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Forest Fire Area, Industrial GRDP, Population Density, and Environmental Quality in Indonesia

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Abstract

Purpose— This study examines how forest fire area, industrial-sector gross regional domestic product (GRDP), and population density are associated with Indonesia's Environmental Quality Index (Indeks Kualitas Lingkungan Hidup, IKLH) at the provincial level.

Research Methodology— A quantitative panel-data design uses 150 province-year observations from 30 Indonesian provinces during 2020–2024. Common-, fixed-, and random-effects specifications are considered, with the Chow and Hausman tests supporting a fixed-effects model.

Results— Forest fire area is not statistically associated with IKLH in the selected model, whereas industrial GRDP and population density show positive conditional associations. The full fixed-effects specification is statistically significant, but its overall model test includes province effects and therefore does not isolate the joint contribution of the three substantive regressors.

Research limitations/Implications— The analysis covers three predictors, 30 provinces, and five years; omitted time effects, spatial dependence, and robust inference limit generalization. The findings support continued fire prevention, cleaner industrial development, and environmental infrastructure in densely populated areas.

Originality— The study integrates ecological, industrial, and demographic pressures within one provincial panel framework while controlling for time-invariant provincial heterogeneity.

Keywords: Environmental Quality Index; Forest Fire Area; Industrial GRDP; Population Density; Panel Data.

Paper type: Research Paper

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1. Introduction

Economic development can improve social welfare while simultaneously intensifying pressure on environmental systems. Expanding production, industrial areas, land-use change, and population growth increase demand for natural resources and environmental carrying capacity. These processes can contribute to air pollution, declining water quality, land degradation, and reduced ecological functions. The central challenge is therefore not economic expansion alone, but whether development can proceed while maintaining environmental quality over time.

Indonesia provides an important setting for this issue because environmental pressures differ substantially across provinces. Forest and land fires, industrial expansion, and population concentration represent distinct ecological, economic, and demographic pressures that can be examined jointly. Indonesia's Environmental Quality Index (IKLH) summarizes environmental conditions across regions and over time. Prior Indonesian studies show that IKLH and related environmental-quality measures are associated with economic and demographic conditions, although the direction and strength of these



relationships vary across specifications and periods (Aldilla *et al.*, 2024; Ginting *et al.*, 2023; Kusumadewi & Kristanto, 2025; Sihombing *et al.*, 2025; Wafiq & Suryanto, 2021).

The ecological pathway is particularly relevant because forest and peatland fires can alter land cover, disturb ecosystem functioning, and deteriorate air quality. Indonesian fire episodes have been associated with substantial particulate and atmospheric pollution (Siregar *et al.*, 2022; Yin *et al.*, 2020), while regional panel evidence links forest fires to poorer air quality (Rahman *et al.*, 2024). Recent work also documents spatial vulnerability to forest and land fires in Indonesia and the broader ecosystem consequences of fire disturbance (Afrizal *et al.*, 2025; Arshad *et al.*, 2022). Because IKLH is a composite environmental index rather than a single air-quality measure, however, the association between fire area and overall environmental quality may be weaker or less immediate than effects observed for specific environmental components.

Industrial activity may affect environmental quality through energy use, emissions, resource extraction, and waste generation. Environmental Kuznets Curve (EKC) reasoning implies that the development-environment relationship may change as income, technology, production structure, and regulation evolve (Grossman & Krueger, 1995). Indonesian evidence remains mixed across indicators and model specifications (Aldilla *et al.*, 2024; Elfaki & Heriqbaldi, 2023; Ginting *et al.*, 2023; Rahman & Kurniawati, 2025). Sectoral economic activity has also been linked to air-quality outcomes in Indonesia, reinforcing the need to distinguish economic scale from the environmental conditions under which production occurs (Sasmita *et al.*, 2023).

Population density introduces another form of pressure through land demand, mobility, energy and water consumption, infrastructure use, and waste generation. IPAT reasoning emphasizes that environmental impact reflects the interaction of population, affluence, and technology rather than population alone (Ehrlich & Holdren, 1971), and broader evidence similarly identifies population and affluence as important drivers of environmental stress (Rosa & Dietz, 2012). Indonesian studies suggest that the population-environment relationship is sensitive to economic structure, technology, governance, and environmental management (Aldilla *et al.*, 2024; Ginting *et al.*, 2023; Navila & Cerya, 2025; Wafiq & Suryanto, 2021).

