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MORALITY BEFORE KNOWLEDGE

Analysis of factors affecting the Environmental Quality Index (EQI) and its implications for sustainable development

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ABSTRACT

Background: The Environmental Quality Index (EQI) reflects environmental performance and sustainability, with DKI Jakarta scoring 54.57—below its target. This study analyzes the influence of the Human Development Index (HDI), population growth, and the Information, Communication, and Technology Development Index (IDI) on DKI Jakarta's EQI. **Methods:** A quantitative approach using time-series data (2008–2023) and multiple linear regression analysis was applied to evaluate the relationship between HDI, population growth, and IDI with environmental quality. **Findings:** HDI positively impacts environmental quality, contributing 5.776%. In contrast, a 1% increase in IDI and population growth correlates with a 2.183% and 173.456% decline in EQI, respectively, highlighting the environmental challenges of urbanization and technological expansion. **Conclusion:** Improving human resources, adopting green technologies, and fostering collaboration among stakeholders are critical to enhancing environmental quality. **Novelty/Originality of this article:** This study provides new insights into the interplay of HDI, IDI, and population growth in influencing environmental quality in a major urban area.

KEYWORDS: environmental performance index, human development index, multiple linear regression, population growth.

1. Introduction

Environmental conservation has become a critical issue in recent decades. The degradation of environmental quality has posed significant challenges for many countries, necessitating special attention from government and society. Continuous economic development to meet human needs has the potential to create environmental issues. Conventional economic development practices often involve the exploitation of natural resources and the environment. Exploitation beyond environmental thresholds can have long-term detrimental effects. A major challenge in economic development is the trade-off between economic growth and environmental protection. Economic development is often perceived to be in conflict with environmental conservation efforts (Ghifary et al., 2022).

Environmental degradation has prompted the adoption of a sustainable development paradigm. Sustainable development is measured through dimensions that are latent variables, which cannot be directly measured but can be observed through representative

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indicators. The concept of sustainable development originated from the Brundtland Commission's report, "Our Common Future," which states that sustainable development aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development is defined as a multifaceted concept encompassing economic, social, and environmental aspects (Setianingtias et al., 2019). This paradigm has been integrated into the development goals of both developed and developing countries. The reducing in environmental quality and the push for sustainable development have led to the creation of numerical and quantitative methods for measuring a country's environmental performance, known as the Environmental Performance Index (EPI) that's developed by Yale University. The EPI methodology continues to evolve, highlighting emerging environmental issues. The EPI also identifies trends and dominant sectors within a country. It employs 40 performance indicators related to national efforts to protect environmental health, preserve ecosystems, and mitigate climate change. EPI has a different condition in every country. The 2022 Environmental Performance Index report placed India at the lowest rank, with critical challenges linked to declining air quality and increasing greenhouse gas emissions. Countries with low environmental indices often face adverse conditions, including conflict, political instability, and insufficient investment and financial resources (Luhung & Yuniasih, 2023)

In the 2022 Environmental Performance Index report, Indonesia scored 28.2 globally, ranking 164th worldwide and 22nd in the Asia-Pacific region. Among ASEAN countries, Indonesia is ranked 9th, above Vietnam with a score of 20.1 and Myanmar with a score of 19.4. One of the key categories of concern for Indonesia in the EPI is environmental health. Indonesia ranks 134th out of 180 countries in this category, with a score of 25.30. This relatively low score indicates that Indonesia faces significant environmental health challenges, including air pollution, clean water sanitation issues, heavy metal contamination, and ineffective waste management. (Bilqisti et al., 2023). Indonesia's low EPI score indicates the need for further efforts to enhance environmental quality. The Ministry of Environment and Forestry has also advocated for the assessment of the Environmental Quality Index (EQI) or IKLH across 34 provinces nationwide. The EQI serves as a metric providing insights into the environmental condition within specific spatial or temporal parameters including the 4 indicators, as Air Quality Index (AQI), Water Quality Index (WQI), and Land Coverage Quality Index (LCQI), and Sea Water Quality Index (S). Performance benchmarks for the EQI have been previously established, both at provincial and national levels, as mandated in the Medium-Term Development Plan/*Rencana Pembangunan Jangka Menengah Nasional* (RPJMN) for 2020-2024, with a target set at 69.75. While the targeted EQI for DKI Jakarta Province in 2023 is 54.93 (DLH DKI Jakarta, 2023). According to data from the Environmental Quality Index Report of DKI Jakarta Province, the achievement for DKI Jakarta in 2023 stood at 54.57, categorized as moderate. This score falls short of the target set by the DKI Jakarta Province for 2023. A breakdown of the EQI scores for DKI Jakarta Province in 2023 is illustrated in Figure 1.

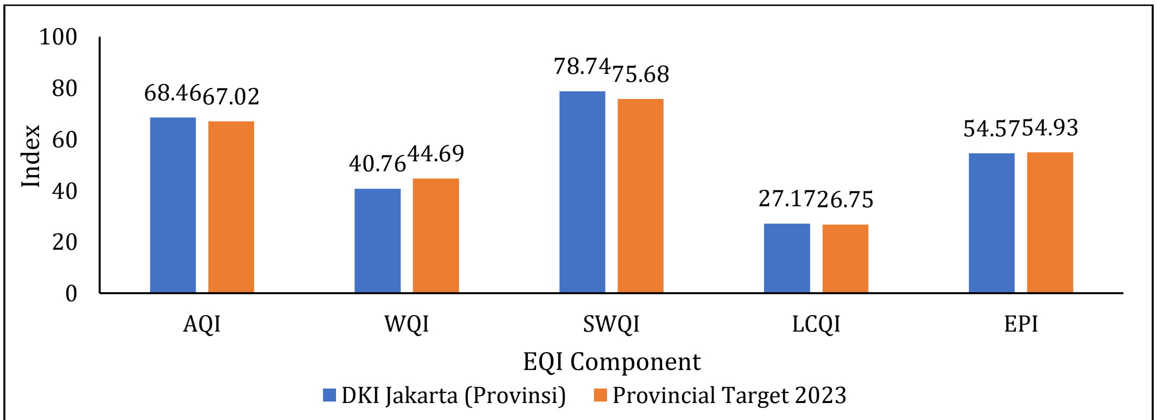

Fig 1. EQI of DKI Jakarta 2023
(DLH DKI Jakarta, 2023)

