Determinants of Sustainable Development Goals (SDGs) in Indonesia: Mapping with Cartesius Diagram

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Abstract

This research aims to explore the long- and short-term relationships and the quality of interactions between variables within the framework of the Sustainable Development Concept, focusing on the social aspect (Human Development Index), economic aspect (economic growth), and environmental aspect (Environmental Quality Index) in the context of reducing poverty rates in Indonesia. The methodology employed is the Panel Vector Error Correction Model (P-VECM) analysis for panel data, combining time series (2010-2022) and cross-section data (34 provinces in Indonesia), along with a Cartesian diagram to identify which provinces have the greatest potential for achieving evenly distributed SDG progress. The results show that the Granger causality test reveals no one-way or two-way causal relationships or interactions between the human development index, economic growth, and environmental quality index. In the long-term analysis, only the human development index significantly impacts poverty, with a negative correlation. In contrast, economic growth and the environmental quality index do not have a long-term relationship with Indonesia's poverty levels. These findings suggest that improving the quality of education, healthcare, and living standards in the long term can effectively reduce poverty, especially in Indonesia. Pro-poor government policies are crucial to prevent widening inequality and ensure that economic growth benefits the upper class and the lower and middle classes through more equitable income distribution.

Keywords: *Economic growth, Environmental quality, Human development, Poverty, Sustainable Development Goals (SDGs)*

JEL Classification: I30, I25, O40, O44

INTRODUCTION

The Sustainable Development Goals (SDGs) have become a global discourse following the previous agenda, the Millennium Development Goals (MDGs), which were not fully implemented as intended (Dixon & Fallon, 1989). Essentially, the SDGs are an evolution of the MDGs (Loewe, 2012). The SDGs aim to be achieved by 2030, addressing challenges oriented towards quantitatively measurable results and focused on quality (Hák et al., 2016). Sustainable development is guided by the principle of

"meeting the needs of the present without sacrificing meeting the needs of future generations."

Sustainable development is built on three integrated pillars: economic (economic sustainability), social (social sustainability), and environmental (environmental sustainability), which are interdependent and reinforce each other (Littig & Grießler, 2005). It is defined as development that meets current needs without compromising future generations' ability to meet theirs, ensuring the quality of human life without exceeding the ecosystem's capacity to sustain it. In alignment with Sudarmadji's view, sustainability is an activity that satisfies current needs, representing the fundamental exchange process between society and nature (Littig & Grießler, 2005).

The SDGs comprise 17 pillars. However, this research does not address all 17; it focuses on poverty and the Human Development Index for the social pillar, economic growth for the economic pillar, and the environmental quality index and climate change for the environmental pillar. These three pillars form an interconnected unit that interacts to achieve sustainability. Social and economic goals must be pursued while also considering their environmental impacts. The social pillar begins with indicators such as poverty or its eradication, as poverty represents a form of injustice experienced by groups in developed and developing countries. Social injustice, an external factor of poverty, is evident in the unmet basic needs for survival in good health, limited access to public services (such as sanitation, clean water, and waste management), healthy housing, and educational services. Injustice is also reflected in the lack of land ownership rights, which often hinders access to stable, well-paying jobs.

Indonesia has vast and abundant natural resources distributed across various regions. These resources include agriculture, plantations, mineral commodities, and energy from mining, as well as fisheries and marine resources. Ironically, despite this wealth, Indonesia's poverty rate remains high. Over the past three years, the number of poor people in Indonesia was 27.5 million in 2020, 26.5 million in 2021, and 26.3 million in 2022. As of 2022, the percentage of poor people stood at 9.57%. This persistent poverty is a significant challenge for Indonesia, especially considering the SDGs, which aim to eradicate poverty by 2030. The slow pace of poverty reduction, only 5% between 2020 and 2022, underscores this challenge.