Across 2020–2024, environmental conditions and the three explanatory pressures vary across provinces rather than moving in a uniform pattern. This heterogeneity creates an empirical need to evaluate forest fire area, industrial-sector GRDP, and population density within the same provincial panel specification while accounting for persistent differences among provinces.

The research gap is therefore twofold. First, prior findings concerning the determinants of Indonesian environmental quality are not fully consistent across studies. Second, ecological pressure from forest fires, industrial activity, and population density are commonly examined using different combinations of variables and environmental indicators, limiting evidence on their joint role within a common provincial IKLH framework. This study addresses that gap by estimating a panel model for 30 provinces over 2020–2024 and using province fixed effects to control for time-invariant provincial heterogeneity.

The study asks: how are forest fire area, industrial-sector GRDP, and population density associated with IKLH across the analyzed Indonesian provinces during 2020–2024, individually and within the same fixed-effects specification? Its objective is to estimate these relationships and interpret them in relation to sustainable development, ecological disturbance, industrial development, and demographic pressure. The contribution lies in integrating ecological, industrial, and demographic determinants within one provincial panel framework. The remainder of the article reviews the theoretical and empirical literature, explains the research methodology, presents and discusses the results, and concludes with implications, limitations, and directions for future research.

2. Review of Literature

2.1 Environmental Quality Index

The Environmental Quality Index (IKLH) is used in Indonesia as a composite indicator of environmental conditions. In this study, IKLH is the dependent variable representing overall environmental quality across provinces. Prior empirical work associates variation in IKLH with economic conditions, demographic pressure, institutional factors, and other environmental stressors (Aldilla *et al.*, 2024; Fatmawati *et al.*, 2025; Kusumadewi & Kristanto, 2025; Sihombing *et al.*, 2025; Yani *et al.*, 2023).

The broader conceptual foundation is sustainable development, which emphasizes balancing economic development, social welfare, and environmental preservation (World Commission on Environment and Development, 1987). Within this study, forest fire area, industrial GRDP, and population density represent ecological, economic, and demographic pressures that may be associated with provincial environmental quality.

2.2 Forest Fire Area and Environmental Quality

Forest fire area captures the extent of forest and land affected by fire during a given period. Fires can remove vegetation cover, disturb habitats, alter soil and water processes, release carbon, and increase particulate and gaseous pollutants. Indonesian evidence demonstrates that severe forest and peatland fires can substantially degrade air quality (Siregar *et al.*, 2022; Yin *et al.*, 2020), while regional panel evidence links forest fires to poorer air quality (Rahman *et al.*, 2024). Spatial fire-vulnerability research and broader ecosystem reviews further document the ecological significance of forest and land fire disturbance (Afrizal *et al.*, 2025; Arshad *et al.*, 2022).

The expected relationship can be interpreted through land-use and land-cover change reasoning and disturbance ecology. Disturbance ecology emphasizes that ecological disturbances can alter ecosystem structure and functioning, particularly when disturbance intensity exceeds recovery capacity (Pickett & White, 1985). Because fire can damage both land and atmospheric conditions, a larger burned area is expected to be associated with lower overall environmental quality, although the magnitude may depend on ecosystem resilience, regional characteristics, and environmental management.

H1. Forest fire area is negatively associated with the Environmental Quality Index in Indonesia.

2.3 Industrial GRDP and Environmental Quality

Industrial-sector GRDP represents the value added generated by manufacturing and related industrial activity in a province. A larger industrial sector can increase resource use, energy demand, emissions, and waste, but its environmental consequences depend on production technology, regulation, energy efficiency, and industrial structure. International evidence shows that industrial pollution can impose substantial environmental and public-health costs (Rahman *et al.*, 2021), while Indonesian evidence links sectoral economic activity to air-quality outcomes (Sasmita *et al.*, 2023).