The Figure 1 shows the Environmental Quality Index (EQI) component values for DKI Jakarta. The Environmental Quality Index (EQI) levels are classified into the following categories: 80–100: Excellent environmental quality. Environmental quality in the range of 60–79 is considered good. 40–59 indicates that the environmental quality is at a moderate level; 20–39 reflects substandard environmental conditions; and 0–19 signifies extremely low environmental quality. In Jakarta, the EQI is particularly important within the context of Indonesia, as it serves as a valuable tool for governmental authorities in crafting environmental and health management policies. EQI stands as an integrated measure evaluating a nation's capacity to address environmental challenges from both human health and ecosystem perspectives (Nowak & Kasztelan, 2022). Moreover, empirical evidence has underscored a negative correlation between tourism density and environmental performance indices across ASEAN nations, underscoring the significance of tourism activities in shaping environmental outcomes (Yassin et al., 2021).

Based on the 2023 Environmental Quality Index (EQI), Jakarta confronts a multitude of significant environmental challenges. Foremost among these is the issue of flooding, often intricately linked with political circumstances, particularly surrounding governor elections (Gunawibawa & Oktiani, 2020). Additionally, the Jakarta Bay reclamation project has led to repercussions in fisheries and the diversity of marine resources (Rizqiah & Puspita, 2023). Other pressing concerns encompass the alarming quality of well water (Mutoffar et al., 2022), land subsidence (Antomi & Fajrin, 2022), and alterations in coastline dynamics (Hidayah & Apriyanti, 2020). Furthermore, air quality in Jakarta warrants serious attention, particularly regarding the exceedance of health thresholds for PM2.5 particulate matter (Sembiring, 2020).

Furthermore, Jakarta is confronted with the issue of suboptimal waste management (Sukwika & Noviana, 2020). Efficient waste management in Jakarta remains a significant obstacle (Avarand et al., 2023), as does the impact of discharge on the effectiveness of home wastewater treatment facilities (Kautsar et al., 2021). Given the circumstances, Jakarta must prioritize the sustainability of integrated waste management (Sukwika & Noviana, 2020) and household wastewater management. When protecting Jakarta's environment, other things that need to be thought about are the city's high population density (Salsabila & Solikhah, 2023), changes in radionuclide distribution coefficients (Latifah et al., 2022), traffic noise, and the effect of tourism on the Environmental Performance Index (EPI) (Yassin et al., 2021).

The regulations governing air quality, drinking water sanitation, heavy metal exposure, and waste management in DKI Jakarta constitute foundational elements in preserving both environmental health and public welfare. Regional Regulation No. 4 of 2019 provides a comprehensive framework to ensure a healthy and sustainable environment for the residents of Jakarta. The observed improvement in air quality during the COVID-19 pandemic underscores the efficacy of these regulations in addressing the policy impacts on clean air (Fatimah et al., 2024). Furthermore, the significance of regulations related to drinking water sanitation is underscored by examining weather-related risk factors for diarrheal incidents in East Jakarta Administrative City (Nuha, 2022). In addition to the imperative of environmentally sound waste management and the sustainable operation of the integrated waste management facility at TPST-Bantargebang, Bekasi, robust regulations regarding plastic waste distribution at Jakarta's estuary are also essential. Thus, these regulations serve not merely as legal documents but as pivotal instruments in safeguarding the environmental health and societal well-being of Jakarta. Through diligent implementation, it is anticipated that these regulations will continue to foster a healthier and more sustainable environment for Jakarta's inhabitants.

According to a previous study conducted by Luhun & Yuniasih in 2021, there are multiple elements that influence the environmental quality in Indonesia. This study demonstrates the intricate connection between economic progress, environmental degradation, and quality of life using two primary indicators: the Environmental Performance Index (EPI) and the Quality of Environmental Life Index (QELI). This study utilizes regression analysis and panel data to determine the influence of economic factors, such as Gross Regional Domestic Product (GRDP) per capita and industrial GRDP, on environmental quality. In addition, it analyzes the idea of the Environmental Kuznet Curve (EKC) and explores the impact of urbanization and financial development on environmental quality. It emphasizes the significance of sustainable economic development in enhancing environmental quality. This study highlights the necessity of promoting ecologically sustainable economic development in Indonesia and underscores the significance of striking a balance between economic growth and environmental conservation in order to attain sustainable economic progress. This study reaffirms the importance of investing in energy-efficient technology in Indonesia to decrease carbon emissions and enhance environmental quality. It provides useful insights into the intricate relationship between economic variables, urbanization, and environmental sustainability.

When discussing Jakarta Province, it is vital to take into account major factors such as the total population and the level of urbanization. These variables have a significant impact on the environmental conditions and community development in the area. Green spaces, such as recreational parks and urban forests, are crucial for enhancing the quality of life in densely crowded areas like Jakarta. Hence, it is crucial to investigate the correlation between the advancement of Information and Communication Technology (ICT) and population density in order to comprehend the intricacies of urban growth and its influence on the welfare of the community. Therefore, it is crucial to have a comprehensive comprehension of the correlation between environmental health and factors such as the Human Development Index (HDI), population density, and Information and Communication Technology (ICT) in order to formulate sustainable policies and enhance living circumstances in Jakarta.