Several factors contribute to this limited reduction in poverty, which can be understood by examining community welfare. Welfare assessments are based on socio-economic conditions over a specific period, using various development output indicators. Numerous indicators are available and relevant for evaluating progress toward the SDGs. Key indicators of community welfare include life expectancy, literacy rates, average years of schooling, and population expenditure composition (per capita expenditure), all of which are integrated into the Human Development Index (HDI). The HDI serves as a benchmark for human development.

The HDI comprises three main components: health, education, and income. Indonesia's HDI remains low. According to the UNDP’s Human Development Report, Indonesia ranked 114th out of 188 countries in 2016, lagging far behind neighboring Malaysia, which ranked 63rd (UNDP, 2022). The HDI is divided into four categories: Very High Human Development (ranks 1-51), High Human Development (ranks 52-106), Medium Human Development (ranks 107-147), and Low Human Development (ranks 148-188). Indonesia falls into the Medium Human Development category (UNDP, 2022).

The HDI reflects the development process in Indonesia. Every country or region worldwide engages in economic development activities to achieve social welfare (shared prosperity) and eliminate poverty. Sustainable development seeks to reconcile two often conflicting paradigms: economic growth and the conservation of natural resources. Meadows (1972) argued that high and sustainable economic growth often comes at the expense of efficient natural resource use.

Indonesia's economic growth over the past five years, particularly in 2020, experienced fluctuations, with a contraction of -2.07% (year-on-year) in 2020, followed by growth rates of 3.70% in 2021 and 5.31% in 2022. The circular economy concept, introduced by Pearce and Turner in 1990, posits that the environment is an input in the production process, ultimately contributing to social welfare (Andersen, 2007). Previous research on the environment has largely focused on the impact of state income, including per capita income and Gross Domestic Product (GDP), on environmental degradation and quality (Sarkodie & Strezov, 2019). However, welfare should be viewed not only as an increase in income but also as a reduction in poverty and income inequality. Despite this, the literature addressing the relationship between poverty and the environment remains limited (Khan, 2019). Poverty alleviation and environmental change are, in fact, two critical agendas within the SDGs (Baloch et al., 2020).

If pursued without considering its environmental impact, poverty reduction cannot be regarded as sustainable development. This is why the third pillar of sustainable development is the environment. The challenge lies in achieving development while maintaining environmental sustainability. Environmental degradation is a core issue for sustainable development and can be mitigated by preserving environmental quality. This quality is represented by the Environmental Quality Index (EQI), a composite index that includes the Air Quality Index, Water Quality Index, and Land Cover Quality Index. These indices reflect the levels of environmental pollution and the complexity of environmental problems. The EQI serves as a ranking and a tool to encourage efforts to improve environmental quality, contributing to achieving the SDGs.

In Indonesia, environmental quality has seen some improvement. From 2015 to 2021, environmental quality showed an upward trend. Specifically, in 2020, the Environmental Quality Index increased by 2.4 points, from 66.5 in 2019 to 68.9 in 2020. This improvement was driven by enhancements in the Air Quality Index and Water Quality Index, largely due to the continued control of emissions in transportation, industrial, residential, and office areas. Additionally, successful programs to improve river water quality and monitor polluting industries contributed to this positive trend.

Between 2015 and 2021, Indonesia's average environmental quality score ranged from 60 to 70, indicating that while the environmental quality is fairly good, it has not yet reached optimal levels (Environmental Statistics, 2020). This suggests that there is still significant pressure on environmental resources, and efforts to improve environmental quality are not keeping pace with the degradation caused by their use.

The growing levels of environmental degradation, coupled with significant economic and social development gaps, present challenges for achieving the SDGs. Addressing these issues requires a focus on quantitative and qualitative environmental quality improvements. Therefore, understanding Indonesia's potential to achieve the SDGs necessitates examining the influence of factors such as economic growth, the HDI, the Environmental Quality Index, climate change, and poverty.