The Environmental Kuznets Curve framework proposes that the relationship between economic development and environmental pressure can change across development stages as technology, regulation, and structural transformation evolve (Grossman & Krueger, 1995). Industrial ecology similarly emphasizes resource efficiency, waste minimization, and material reuse as mechanisms for reducing industrial environmental pressure (Frosch & Gallopoulos, 1989). Indonesian research provides mixed evidence on the direction of the development-environment relationship and the validity of EKC-type patterns (Elfaki & Heriqbaldi, 2023; Fatmawati *et al.*, 2025; Ginting *et al.*, 2023; Nurcahyo *et al.*, 2025; Rahman & Kurniawati, 2025). Accordingly, the study tests a negative association between industrial-sector GRDP and IKLH.

H2. Industrial-sector GRDP is negatively associated with the Environmental Quality Index in Indonesia.

2.4 Population Density and Environmental Quality

Population density indicates the number of residents occupying a unit of land area and is commonly used as a measure of demographic pressure. Higher density can increase demand for land, water, energy, housing, transport, and waste-management capacity. The IPAT framework argues that environmental impact emerges from interactions among population, affluence, and technology (Ehrlich & Holdren, 1971); related evidence also shows that population and affluence contribute to environmental stress while institutional and technological conditions shape outcomes (Rosa & Dietz, 2012). Carrying-capacity reasoning likewise emphasizes that environmental systems have limits in providing resources and absorbing waste (Odum, 1971).

Empirical evidence does not imply that density is uniformly harmful in every context. Indonesian studies report relationships between population density and environmental quality whose direction and magnitude depend on economic structure, environmental management, and other regional characteristics (Aldilla *et al.*, 2024; Ginting *et al.*, 2023; Navila & Cerya, 2025; Wafiq & Suryanto, 2021; Yani *et al.*, 2023). The study therefore tests the pressure-based expectation that higher density is associated with lower IKLH in the absence of offsetting institutional, technological, and infrastructure conditions.

H3. Population density is negatively associated with the Environmental Quality Index in Indonesia.

2.5 Joint Association of Ecological, Industrial, and Demographic Pressures

Forest fire area, industrial GRDP, and population density represent different channels through which provincial environmental quality may vary. Fires capture ecological disturbance, industrial GRDP captures the scale of industrial economic activity, and population density captures demographic pressure. Their joint inclusion provides a more integrated specification than evaluating any single pressure in isolation.

From a sustainable-development perspective, environmental quality depends on how economic and demographic activity is managed relative to ecological limits. Accordingly, the study examines whether the substantive explanatory variables are jointly relevant within the selected panel framework, while recognizing that the reported full-model F statistic also incorporates the province fixed effects.

H4. Forest fire area, industrial-sector GRDP, and population density are jointly associated with the Environmental Quality Index in Indonesia.

3. Research Methodology

3.1 Research Design, Unit of Analysis, and Data Source

This study uses a quantitative panel-data design covering 30 Indonesian provinces over the 2020–2024 period, producing 150 province-year observations. The unit of analysis is the province-year. The dataset is based on secondary data obtained from Statistics Indonesia (Badan Pusat Statistik/BPS), the Ministry of Environment and Forestry, and other official sources used in the underlying study dataset.

The dependent variable is the Environmental Quality Index (IKLH). The explanatory variables are forest fire area (LKH), industrial-sector gross regional domestic product (PDRBSI), and population density (KP). The panel structure allows the selected fixed-effects specification to account for persistent time-invariant differences across provinces.

3.2 Model Specification

The panel regression model is specified as follows:

$$IKLHit = \alpha + \beta_1 LKH_{it} + \beta_2 PDRBSI_{it} + \beta_3 KP_{it} + \varepsilon_{it} \quad (1)$$

Where IKLH denotes the Environmental Quality Index; LKH is forest fire area; PDRBSI is industrial-sector GRDP; KP is population density; α is the intercept; β_1 – β_3

3 are regression coefficients; ε is the error term; i denotes province; and t denotes the 2020–2024 observation period.

3.3 Analytical Procedure

The analysis considers the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). The Chow test is used to compare CEM and FEM, and the Hausman test is used to compare FEM and REM. Both reported tests support the use of a cross-section fixed-effects specification.