2. Methods

This research employs secondary regression data sourced from reports by the Central Statistics Agency and the Environmental Agency of DKI Jakarta Province. The study period spans from 2008 to 2023. The research design approach employed is a quantitative methodology. The methodological adopted is a mixed-method both quantitative and qualitative. The empirical model utilizes the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model. The application of the STIRPAT model is widely recognized for its efficacy in examining the relationship between sustainability and socio-economic variables. Moreover, it offers insights into the environmental impacts resulting from changes in driving factors, including those influenced by human behavior (Nasrollahi et al., 2020; Theofani & Sediyono, 2022; Luhung & Yuniasih, 2023). The foundational formulation of the STIRPAT model is expressed as follows:

$$I = aP^{b}A^{c}T^{d} \quad \text{(Eq. 1)}$$

With coefficient a while variables b, c and d represent the exponential factors of population scale (P), affluence level (A), and technology (T). The population scale utilizes the total population approach in DKI Jakarta, the affluence level employs the Human Development Index (HDI), and the technology factor uses the Information, Communication and Technology Development Index (IDI). Variable descriptions are provided in Table 1.

Table 1. Variable description

Variable	Acronym	Measure	Source
Environmental Quality Index	EQI	Index	DLH DKI Jakarta Province
Human Development Index	HDI	Index	BPS
Human population	POP	Index	BPS
Information, Communication and Technology Development Index	IDI	Index	BPS

Table 1 presents a comprehensive overview of the variables contained in a dataset, including their names, acronyms, measurement scales, and relevant data sources. This information is vital for understanding the essence of the data and using it efficiently for analysis. The table showcases four crucial variables: Environmental Quality Index (EQI), Human Development Index (HDI), Human Population (POP), and Information, Communication and Technology Development Index (IDI). Every variable is denoted by a unique acronym and is quantified using an index, which functions as a numerical representation of an intricate idea. Based on the variable descriptions provided in Table 1, multiple linear regression analysis was conducted by incorporating these variables into an analytical in Equation 1, yielding the following result:

$$\text{EQI} = \alpha+\beta 1\ \text{HDI}it + \beta 2\ \text{lnPOP}it + \beta 3\ \text{IDI}it + uit \qquad \text{(Eq. 2)}$$

The variables in this study are defined as follows: EQI represents the Environmental Quality Index, while α denotes the intercept. The Human Development Index (HDI) and the Human Population (POP) are key factors influencing environmental quality. Additionally, the Information, Communication, and Technology (ICT) Development Index (IDI) is included as a determinant of technological advancement. The residual series is represented by u, accounting for unexplained variations in the model. The specific indicators are denoted by i, where i = 1, 2, 3, referring to different measured variables. Lastly, t represents the year interval, covering the period from 2008 to 2023.

2.1 Multicollinearity and autocorrelation

This test is utilized to determine the presence of high correlation among variables in the regression model. The model is deemed insignificant if multicollinearity occurs between the dependent and independent variables. When there is a high correlation among the independent variables, the dependent variable will also fluctuate. Multicollinearity can be assessed using the Variance Inflation Factor (VIF) and tolerance, as indicated in the following formula (Kutner et al., 2004).

$$\text{VIF} = \frac{1}{(1-R^2)}\ \text{, where} \qquad \text{(Eq. 3)}$$

$$R_n = \frac{b_1\ \Sigma X_1 Y + b_2\ \Sigma X_2 Y + \cdots + b_n\ \Sigma X_n Y}{\sum Y^2} \qquad \text{(Eq. 4)}$$

The Variance Inflation Factor (VIF) is used to assess multicollinearity among independent variables in a regression model. In this context, VIF represents the Variance Inflation Factor, R is the correlation coefficient of the independent variable, and N denotes the total number of independent variables (1, 2, ..., n). The significance of multicollinearity is determined based on the following criteria if VIF < 10 and the tolerance value > 0.10, there is no multicollinearity. Then, if VIF > 10 and the tolerance value < 0.10, multicollinearity is present. These thresholds help determine whether independent variables are highly correlated, which could affect the reliability of regression estimates.

The autocorrelation test serves to analyze the linear relationship among regression errors, particularly in research organized as time series data. It aids in identifying patterns of dependence among adjacent data values within a temporal or sequential context. This test is indispensable for scrutinizing time series datasets, ensuring that assumptions regarding autocorrelation remain valid in statistical models (Gujarati, 2003; Ainiyah et al., 2016). The examination is typically conducted using the Durbin-Watson statistic (DW). The Durbin-Watson test evaluates autocorrelation and yields values within the range of 0 to 4. A DW value of 2 suggests the absence of autocorrelation in the sample, while values below 2 indicate positive autocorrelation within the data set (Fahidy, 2006).

2.2 Heteroscedasticity, normality, regression

The heteroscedasticity test is used to model residual variance on regression, with inequality testing to other models. Variable contained on this test, assumes constant residual variance (range of error). Heteroscedasticity occurs if there is residual variance in regression shown with not constant value. In many cases on cross-section data containing the heteroscedasticity because the data have representative of many small data categorize. The regression model have significant model, when the data not have any heteroscedasticity (Gujarati, 2003).

The heteroscedasticity test is employed to model residual variance in regression analysis, with comparisons made to alternative models. Variables involved in this test presume a constant residual variance (error range). Heteroscedasticity is present when there is non-constant residual variance in regression. In cross-sectional data, heteroscedasticity often arises due to the representation of numerous small data categories. A regression model is considered significant when the data exhibit no heteroscedasticity (Gujarati, 2003).