Various studies related to the SDGs have been conducted to explore different aspects of sustainability. Littig and Grießler (2005) proposed a sustainability concept

based on the principles of need and work, emphasizing the exchange process between society and nature. Their research supports social sustainability from both conceptual and analytical perspectives. Kemp et al. (2005) identified the main elements of sustainable development and governance, suggesting that sustainability is an adaptive management process institutionalized within social institutions. Their work also highlights the importance of innovation and provides a conceptual framework for sustainability-oriented policymaking.

Anger (2010) conducted a significant study in Nigeria, finding that the MDGs program positively impacted poverty reduction in the country. Anger recommended that governments at various levels develop appropriate and sustainable poverty reduction programs to achieve the SDGs.

Research by Hák et al. (2016) emphasized the need for a comprehensive conceptual and methodological framework to achieve the SDGs. Their study highlighted the importance of socio-economic and environmental statistics and the relevance of SDG indicators for meeting the targets. They also concluded that the success of the SDGs depends on political processes informed by scientific knowledge and fact-based policymaking.

Further research by Pradnyadewi and Purbadharmaja (2017) found that the HDI directly and significantly affects economic growth. In addition, infrastructure costs and economic growth significantly impacted income distribution inequality in Bali Province. The study noted that improvements in HDI and infrastructure could indirectly reduce inequality through increased economic growth, ultimately enhancing regional economic capacity and reducing income inequality.

Efforts to alleviate poverty within the SDG framework, particularly SDG 1, which aims to eliminate poverty in all its forms by 2030, continue to face significant challenges. One of the major obstacles is the impact of the COVID-19 pandemic, which led to a global increase in extreme poverty in 2020 for the first time in 20 years. Additionally, multidimensional poverty, which encompasses income, education, and health (key indicators of human development), affects around 1.3 billion people, primarily in developing countries (Azwardi et al., 2022).

The SDGs advocate for a simultaneous approach, where governments and organizations work to improve human well-being and economic growth while safeguarding environmental benefits. Direct investments in education, health, and economic policies can yield short-term positive effects on poverty reduction. Achieving the SDGs, especially SDG 1 (poverty eradication), requires an integrated approach encompassing human, economic, and environmental development. In the long term, cross-sector collaboration is essential for improving the quality of life and maintaining environmental sustainability, which will foster inclusive growth and sustainable poverty reduction (Sipahutar, 2024; Sumargo & Haida, 2020; Yu & Huang, 2021; Zhu et al., 2022).

In summary, the relationship between economic growth, human development, and environmental quality is crucial for sustainable poverty alleviation. These factors must be addressed collectively to ensure that poverty reduction is both long-term and sustainable. Therefore, this research examines the long- and short-term relationships between these variables within the framework of the Sustainable Development Concept, with a focus on the social aspect (human development), the economic aspect (economic growth), and the environmental aspect (environmental quality) to emphasize poverty trends in Indonesia.

METHODS

The scope of this research is to examine causal relationships over the long and short term between key variables of SDGs across 34 provinces in Indonesia for the period 2010-2022. The data used in this study is quantitative descriptive data, represented in numbers and statistics, either derived directly or through the conversion of qualitative data into quantitative form (Teguh, 2011). This research employs the Panel Vector Error Correction Model (P-VECM) technique, which is appropriate for panel data, combining time series and cross-sectional data.

Secondary data is sourced from records collected by various institutions, such as Indonesia's Central Statistics Agency (BPS), the Ministry of Environment and Forestry (KLHK), the United Nations Development Programme (UNDP), and the International Monetary Fund (IMF), as well as other organizations relevant to the variables in this study.

The data analysis in this research utilizes a quantitative descriptive approach with the P-VECM analysis technique, which integrates both time series and cross-sectional data. The purpose of this method is to identify causal relationships in both the long and short term and to analyze the proportion of influence each variable holds. This approach ensures the data obtained is more valid and that the research results are objective and systematic. Applying the P-VECM technique in examining the relationships between variables such as human development, economic growth, environmental quality, and poverty is an effective econometric approach for understanding long-term and short-term dynamics. This approach has been widely used in studies mapping the SDGs (Gherghina, 2023a, 2023b; Sumargo & Haida, 2020; Zhu et al., 2022).