Multicollinearity is screened using correlations among the explanatory variables, with the highest reported pairwise correlation equal to 0.8514. Heteroskedasticity is assessed using the reported auxiliary regression probabilities, all of which exceed 0.05. Individual associations are evaluated using coefficient t -tests, while the reported model F -test assesses the statistical significance of the full fixed-effects specification. Model explanatory power is summarized using R -squared and adjusted R -squared. All reported estimates were produced in EViews 10.

4. Results and Discussion

4.1 Research Result

The panel-model selection tests indicate that the fixed-effects specification is preferred. The Chow test rejects the common-effects specification, and the Hausman test rejects the random-effects specification in favor of fixed effects.

Table 1. Results of the Chow Test

Effect test	Statistic	d.f.	Probability
Cross-section F	18.914368	(29, 117)	0.0000
Cross-section Chi-square	260.758460	29	0.0000

Source: Study output based on the analyzed dataset and reported EViews 10 estimates.

The cross-section Chi-square probability is below 0.05, supporting the fixed-effects specification over the common-effects specification.

Table 2. Results of the Hausman Test

Test summary	Chi-square statistic	d.f.	Probability
Cross-section random	32.167000	3	0.0000

Source: Study output based on the analyzed dataset and reported EViews 10 estimates.

The Hausman probability is below 0.05, supporting the fixed-effects specification over the random-effects specification. The subsequent regression analysis therefore uses cross-section fixed effects.

Table 3. Correlation Matrix for the Explanatory Variables

Variable	LKH (X1)	PDRBSI (X2)	KP (X3)
LKH (X1)	1	-0.082408	-0.050387
PDRBSI (X2)	-0.082408	1	0.851446
KP (X3)	-0.050387	0.851446	1

Source: Study output based on the analyzed dataset and reported EViews 10 estimates.

The highest pairwise correlation is 0.851446 between industrial GRDP and population density. This value remains below the 0.90 screening threshold used in the study, so the correlation matrix does not breach that criterion; nevertheless, the relatively strong association warrants caution when interpreting the two coefficients independently.

Table 4. Heteroskedasticity Test

Variable	Coefficient	Std. error	t-statistic	Probability
C	292.7044	314.6470	0.930263	0.3542
LKH (X1)	-0.000206	0.000312	-0.660839	0.5100
PDRBSI (X2)	0.000413	0.000836	0.494805	0.6217
KP (X3)	-0.968220	1.485621	-0.651728	0.5159

Source: Study output based on the analyzed dataset and reported EViews 10 estimates.

All reported probabilities for the explanatory variables exceed 0.05. Under the diagnostic criterion used in the study, the reported auxiliary regression does not indicate heteroskedasticity. X3 is consistently identified as population density.

Table 5. Fixed-Effects Regression Results

Variable	Coefficient	Std. error	t-statistic	Probability
C	4805.506	558.9678	8.597106	0.0000
LKH (X1)	0.000351	0.000554	0.634384	0.5271
PDRBSI (X2)	0.006920	0.001484	4.661441	0.0000
KP (X3)	11.49392	2.639193	4.355088	0.0000

Note: Cross-section fixed effects. $R^2 = 0.902457$; adjusted $R^2 = 0.875778$; S.E. of regression = 154.2609; F-statistic = 33.82712; Prob(F-statistic) = 0.000000; Durbin-Watson statistic = 1.470953. Source: Study output based on the analyzed dataset and reported EViews 10 estimates.

The estimated equation is $IKLH = 4805.506 + 0.000351 LKH + 0.006920 PDRBSI + 11.49392 KP$. Forest fire area has a positive coefficient but is not statistically significant, so H1 is not supported. Industrial GRDP and population density have positive and statistically significant coefficients, so H2 and H3 are not supported in their predicted negative directions. These coefficients represent conditional within-model associations and do not establish that industrialization or greater density inherently improves environmental quality.

The full fixed-effects specification is statistically significant and has substantial adjusted explanatory power. Because the reported model F-test applies to the full specification, including province fixed effects, it cannot be interpreted as a separate joint significance test of only LKH, PDRBSI, and KP. Accordingly, H4 cannot be directly confirmed from the reported output without a distinct joint restriction test for the three substantive regressors.