Hypothesis testing is conducted using the F-test to determine if at least one independent variable significantly influences environmental quality in DKI Jakarta. The hypothesis is deemed valid when the test yields a significance level <0.01. The t-test is also employed to ascertain which independent variables, if any, partially affect environmental quality. Acceptance of the hypothesis occurs when the significance level of t<0.01. The coefficient of determination (R^2) is utilized to ascertain the percentage of variability in environmental quality explained by independent variables in the study (Mardiatmoko, 2020). The results obtained from regression analysis are further analyzed descriptively and qualitatively to classify, analyze, and interpret data, aiming to derive appropriate strategic and recommendations for environmental quality improvement in DKI Jakarta (Marliana & Fachruddin, 2020; Jahanger et al., 2022).

3. Results and Discussion

3.1 General background Environmental Quality Index (EQI)

There is interrelatedness and interaction between the Environmental Quality Index (EQI), Human Development Index (HDI), and Information and Communication Technology Development Index (IDI). Therefore, progress in one index can influence, support, or strengthen progress in the others in achieving sustainable development. The Environmental Performance Index (EPI), which is made up of the Air Quality Index (AQI), the Seawater Quality Index (SEI), the Land Cover Quality Index (LQI), the Peat Ecosystem Quality Index (PEI), and the Land Quality Index (LQI), gives a picture of the environmental quality of a place at a certain point in time, according to Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 27 of 2021. Humans, being social creatures, have a reciprocal relationship with their environment. As a result, the Human Development Index (HDI), which consists of three main dimensions: knowledge, longevity and health, and decent livelihood, is highly dependent on the quality of the human environment. In addition, there is a relationship between the former index and the Information and Communication Technology Development Index (IDI), which measures the level of information and communication technology progress in a region. Efforts to improve the quality of the living environment (IKLH) can have a positive impact on the long-term use of information and communication technology (ICT) and human well-being (HDI).

Figure 2 displays the Environmental Quality Index (EQI) value for DKI Jakarta on the Y-axis. The EQI value serves as a measure of the environmental management performance. A higher EQI value signifies superior environmental quality. The X-axis represents the years from 2008 to 2023, which are used to analyze the EQI trend in DKI Jakarta throughout this time frame. With the highest value in 2018 (54.65) and the lowest in 2010 (31.97), fluctuations in the Environmental Performance Index (EPI) show the state of the environment in Jakarta. Jakarta's EPI is currently in the 'moderate' category, which indicates that the quality of the environment is still not optimal and requires serious efforts to improve.

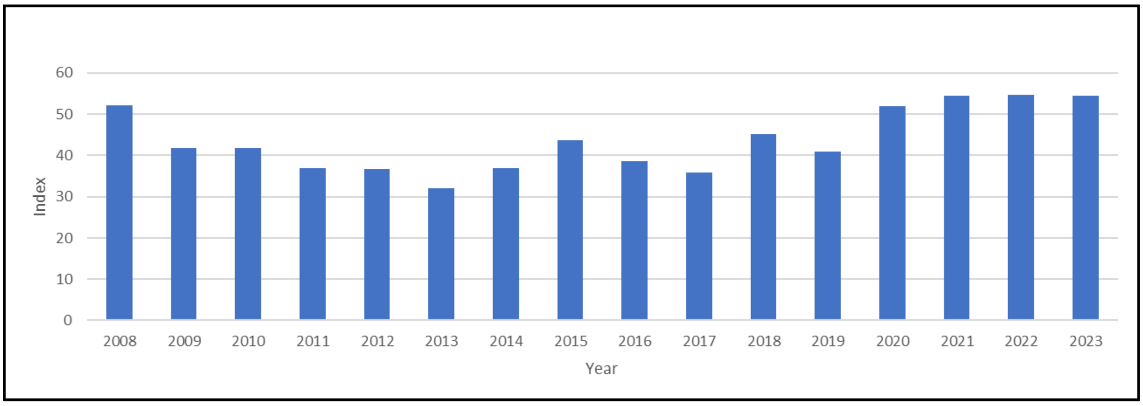

Fig 2. Environmental Performance Index DKI Jakarta 2008-2023
(BPS, 2024)

In-depth analysis reveals several important components that contribute to changes in Jakarta's EPI. Air pollution is one of the main problems, with motor vehicle exhaust emissions at 59% being the biggest contributor, especially in densely populated and industrialized areas. Forest and land fires in areas surrounding Jakarta at 12%, road dust at 10%, and industrial emissions at 9% also contribute to the decline in air quality. In addition, domestic waste is the main cause of river and stream water pollution, with domestic waste (62%), industrial waste (23%) and plastic waste (15%) each contributing to water quality degradation. The flow of land use into residential (46%) and industrial (32%) areas has also led to a decline in the quality of land cover, leading to less green open space (11%) and increasing the potential for flooding. Marine debris (68%), as well as domestic sewage (32%), degrade seawater quality in coastal Jakarta.