The specific indicators used in this research include human development, economic growth, environmental quality Index, and poverty. Human development is measured through the HDI, which captures key aspects such as education, health, and the standard of living. An improvement in human development is expected to help reduce poverty by enhancing the skills and well-being of the population, thereby creating better opportunities for economic participation. Economic growth, measured by GDRP per capita, plays a crucial role in poverty reduction, as it increases income per capita and creates more employment opportunities, leading to improved living standards.

The Environmental Quality Index (EQI) is another significant indicator, as poor environmental quality—manifested in issues such as air pollution and environmental degradation—negatively affects human health and productivity, exacerbating poverty. The dependent variable in this study is poverty (PVRTY), which can be measured in relative terms. The independent variables—HDI, GDRP, and EQI—are analyzed to assess their collective impact on poverty within the sustainable development framework.

The Panel Vector Error Correction Model (P-VECM) equations used in this research are as follows:

$$\Delta PVRTY_{\mathrm{it}} = a\,\mathrm{o} + \Sigma_j^n = {}_1\,\beta_1 j\,\Delta PVRTY_{\mathrm{i},t-\mathrm{j}} + \Sigma_j^n = {}_1\,\beta_2 j\,\Delta HDI_{\mathrm{i},t-\mathrm{j}} + \Sigma_j^n = {}_1\,\beta_3 j\,\Delta GDRP_{\mathrm{i},t-\mathrm{j}} + \Sigma_j^n = {}_1\,\beta_4 j\,\Delta EQI_{\mathrm{i},t-\mathrm{j}} + ye_{\mathrm{i},t-\mathrm{j}} + \mathrm{U_{it}} \quad \ldots\ldots\ldots\ldots (1)$$

$$\Delta HDI_{\mathrm{it}} = a\,\mathrm{o} + \Sigma_j^n = {}_1\,\beta_1 j\,\Delta HDI_{\mathrm{i},t-\mathrm{j}} + \Sigma_j^n = {}_1\,\beta_2 j\,\Delta PVRTY_{\mathrm{i},t-\mathrm{j}} + \Sigma_j^n = {}_1\,\beta_3 j\,\Delta GDRP_{\mathrm{i},t-\mathrm{j}} + \Sigma_j^n = {}_1\,\beta_4 j\,\Delta EQI_{\mathrm{i},t-\mathrm{j}} + ye_{\mathrm{i},t-\mathrm{j}} + \mathrm{U_{it}} \quad \ldots\ldots\ldots\ldots (2)$$

$$\Delta GDRP_{\text{it}} = a\,\text{o} + \Sigma_j^n = {}_1\beta_1 j\ \Delta GDRP_{\text{i},t-\text{j}} + \Sigma_j^n = {}_1\beta_2 j\ \Delta PVRTY_{\text{i},t-\text{j}} + \Sigma_j^n = {}_1\beta_3 j\ \Delta HDI_{\text{i},t-\text{j}} + \Sigma_j^n = {}_1\beta_4 j\ \Delta EQI_{\text{i},t-\text{j}} + ye_{\text{i},t-\text{j}} + \text{U}_{\text{it}} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$$\Delta EQI_{\text{it}} = a\,\text{o} + \Sigma_j^n = {}_1\beta_1 j\ \Delta EQI_{\text{i},t-\text{j}} + \Sigma_j^n = {}_1\beta_2 j\ \Delta PVRTY_{\text{i},t-\text{j}} + \Sigma_j^n = {}_1\beta_3 j\ \Delta HDI_{\text{i},t-\text{j}} + \Sigma_j^n = {}_1\beta_4 j\ \Delta GDRP_{\text{i},t-\text{j}} + ye_{\text{i},t-\text{j}} + \text{U}_{\text{it}} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

RESULTS AND DISCUSSION

Data stationary test

Stationarity is a crucial prerequisite in econometric models, particularly when dealing with time series data. Stationary data are characterized by a mean, variance, and autovariance (across various lags) that remain constant over time. This stability implies that the time series model is more reliable. Suppose the data used in a model are not stationary. In that case, the validity and stability of the results must be questioned, as regressions based on non-stationary data can lead to spurious results. A spurious regression occurs when the regression model shows a high R^2 but has no real or meaningful relationship between the variables.