4.2 Discussion

4.2.1 Forest Fire Area and Environmental Quality

Forest fire area is positive in sign but statistically non-significant in the selected fixed-effects model, which does not support H1. The absence of statistical significance should not be interpreted as evidence that forest fires are environmentally benign. Rather, within this provincial panel specification and study period, variation in burned area is not independently associated with statistically detectable changes in the composite IKLH after accounting for the other regressors and province fixed effects.

This interpretation is compatible with the composite nature of IKLH. Fire events can strongly affect air quality, land cover, and ecosystem functioning, while the overall index also reflects other environmental dimensions. Indonesian studies document marked atmospheric effects of forest and peatland fires (Siregar *et al.*, 2022; Yin *et al.*, 2020) and broader regional evidence links forest fires to poorer air quality (Rahman *et al.*, 2024). The present result therefore suggests that the relationship between fire area and aggregate IKLH may depend on index composition, temporal timing, local ecological resilience, and environmental management.

4.2.2 Industrial GRDP and Environmental Quality

Industrial GRDP is positively and statistically associated with IKLH in the selected model, contrary to H2. This relationship should be interpreted conditionally rather than causally: the analysis does not establish that industrial expansion itself improves environmental quality.

The finding is consistent with the broader EKC proposition that the relationship between economic activity and environmental pressure can change with technology, regulation, and structural transformation (Grossman & Krueger, 1995). Indonesian studies likewise show that the sign and significance of development variables vary across environmental indicators and model designs (Elfaki & Heriqbaldi, 2023; Fatmawati *et al.*, 2025; Ginting *et al.*, 2023; Nurcahyo *et al.*, 2025; Rahman & Kurniawati, 2025). A plausible explanation is that industrial expansion may coincide with cleaner technologies, more efficient production, stronger waste management, or tighter environmental regulation, but these mechanisms are not measured in the present model and therefore remain explanatory possibilities rather than established mediators.

4.2.3 Population Density and Environmental Quality

Population density is positively and statistically associated with IKLH in the selected model, which does not support H3. Conditional on the other model components and time-invariant provincial characteristics, the result indicates that higher density is associated with higher measured environmental quality during the study period.

This pattern reinforces the IPAT insight that population pressure cannot be interpreted independently of affluence and technology (Ehrlich & Holdren, 1971) and is compatible with evidence that demographic effects are shaped by broader socioeconomic and institutional conditions (Rosa & Dietz, 2012). Indonesian studies similarly show that the population-environment relationship depends on development conditions and regional management (Ginting *et al.*, 2023; Navila & Cerya, 2025; Wafiq & Suryanto, 2021; Yani *et al.*, 2023). Densely populated provinces may also have more concentrated environmental infrastructure or regulatory responses; because these mechanisms are not measured here, the result should not be generalized into a claim that greater density inherently improves environmental quality.

4.2.4 Joint Interpretation of the Fixed-Effects Model

The selected fixed-effects specification is statistically significant overall and has high explanatory power, but those model-level statistics incorporate province fixed effects as well as the three substantive regressors. Because the reported output does not provide a separate joint restriction test for LKH, PDRBSI, and KP, H4 remains unconfirmed rather than supported by the overall model F-test alone.

Taken together, the results show that the hypothesized pressures do not operate in a uniform direction. Forest fire area is not statistically significant, while industrial GRDP and population density are positively associated with IKLH. The pattern underscores the importance of provincial heterogeneity and supports a contextual interpretation of environmental quality. Practical implications include maintaining forest-fire prevention and ecosystem rehabilitation while encouraging cleaner industrial development, emission and waste control, and environmental infrastructure capable of serving densely populated areas.

5. Conclusion

This study examines the association of forest fire area, industrial-sector GRDP, and population density with Indonesia's Environmental Quality Index using panel data for 30 provinces over 2020–2024. Model-selection tests support a cross-section fixed-effects specification. Within that model, forest fire area is not statistically associated with IKLH, whereas industrial GRDP and population density show positive conditional associations. These results do not support the three hypotheses that predicted negative individual relationships. The reported overall model test confirms significance of the full fixed-effects

specification but does not separately establish the joint significance of only the three substantive regressors.