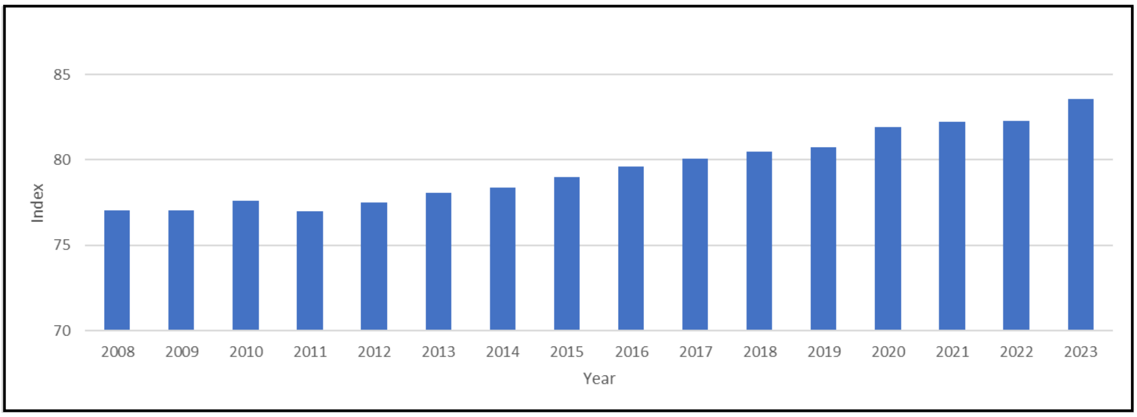

Fig 3. Human Development Index DKI Jakarta 2008-2023
(BPS, 2024)

The Y-axis of Figure 3 represents the Human Development Index (HDI) value, with a higher value indicating a greater level of human development in a certain location. The evaluation categories are listed on the Y-axis. The range of values is divided into four categories: low (0-54.99), medium (55.00-69.99), high (70.00-79.99), and very high (80.00-100.00). The X-axis represents the years from 2008 to 2023, which are used to analyze the trend of the HDI in a specific region throughout this time frame. The Human Development Index (HDI) has had a favorable trajectory in recent years. The Human Development Index (HDI) is projected to reach 83.55 by 2023, placing it in the 'Very High' category. This signifies a notable enhancement in the quality of life for the city's inhabitants. Several key aspects contributing to this enhancement encompass heightened life expectancy, elevated education levels, and higher per capita income. The life expectancy in Jakarta has been steadily rising, with a projected value of 75.81 years in 2023. The education levels have shown remarkable advancement, reaching an average of 10.68 years of study in the same year. The per capita income in Jakarta is experiencing strong growth, reaching Rp. 406.94 million by 2023.

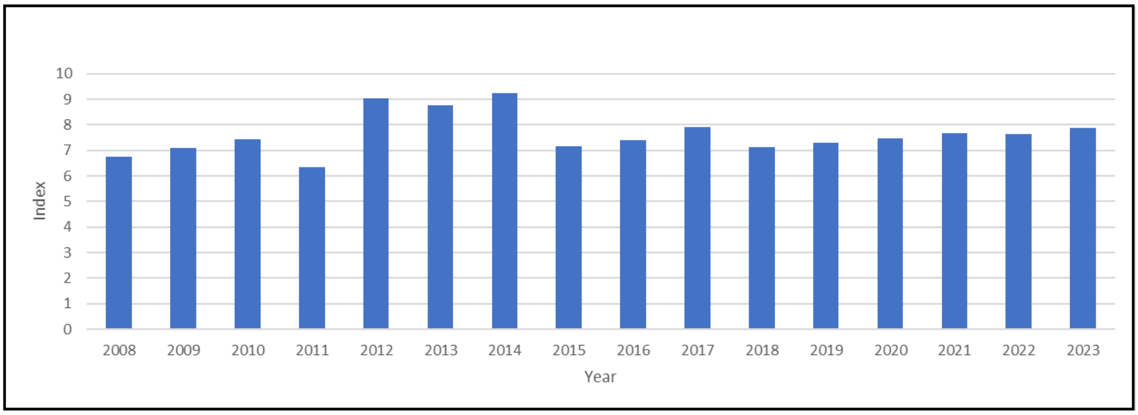

Fig 4.Information and Communication Technology Development Index DKI Jakarta 2008-2023 (BPS, 2024)

The Y-axis in Figure 4 displays the Information and Communication Technology Development Index (IDI) value for DKI Jakarta. A higher IDI value indicates a superior degree of information and communication technology development. The evaluation categories on the Y-axis are as stated below: The range of values is divided into three categories: 0-3.99 is considered low, 4-6.99 is considered medium, and 7-10 is considered high. The X-axis represents the years from 2008 to 2023, and it is used to assess the trend of the IDI in DKI Jakarta throughout this period. In recent years, Jakarta's Information and Communication Technology Development Index (IDI) has demonstrated a favorable trend. In 2022, Jakarta's IDI score reached 7.64, placing it in the 'High' category. This demonstrates the swift advancement of information and communication technologies in Jakarta. The rise in ICT infrastructure is propelled by many government initiatives to construct and enhance internet networks, fibre optics, and cellular towers. Furthermore, Jakarta's internet adoption rate shows a consistent upward trend each year. By the year 2022, the level of penetration will increase to 86.9%. This progress is also influenced by the rise in digital literacy among Jakarta's population. An increasing number of individuals are accessing the internet for a multitude of purposes, including information retrieval, social interaction, and conducting business. This demonstrates the city's advancement in understanding and applying digital technology.

Figure 5 displays the population of Jakarta in millions on the Y-axis. As the value increases on the Y-axis, the population of Jakarta also increases. The X-axis represents the time span from 2008 to 2023, which is used to analyze the pattern of population growth in Jakarta throughout this period. According to data from Badan Pusat Statistik (BPS), Jakarta's population has consistently grown over the past few decades. In 2020, Jakarta's population experienced an average yearly growth rate of 1.36%, highlighting the consistent pattern of growth observed from 2008 to 2023. Jakarta's population increase can be attributed to several significant causes, such as rapid urbanization, high fertility rates, and the presence of sufficient infrastructure. Jakarta experiences a significant pace of urbanization due to its status as Indonesia's capital and economic hub, which draws people from many locations in search of employment opportunities. The fertility rate in Jakarta is relatively high, with an average of 2.1 children per woman. Jakarta's superior infrastructure relative to other locations in Indonesia attracts those who choose to reside there. These factors contribute to the ongoing increase in population in Jakarta.