One of the formal methods used to test for data stationarity is the unit root test. A widely used version of this test is the Augmented Dickey-Fuller (ADF) test, developed by David Dickey and Wayne Fuller. Suppose a time series is not stationary at the level of order zero, I(0). The test is applied to the next order of difference, such as the first difference I(1), or even higher until stationarity is achieved. Table 1 presents the results of the stationary data test.

Table 1. Stationary data test results

Variable	Unit Root Test			
	Level		1st difference	
	t-statistic	ADF-test	t-statistic	ADF-Test
PVRTY	73.361	0.249	173.218	0.000
HDI	45.493	0.974	124.212	0.000
GDRP	62.289	0.606	94.262	0.012
EQI	166.348	0.000	215.942	0.000

Based on Table 1, at the level stage, several variables, such as poverty PVRTY, HDI, and GDRP, are not stationary. However, after applying the first difference, all variables become stationary under various conditions. This confirms that the data can be used for further analysis, ensuring the model's stability and validity.

Optimum lag test

To conduct a Granger causality test, determining the appropriate lag length is essential. Rosadi (2012) explains that if the lag length is too short, it may not provide a comprehensive estimation model. In contrast, if it is too long, there is a risk of inefficient estimation results, particularly when the dataset is limited. Several criteria are used to determine the optimum lag, including the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ), with the smallest value being the optimal choice. The results of the optimum lag test in this study are presented in Table 2.

Table 2. Optimum lag test results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-595.430	NA	0.001102	4.541137	4.595318	4.562909
1	-503.422	180.5319	0.00062	3.965315	4.236220*	4.074173
2	-474.74	55.40806	0.000563	3.869241	4.35687	4.065185
3	-446.473	53.74927	0.000513	3.776312	4.480666	4.059343*
4	-419.65	50.19227*	0.000473*	3.694317*	4.615395	4.064434

Based on Table 2, the smallest values for LR, FPE, and AIC are found at lag 4, while SC and HQ show the smallest values at lag 1 and lag 3, respectively. Therefore, this study uses the AIC criterion, and the optimum lag is determined to be lag 4.

VAR stability test

The VAR (Vector Autoregression) stability test is essential to ensure that the Impulse Response Function (IRF) test is valid. If the modulus value from the stability test exceeds 1, the IRF results will be invalid. The results of the VAR stability test in this research are shown in Table 3.

Table 3. VAR stability test results

Root	Modulus
-0.334219 - 0.469825i	0.576574
-0.334219 + 0.469825i	0.576574
0.484346	0.484346
0.079637 - 0.417213i	0.424746
0.079637 + 0.417213i	0.424746
-0.17812	0.178123
-0.13103	0.131027
0.004192	0.004192

As seen in Table 3, all modulus values are less than 1, confirming that the VAR model is stable. Therefore, the results of the IRF test are valid.

Cointegration test

The cointegration test is used to determine whether a long-term relationship exists between the research variables. According to Ajija (2011), variables are considered to have a long-term relationship if they are cointegrated. If no cointegration is found, the variables do not share a long-term relationship. This study applied Johansen's Cointegration Test to analyze the long-term relationship between poverty, HDI, GDRP, and EQI in Indonesia's 34 provinces during the study period. The results are shown in Table 4.