The study contributes by integrating ecological, industrial, and demographic pressures within one provincial panel framework and by showing that their observed associations with environmental quality are context dependent once time-invariant provincial heterogeneity is controlled. The findings support a non-deterministic reading of sustainable-development, EKC, IPAT, and carrying-capacity arguments: similar pressures can be associated with different environmental outcomes depending on technology, infrastructure, governance, and other regional conditions that are not fully observed in the model.

For practice and policy, the results support continued forest-fire prevention and land rehabilitation while emphasizing cleaner industrial development, emission and waste management, and environmental infrastructure in densely populated provinces. The positive industrial and population coefficients should not be interpreted as evidence that pollution pressure or density is environmentally beneficial; they indicate conditional associations within the observed model and period.

The study is limited to three substantive explanatory variables, 30 provinces, and the 2020–2024 period, so the findings do not represent complete coverage of all Indonesian provinces. Potentially relevant factors such as carbon emissions, energy structure, waste management, land-use change, environmental expenditure, environmental policy, and climate conditions are not included. The reported model also does not incorporate time effects, spatial dependence, or robust standard-error corrections. Future research should extend the observation period, document province inclusion criteria explicitly, add theoretically relevant controls, test time and spatial effects, and assess alternative robust inference procedures.

REFERENCES

- Afrizal, D., Putra, R. M., & Syafii, M. (2025). Analisis spasial tingkat kerawanan kebakaran hutan dan lahan di Kabupaten Indragiri Hulu. *Daun: Jurnal Ilmiah Pertanian dan Kehutanan*, 12(1), 77–87. <https://doi.org/10.33084/daun.v12i1.9750>
- Aldilla, R., Restiatun, R., & Afrizal, A. (2024). Faktor-faktor yang mempengaruhi indeks kualitas lingkungan hidup (IKLH) di Indonesia. *Jurnal Ilmu Lingkungan*, 22(6), 1494–1503. <https://doi.org/10.14710/jil.22.6.1494-1503>
- Arshad, A., Azhar Ali, A., & Anjali, K. S. (2022). Impact of forest fire on forest ecosystem. *Journal of Agriculture and Technology*, 9(1–2), 18–29.
- Ehrlich, P. R., & Holdren, J. P. (1971). Impact of population growth. *Science*, 171(3977), 1212–1217. <https://doi.org/10.1126/science.171.3977.1212>
- Elfaki, K. E., & Heriqbaldi, U. (2023). Analyzing the moderating role of industrialization on the Environmental Kuznets Curve (EKC) in Indonesia: What are the contributions of financial development, energy consumption, and economic growth?. *Sustainability*, 15(5), 4270. <https://doi.org/10.3390/su15054270>
- Fatmawati, A., Yuliawan, D., Emalia, Z., & MK, I. F. (2025). Analisis faktor-faktor yang mempengaruhi kualitas lingkungan Indonesia. *E-Journal Bidang Ekonomi, Bisnis dan Kewirausahaan (EFEBE)*, 3(3), 478–488. <https://doi.org/10.23960/efebe.v3i3.269>
- Frosch, R. A., & Gallopoulos, N. E. (1989). Strategies for manufacturing. *Scientific American*, 261(3), 144–152. <https://doi.org/10.1038/scientificamerican0989-144>
- Ginting, R. F., Prajanti, S. D. W., & Setyadharma, A. (2023). Determinan Indeks Kualitas Lingkungan Hidup dengan pengujian Environmental Kuznet Curve. *Business and Economic Analysis Journal*, 3(1), 16–24. <https://doi.org/10.15294/beaj.v3i1.41646>
- Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, 110(2), 353–377. <https://doi.org/10.2307/2118443>