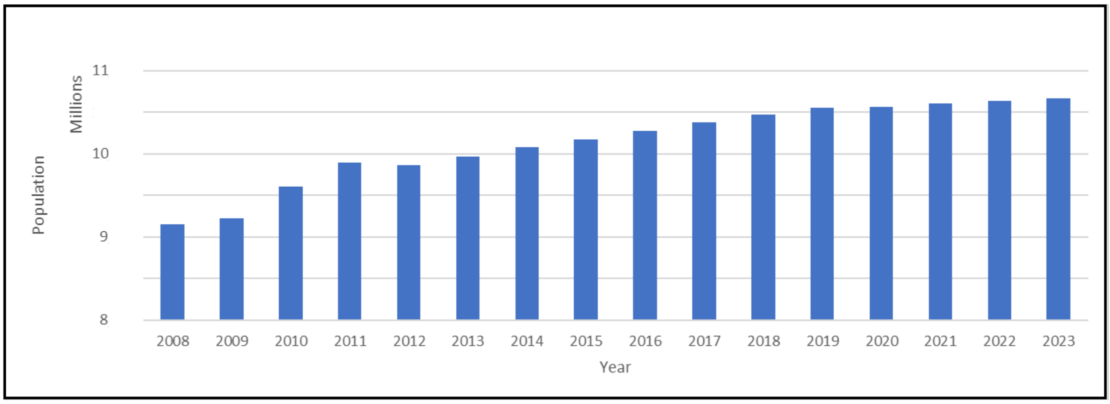

Fig 5. Human Population in DKI Jakarta 2008-2023
(BPS, 2024)

3.2 *Classic assumption test*

Classic assumption testing is conducted to verify the fundamental assumptions underlying regression models, assessing the validity of the model and the variables utilized. It encompasses several assumptions, including multicollinearity test, autocorrelation test, heteroscedasticity test, dan normality test. The multicollinearity test is performed to identify correlations among the dependent variable (Y), namely the Environmental Quality Index (EQI), and independent variables, namely HDI, Population, and IDI. The results of the multicollinearity test are as follows:

Table 2. Multicollinearity test result for VIF

Variable	Collinearity Statistics	
	Tolerance	VIF
HDI	0.216	4.631
IDI	0.928	1.078
Population	0.210	4.751

Table 2 displays the tolerance and collinearity statistics for three variables: HDI, IDI, and population. Tolerance quantifies the extent to which a variable is correlated with other variables in a regression model, whereas VIF quantifies its influence on other variables. The HDI and population variables have low tolerance levels and high VIF values, suggesting a significant connection with other variables, which may result in multicollinearity problems during regression analysis. Nevertheless, the IDI variable exhibits a substantial tolerance level and a low VIF, suggesting that it does not have a noteworthy connection with other variables, hence mitigating worries about multicollinearity. Based on the obtained results, the VIF values for all three variables (HDI, IDI, and Population) are less than 10, and the tolerance values are less than 0.10. Therefore, it can be concluded that there is no multicollinearity concerning the dependent variable. The result for the autocorrelation test indicates with index of Durbin Watson test, shown in Table 3.

Table 3. Autocorrelation result Durbin Watson

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.900[a]	0.810	0.762	3.72770	2.127

a. Predictors: (Constant), log_POP, IDI, HDI

b. Dependent Variable: EQI

Table 3 presents the results of the autocorrelation analysis using the Durbin-Watson test to evaluate the regression model used. With an R value of 0.900 and R Square of 0.810, the model shows a strong relationship between the predictor variables, namely log_POP, IDI, and HDI, and the dependent variable EQI. The Adjusted R Square value of 0.762 indicates that about 76.2% of the variation in EQI can be explained by this model. In addition, the Durbin-Watson value of 2.127 indicates that there is no significant autocorrelation in the residuals, so this regression model fulfills the assumption of error independence.

3.2.1 Heteroscedasticity test result and normality

The Heteroscedasticity test in this study was conducted using time series data, examining the distribution graphically through scatterplots or the predicted values of the dependent variable (Y), namely SRESID, against the residual error ZPRED. The results of the Heteroscedasticity test in this study are as follows. According to the Figure 6, it is observed that the data distribution pattern exhibits small clusters and tends to be dispersed, without any discernible regular pattern. Therefore, it is concluded that heteroscedasticity does not occur in the regression model of this study.