Table 4. Cointegration test results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.812493	555.1624	47.85613	0.0001
At most 1 *	0.440824	168.4824	29.79707	0.0001
At most 2 *	0.116597	34.20404	15.49471	0.0000
At most 3 *	0.023808	5.566064	3.841466	0.0183

The results show that the probability values for all tests are less than 0.05, indicating that the variables are cointegrated. Additionally, both the Max-Eigen Statistics and Trace Statistics are greater than the critical values at a significance level

of 0.05. This confirms that the variables in this study—poverty, HDI, GDRP, and EQI—have a long-term relationship.

Granger causality

Rosadi (2012) explains that the Granger causality test is used to determine whether there is a one-way or two-way relationship between variables. This test was conducted to examine the relationship between PVRTY, HDI, GRDP, and EQI. The results of the Granger causality test are presented in Table 5.

Table 5. Granger Causality test results

Null Hypothesis:	Obs	F-Statistic	Prob.
HDI does not Granger Cause PVRTY	297	0.59097	0.6694
PVRTY does not Granger Cause HDI		0.72025	0.5787
GDRP does not Granger Cause PVRTY	297	0.50094	0.7351
PVRTY does not Granger Cause GDRP		0.05624	0.9941
EQI does not Granger Cause PVRTY	297	0.93216	0.4456
PVRTY does not Granger Cause EQI		0.30326	0.8757
GDRP does not Granger Cause HDI	297	4.19909	0.0025
HDI does not Granger Cause GDRP		9.4559	3.00E-07
EQI does not Granger Cause HDI	297	2.74491	0.0288
HDI does not Granger Cause EQI		2.81188	0.0258
EQI does not Granger Cause GDRP	297	0.85125	0.4937
GDRP does not Granger Cause EQI		1.99746	0.095

Based on the results of the Granger causality test, a relationship exists if the probability value is smaller than the alpha value of 5% (0.05). If the value is greater than 5%, the null hypothesis (H_0) is not rejected, indicating no significant relationship. The following is a detailed explanation of the Granger causality test results for the variables under study:

a. The results show no significant one-way or two-way relationship between the HDI and PVRTY. The probability values for the HDI on PVRTY (0.669) and poverty on the HDI (0.579) are both greater than 0.05, indicating no causal interaction between these variables.
b. There is no significant relationship between GDRP and PVRTY. The probability value for GDRP on PVRTY is 0.735, and for PVRTY on GDRP, it is 0.994. Both values are greater than 0.05, suggesting no causal interaction between these variables.
c. The test results show no significant relationship between the EQI and PVRTY. The probability value for EQI on PVRTY is 0.446, and for PVRTY on EQI, it is 0.876, both of which are greater than 0.05, indicating no causal relationship.
d. The Granger causality test shows a significant two-way relationship between GDRP and the HDI. The probability values are 0.002 for economic growth on the HDI and less than 0.0001 for the HDI on GDRP, both of which are smaller than 0.05. This indicates a bidirectional causal interaction between these variables.
e. The test shows a significant two-way relationship between the EQI and the HDI. The probability values for EQI on HDI (0.029) and for HDI on EQI (0.026) are both less than 0.05, indicating a bidirectional relationship between these variables.
f. There is no significant relationship between EQI and GDRP. The probability value for EQI on GDRP is 0.494, and for GDRP on EQI, it is 0.095, both of which are greater than 0.05. Therefore, no causal interaction exists between these variables.

In summary, the Granger causality test reveals that there is no significant causal relationship between poverty and the other variables (HDI, GDRP, and EQI). However, there is a significant bidirectional relationship between GDRP and HDI, as well as between EQI and HDI.

Empirical Panel Vector Error Correction Model (P-VECM)

After confirming the cointegration relationship between the research variables, the next step is to perform a regression using the Panel Vector Error Correction Model (P-VECM). The P-VECM can explain the long-term relationships between the variables. In this study, the P-VECM results use a lag value of 8, based on the optimum lag test. The significance of the variables is tested using the t-statistic to analyze the influence of the variables. The t-test is performed at a 5% significance level ($\alpha = 0.05$), with a critical t-table value of 1.9655. If the t-statistic is greater than the t-table value, the result is significant, and if it is smaller, the result is not significant.