- Kusumadewi, D. A., & Kristanto, B. Y. (2025). Analysis of factors affecting the Environmental Quality Index (EQI) and its implications for sustainable development. *Journal of Sustainability, Society, and Eco-Welfare*, 2(2), 124–140. <https://doi.org/10.61511/jssew.v2i2.2025.1452>
- Navila, Y., & Cerya, E. (2025). Pengaruh pertumbuhan ekonomi, kepadatan penduduk dan kemiskinan terhadap kualitas lingkungan hidup di Indonesia. *Jurnal Ilmiah Pendidikan Lingkungan dan Pembangunan*, 26(1), 15–26. <https://doi.org/10.21009/plpb.v26i01.59043>
- Nurcahyo, Y. B., Fatin, S., & Reza, M. F. (2025). Investigating the theory of environmental Kuznets curve on environmental quality index in Indonesia. *Optimum: Jurnal Ekonomi dan Pembangunan*, 15(1), 111–118. <https://doi.org/10.12928/optimum.v15i1.8752>
- Odum, E. P. (1971). *Fundamentals of ecology* (3rd ed.). W. B. Saunders.
- Pickett, S. T. A., & White, P. S. (Eds.). (1985). *The ecology of natural disturbance and patch dynamics*. Academic Press.
- Rahman, B. K., & Kurniawati, T. (2025). Pengaruh PDRB per sektor terhadap kualitas lingkungan hidup di Indonesia. *Jurnal Pendidikan Tambusai*, 9(3), 32573–32582. <https://doi.org/10.31004/jptam.v9i3.32655>
- Rahman, M. M., Alam, K., & Velayutham, E. (2021). Is industrial pollution detrimental to public health? Evidence from the world's most industrialised countries. *BMC Public Health*, 21, 1175. <https://doi.org/10.1186/s12889-021-11217-6>
- Rahman, R. A., White, B., & Ma, C. (2024). The effect of growth, deforestation, forest fires, and volcanoes on Indonesian regional air quality. *Journal of Cleaner Production*, 457, 142311. <https://doi.org/10.1016/j.jclepro.2024.142311>
- Rosa, E. A., & Dietz, T. (2012). Human drivers of national greenhouse-gas emissions. *Nature Climate Change*, 2, 581–586. <https://doi.org/10.1038/nclimate1506>
- Sasmita, P. Y., Yani, A., & Restiatun, R. (2023). The effects of air quality on economic activity in Indonesia. *Journal of Environmental Science Studies*, 6(1), 12. <https://doi.org/10.20849/jess.v6i1.1348>
- Sihombing, P. R., Erfiani, E., Notodiputro, K. A., & Kurnia, A. (2025). Determinants of Environmental Quality Index (EQI) in Indonesia in 2018–2022. *KEUNIS*, 13(2), 236–245. <https://doi.org/10.32497/keunis.v13i2.6559>
- Siregar, S., Idiawati, N., Lestari, P., Berekute, A. K., Pan, W.-C., & Yu, K.-P. (2022). Chemical composition, source appointment and health risk of PM2.5 and PM2.5–10 during forest and peatland fires in Riau, Indonesia. *Aerosol and Air Quality Research*, 22, 220015. <https://doi.org/10.4209/aaqr.220015>
- Wafiq, A. N., & Suryanto, S. (2021). The impact of population density and economic growth on environmental quality: Study in Indonesia. *Jurnal Ekonomi & Studi Pembangunan*, 22(2), 301–312. <https://doi.org/10.18196/jesp.v22i2.10533>
- World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.
- Yani, A., Restiatun, R., & Nuratika, N. (2023). Indeks kualitas lingkungan hidup dan determinannya: Studi kasus di Indonesia. *Jurnal Ekonomi Pembangunan*, 12(3), 178–186. <https://doi.org/10.23960/jep.v12i3.2132>
- Yin, S., Wang, X., Guo, M., Santoso, H., & Guan, H. (2020). The abnormal change of air quality and air pollutants induced by the forest fire in Sumatra and Borneo in 2015. *Atmospheric Research*, 243, 105027. <https://doi.org/10.1016/j.atmosres.2020.105027>

CONFLICTS OF INTEREST

The author declares no conflict of interest.

DECLARATION OF GENERATIVE AI STATEMENT

During the preparation of this work, the author used generative artificial intelligence tools to support the scientific writing process. All interpretations, analyses, and conclusions presented in this study are the sole responsibility of the author.

AUTHOR'S CONTRIBUTION

FN: corresponding author, conceptualization, methodology, validation, formal analysis, investigation, data curation, visualization, manuscript writing and revision. **FF:** conceptualization, methodology, validation, review, editing, and guidance.