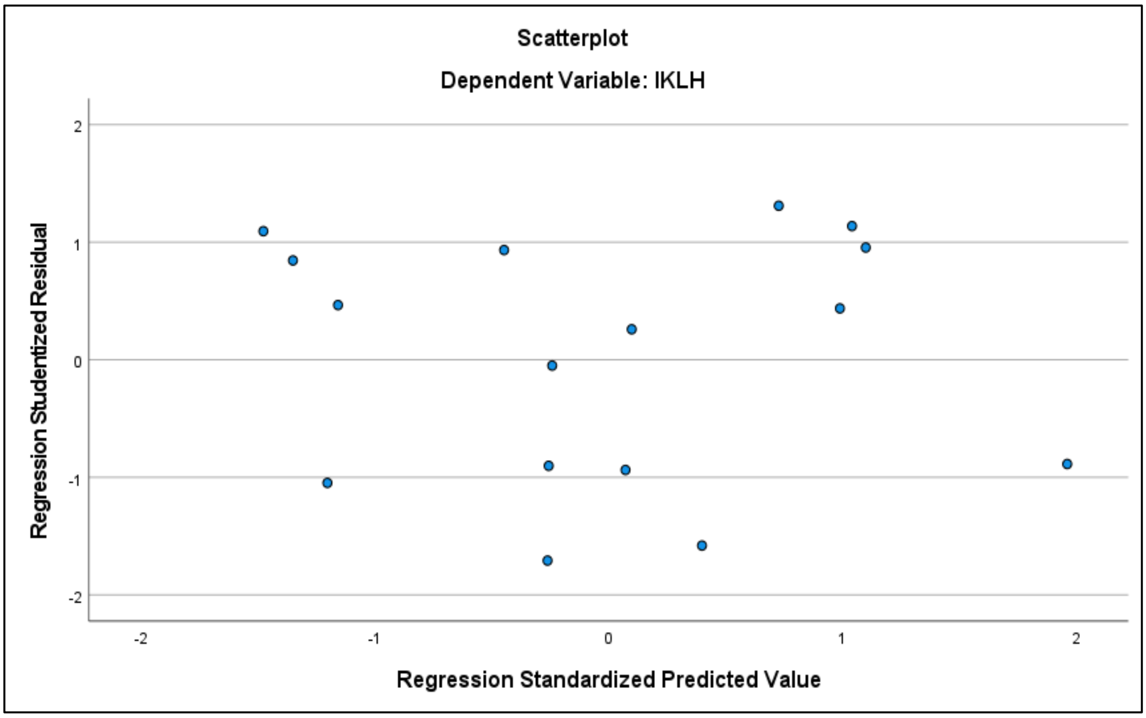

Fig 6. Scatterplot distributed data

Figure 6 shows a scatterplot of the residuals from the regression analysis with the dependent variable IKLH (Environmental Quality Index). This graph illustrates the relationship between the regression standard predicted value and the studentized residuals, which is used to evaluate the assumptions of normality and homoscedasticity in the regression model. A distribution of points that does not form a specific pattern indicates that the residuals are randomly distributed, which may indicate that the assumption of homoscedasticity is met. However, further checks may be needed to confirm the accuracy of the regression model used.

The normality test was conducted to ascertain that the regression model used conforms to the characteristics of a normal distribution, performed using the one-sample Kolmogorov-Smirnov test. The results of the testing are presented in Table 4. This table presents the results of the normality test using Kolmogorov-Smirnov to evaluate the distribution of residuals in the regression model. With a sample size (N) of 16 and a mean residual value of 0.0000000, the test results show that the residual distribution has a significance value of Asymp. Sig. (2-tailed) significance value of 0.200. Based on the Lilliefors criteria, this value indicates that the residuals are normally distributed, as it is greater than

0.05. In addition, the Monte Carlo method shows a significance of 0.263 with a 99% confidence interval between 0.251 and 0.274, which further strengthens the conclusion that the residuals follow a normal distribution.

Table 4. Kolmogorov Smirnov Testing result

One-Sample Kolmogorov-Smirnov Test			
			Unstandardized Residual
N			16
Normal Parameters[a,b]	Mean		0.0000000
	Std. Deviation		3.33415412
Most Extreme Differences	Absolute		0.168
	Positive		0.153
	Negative		-0.168
Test Statistic			0.168
Asymp. Sig. (2-tailed)[c]			0.200[d]
Monte Carlo Sig. (2-tailed)[e]	Sig.		0.263
	99% Confidence Interval	Lower Bound	0.251
		Upper Bound	0.274

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.
e. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 926214481.

3.3 Result and analysis regression

Based on the regression model with independent variables such as Human Development Index (HDI), population and Information, Communication and Technology Development Index or ICT Development Index (IDI), have result of regression by using SPSS software 27. Based on the regression results obtained from the three variables generate a model as follows. Furthermore, Table 5 will explain the statistical regression results.

Table 5. Statistic regression result

Variabel	Unstandardized Coefficient		T statistic	p-value	Decision
	Koefisien	Standard Error			
Koefisien	2395.614	621.573	3.854	0.002	Significant
HDI	5.776	0.960	6.019	0.000	Significant
IDI	-2.183	1.261	-1.731	0.109	Not Significant
Log-POP	-173.456	42.816	-4.047	0.002	Significant
Statistic Summary					
R-square	0.810		F-statistic	16.998	
Adjusted R-square	0.762		Prob (F-statistic)	0.000	

$$Y = 2395.614 + 5.776\,X_1 - 2.183\,X_2 - 173.456\,X_3 \qquad \text{(Eq. 5)}$$

The findings presented in Table 5 indicate that 76.2% of the variance in EQI can be explained by the independent variables utilized in the model, with the remainder attributed to other variables not included in this model. The F-test yields a probability value of 0.000, which is less than the significance level (α) of 0.01, thus leading to the conclusion that, with a significance level of 1%, at least one variable in the modeling significantly influences on EQI in DKI Jakarta. The coefficients of HDI, IDI, and population size elucidate the outcomes of the independent variables.