The long-term results indicate that the only variable with a significant relationship to poverty is HDI, which has a negative impact on poverty. This means that in the long term, an increase in HDI leads to a reduction in poverty. In contrast, economic growth and the Environmental Quality Index (EQI) do not show a significant long-term relationship with poverty, as their t-statistic values are smaller than the critical t-table value of 1.9655 (Table 6).

Table 6. Long term relationships

Cointegrating Eq:	CointEq1
D(PVRTY(-1))	1.00000
D(HDI(-1))	-0.112893
	(0.05531)
	[-2.04111]
D(GDRP(-1))	0.299885
	(0.27617)
	[1.08588]
D(EQI(-1))	-0.004927
	(0.00251)
	[-1.96475]
C	0.049878

In the short term, the HDI has a significant and negative effect on poverty in lags 1 and 2, meaning that an increase in HDI over the past one or two years leads to a reduction in poverty. However, for lags 3 and 4, the effect of HDI on poverty is negative but not significant, suggesting that improvements in HDI three to four years ago have no substantial impact on current poverty levels (Table 7).

GDRP does not show a significant short-term relationship with poverty in any of the lags (1 through 4). This implies that economic growth in the short term does not significantly reduce poverty, reflecting a common issue in developing countries, where high GDRP does not necessarily translate into improved basic living standards or poverty reduction.

EQI shows a significant and negative short-term relationship with poverty across all lags (1 through 4). This suggests that increased poverty is associated with a decline in environmental quality. This negative correlation highlights the cyclical relationship between poverty and environmental degradation: poverty contributes to environmental damage, and environmental degradation exacerbates poverty. In areas with high

poverty, people often overuse natural resources for survival, exceeding the environment's capacity to recover, thereby worsening both poverty and environmental conditions over time. This non-linear, self-perpetuating cycle can lead to a deterioration in both human well-being and the environment.

Table 7. Short Term Relationships

Error Correction:	Coefficient	t-statistic	Information
D(PVRTY(-1),2)	1.634189	[16.3302]	significant positive
D(PVRTY(-2),2)	0.979158	[12.6241]	significant positive
D(PVRTY(-3),2)	0.489618	[9.50353]	significant positive
D(PVRTY(-4),2)	0.163139	[6.41995]	significant positive
D(HDI(-1),2)	-0.320339	[-4.77428]	significant negative
D(HDI(-2),2)	-0.331174	[-4.18736]	significant negative
D(HDI(-3),2)	-0.180065	[-1.69090]	negative is not significant
D(HDI(-4),2)	-0.137146	[-1.49321]	negative is not significant
D(GDRP(-1),2)	0.813413	[1.64699]	positive is not significant
D(GDRP(-2),2)	0.569726	[0.94392]	positive is not significant
D(GDRP(-3),2)	0.419743	[0.59975]	positive is not significant
D(GDRP(-4),2)	0.262253	[0.37285]	positive is not significant
D(EQI(-1),2)	-0.012723	[-5.79701]	significant negative
D(EQI(-2),2)	-0.008174	[-3.12991]	significant negative
D(EQI(-3),2)	-0.005245	[-2.31348]	significant negative
D(EQI(-4),2)	-0.001429	[-1.08439]	significant negative

Impulse Response Function

The Impulse Response Function (IRF) test is used to analyze how shocks to one variable affect other variables in a model. In this research, the IRF is employed to assess the response of variables within P-VECM, focusing on the relationship between PVRTY, HDI, GDRP, and EQI. The vertical axis of the IRF graph shows the magnitude of the response, while the horizontal axis represents the periods into the future. The IRF allows us to observe whether the response is positive or negative over time. The results of the IRF test are shown in Table 8.

