kochubovski, M., Mudu, P. (2018), Health impacts and economic
costs of air pollution in the metropolitan area of skopje. International
Journal of Environmental Research and Public Health, 15(4), 1-11.
Meadows, D.H., Meadows, D.L., Randers, J., Behrens, W. (1972), The
Limit of Growth. New York: Universe Book.
Ministry of Environment and Forestry.2018. Quality Index Indonesian
Environment.Available from: https://www.menlhk [1]. go.id/site/
single post/2516.
Nowak, D.J., Civerolo, K.L., Rao, S.T., Sistla, G., Luley, C.J., Crane, D.E.
(2000), A modeling study of the impact of urban trees on ozone david.
Atmospheric Environment, 34, 1601-1613.
Nowak, D.J., Hirabayashi, S., Bodine, A., Greenfield, E. (2014), Tree and
forest effects on air quality and human health in the United States.
Environmental Pollution, 193, 119-129.
O’Neill, D.W., Fanning, A.L., Lamb, W.F., Steinberger, J.K. (2018), A
good life for all within planetary boundaries. Nature Sustainability,
1(2), 88-95.
Olsen, Y., Najgaard, J.K., Olesen, H.R., Brandt, J., Sigsgaard, T.,
Pryor, S.C., Ancelot, T., del MarViana, M., Querol, X., Hertel, Q.
(2020), Emissions and source allocation of carbonaceous air
pollutants from wood stoves in developed countries: A review.
Atmospheric Pollution Research, 11(2), 234-251.
Onu, F.M., Ikehi, M. (2016), Mitigation and adaptation strategies to
the effects of climate change on the environment and agriculture in
Nigeria. Journal of Agriculture and Veterinary Science, 9(4),
2319-2372.
Ouyang, X., Shao, Q., Zhu, X., He, Q., Xiang, C., Wei, G. (2019),
Environmental regulation, economic growth and air pollution:
Panel threshold analysis for OECD countries. Science of the Total
Environment, 657, 234-241.
Panayotou, T. (1994), Empirical tests and policy analysis of environmental
degradation at different stages of economic development. Pacific and
Asian Journal of Energy, 4, 23-42.
Phairuang, W., Suwattiga, P., Chetiyakanokkul, T., Hongtieab, S.,
Limpaseni, W., Iekomori, F., Hata, M., Furuuchi, M. (2019), The
influence of the open burning of agricultural biomass and forest fires
in thailand on the carbonaceous components in size-fractionated
particles. Environmental Pollution, 247, 238-247.
Pinder, R.W., Klopp, J.M., Kleiman, G., Hagler, G.S.W., Aye, Y., Terry, S.
(2019), Opportunities and challenges for filling the air quality data
gap in low- and middle-income countries. Atmospheric , 215(1),
116794.
Puett, R., Teas, J., España-Romero, V., Artego, E.G., Lee, D.C., Baruth,
Sui, X., Montresor-López, J., Blair, S.N. (2014), Physical activity: Does
environment make a difference for tension, stress, emotional
outlook, and perceptions of health status? Journal of Physical Activity
and Health, 11(8), 1503-1511.
Rosales-Rueda, M., Triyana, M. (2018), The persistent effects of early-life
exposure to air pollution: Evidence from the Indonesian forest fires.
Journal of Human Resources, 2018, 0117-8497TR1.
Samet, J.M., Francesca, D., Curreiro, F.C., Ivan, C., Scott, L.Z. (2000),
Fine particulate air pollution and mortality in 20 U.S. cities, 1987-
1994. The New England Journal of Medicine, 343(24), 1742-1749.
Scherer, L., Behrens, P., de Koning, A., Heijungs, R., F ANDERSEN, S.,
Tukker, A. (2018), Trade-offs between social and environmental
sustainable development goals. Environmental Science and Policy,
90(1), 65-72.
Sun, L., Wei, J., Duan, D.H., Guo, Y.M., Yang, D.X., Jia, C., Mi, X.T.
(2016), Impact of land-use and land-cover change on urban air quality
in representative cities of China. Journal of Atmospheric and Solar-
Terrestrial Physics, 142, 43-54.
Sun, Z., Zhu, D. (2019), Exposure to outdoor air pollution and its human
health outcomes: A scoping review. PLoS One, 14(5), 1-18.
Török, P., Hözel, N., van Diggelen, R., Tischew, S. (2016), Grazing
in European open landscapes: How to reconcile sustainable land
management and biodiversity conservation? Agriculture, Ecosystems
and Environment, 234, 1-4.
Vadrevu, K., Ohara, T., Justice, C. (2017), Land cover, land use changes
and air pollution in asia: A synthesis. Environmental Research
Letters, 12(12), 120201.
Venn, A., Lewis, S., Cooper, M., Hubbard, R., Hill, I., Boddy, R.,
Bell, M., Britton, J. (2000), Local road traffic activity and the
prevalence, severity, and persistence of wheeze in school children:
Combined cross sectional and longitudinal study. Occupational and
Environmental Medicine, 57(3), 152-158.
Wang, Q., Wang, J., Zhou, J., Ban, J., Li, T. (2019), Estimation of PM 2·5
associated disease burden in China in 2020 and 2030 using population
and air quality scenarios: A modelling study. The Lancet Planetary
Health, 3(2), e71-e80.
Xian, G. (2007), Analysis of impacts of urban land use and land cover on
air quality in the las vegas region using remote sensing information
and ground observations. International Journal of Remote Sensing,
28(24), 5427-5445.
Zheng, H., Huai, W., Huang, L. (2015), Relationship between pollution
and economic growth in China: Empirical evidence from 111 cities.
Journal of Urban and Environmental Engineering, 9(1), 22-31.