The Human Development Index (HDI) varies among countries. In a study by (Samimi et al., 2011), developed countries with high HDI demonstrated a positive impact on environmental quality, indicating easier access to education, healthcare, and various economic sectors. The calculation of the Human Development Index (HDI) in Indonesia involves measuring the HDI for each province, encompassing several fundamental components such as quality of life, health represented by life expectancy, knowledge through education indices, and decent living standards through real Gross Domestic Product. In this context, DKI Jakarta has the highest HDI in Indonesia. Correspondingly, the EQI value continues to increase. The regression analysis results presented in Table 5 show that HDI significantly influences the EQI factors, with a regression coefficient of 5.776 and a p-value of 0.000 (less than the significance level of 0.01) in the t-test. This findings indicates the higher Human Development Index in the DKI Jakarta Province can influence better environment quality in DKI Jakarta. The ease of access to education has been demonstrated through the implementation of Provincial Government policies with various educational programs, such as the Kartu Jakarta Pintar dan Kartu Jakarta Mahasiswa Unggul (KJMU). These initiatives are designed to offer fair and equal education opportunities, ensuring that Jakarta residents have reliable access to quality education services. Consistent with the research by Dewi & Fitria (2022), the correlation between EQI and HDI in DKI Jakarta Province from 2019 to 2021 showed an increase in HDI along with an increase in EQI. In this regard, the education index as part of HDI could encourage society to adopt pro-environmental behavior in both daily routines and decision-making processes.

Research conducted by Lazuardi & Muttaqin (2023) shown a positive correlation between the ICT Index and economic growth, highlighting the role of technology in enhancing skills and techniques that improve labor productivity. Similarly with study conducted from Luhung & Yuniasih (2023) reported that Jakarta's Digital Economy Index from 2017 to 2021 has positively influenced environmental quality through technological innovations designed to address environmental issues. The IDI is composed of three sub-indices access and infrastructure, technology usage, and skills, reflecting the proficiency in utilizing Information and Communication Technology (ICT). The IDI varies annually across the provinces. According to Figure 3, Jakarta's IDI from 2008 to 2023 has shown fluctuations, with a significant increase in the last three years, indicating substantial ICT development in Jakarta. Despite these advancements, ICT development does not solely yield positive impacts on environmental quality, also have a negative impact. Regression analysis results in Table 5 reveal a coefficient of -2.183 with a p-value of 0.109 (exceeding the 0.01 significance level), the value indicating that the ICT Index variable does not significantly influence to the regression model. Consequently, a 1% increase in the IDI is associated with a 2.183% decrease in the Environmental Quality Index (EQI), assuming ceteris paribus. Thus, technological, informational, and communication advancements in Jakarta have not fully supported environmental quality recovery. The indispensable role of technology in digital transactions, production, transportation, and various societal aspects can contribute to environmental degradation. A study by Belkhir & Elmeligi (2018) indicates that ICT advancements contributed to a 13% increase in greenhouse gas emissions from 2007 to 2017. Similarly, research by Lee et al. (2023) suggests that ICT growth significantly impacts carbon emissions. Therefore, it is essential to promote environmental conservation, the judicious use of technology, and communication strategies that are accessible to all societal segments. Planning for advanced technological infrastructure should aim not only to stimulate economic activities but also to ensure environmental quality and accessibility for the public. Utilizing ICT, such as social media, can effectively campaign for environmentally friendly behaviors.

The population growth in DKI Jakarta has consistently increased over the years. According to Table 5, the regression analysis indicates a coefficient of -173.456 for the impact of population growth on the Environmental Quality Index (EQI) in DKI Jakarta, with a p-value of 0.002, which is below the 0.01 significance threshold. This finding demonstrates that population growth significantly affects the environment quality. Specifically, a 1% increase in population correlates with a 173.456 decrease in environmental quality, assuming other variables remain constant. The rising population heightens the demand for essential resources, including housing, clothing, and food. As the demand for housing increases, there is a tendency for people to concentrate on specific areas. In DKI Jakarta, this population surge results in the conversion of land for residential and industrial purposes. Additionally, increased food demand places pressure on production processes, generating waste that can pollute water, soil, and air, thereby degrading environmental quality. This observation is consistent with research by Saraswati & Siagian (2019), which found that higher population density and reduced green spaces are associated with lower environmental quality. Similarly, Saraswati et al. (2024) reported that population growth is closely linked to climate change. The increasing population amplifies the demand for resources, leading to significant global environmental risks, including climate disruption, greenhouse gas emissions, air and water pollution, biodiversity loss, and the spread of diseases, all of which pose substantial threats to human health and overall well-being.

4. Conclusions

This study reveals that 76.2% of the independent variables in the model account for the variation in the Environmental Quality Index (EQI), with the Human Development Index (HDI) being the most significant variable. The HDI exhibits a significant and positive impact on the EPI, suggesting that enhanced access to education, healthcare, and economic opportunities contributes to improved environmental quality. The result shown that Information and Communication Technology Development Index (IDI) is not statistically significant to affected with environmental quality in Jakarta. In some cases, increased IDI may adversely affect environmental quality, particularly if technology usage is inappropriate. Additionally, population growth demonstrates a significant impact on the EPI, where an increase in population correlates with a decline in environmental quality. Therefore, it is crucial to manage population growth, promote the use of environmentally friendly technologies, and enhance human development comprehensively to achieve sustainable prosperity and improved environmental quality.

The conclusions suggest that the provincial government should implement innovative development planning strategies. Workforce training is essential for human resource development, therefore education on equitable quality can improve these resources. Adopting a green economy is a progressive approach that aligns economic growth with environmental quality enhancement. Supporting information and communication technology (ICT) can drive the development of a green economy. The provincial government should also advance green industry practices by promoting the use of waste recycling fuels, developing renewable energy sources, and implementing low-carbon technologies. Additionally, the government should increase the provision of credit to economic sector participants, enabling them to upgrade to environmentally friendly equipment and machinery. Effective policies and regulations on environmental care, supported by adequate infrastructure, are expected to raise public awareness of environmental sustainability. Further research should utilize multidimensional approaches to include other independent variables affecting environmental quality, beyond those in the human development, technology, and population sectors.

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Author Contribution

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