Table 8. Impulse Response Function test results

Response of D(PVRTY): Period	D(PVRTY)	D(HDI)	D(GDRP)	D(EQI)
1	0.233477	0.00000	0.00000	0.000000
2	-0.19032	0.011789	-0.01059	0.022069
3	0.006149	-0.01071	-0.00314	0.008371
4	0.008965	0.036798	-0.00344	0.004024
5	0.010052	-0.00453	0.002407	0.013468
6	0.011357	0.012778	-0.01174	0.006363
7	0.012935	-0.00229	0.000253	0.005688
8	-0.0209	0.005976	-0.00076	0.01332
9	0.00144	0.011606	-0.00811	0.006502
10	0.005583	0.011699	0.000946	0.008639

Based on Table 8, it can be explained that the poverty variable responded negatively during the three shock periods influenced by the human development index variable, specifically in periods 3, 5, and 7. Meanwhile, the environmental quality index variable exhibited a consistently positive response, indicating that both at the beginning

and end of the period, it showed positive values for poverty. In contrast, the economic growth variable tended to respond negatively to poverty.

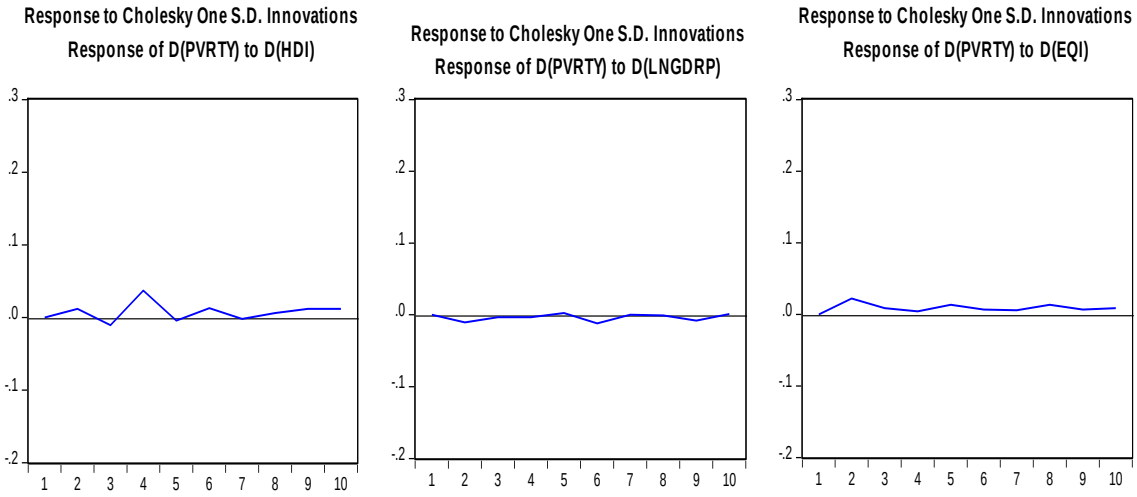

Figure 1. Impulse Response Function

The IRF for the human development index shows a tendency to fluctuate between positive and negative values. The table above indicates that the human development index exhibits a shock of 0.0570 in period 10. Thus, certain periods, such as periods 3, 5, and 7, negatively affect poverty, suggesting that an improvement in the quality of human life reduces poverty.

Referring to the graph, it is evident that the economic growth variable demonstrates both positive and negative responses under various conditions during that period. It can be interpreted that when economic growth in Indonesia decreases under certain conditions, poverty tends to rise, even though the percentage of poor people may decline. However, if a shock is too large—approaching a magnitude of nearly 7—the result is negative. This means that such a significant shock to economic growth would increase poverty. Overall, this indicates instability in the relationship between economic growth and poverty throughout most of the period.

The response shown by the environmental quality variable remains consistently above or along the horizontal line, indicating a permanent positive response. From the first to the tenth period, the results are positive. Therefore, an increase in environmental quality—referring to worsening conditions such as poor land cover, air quality, and water quality—leads to a corresponding increase in poverty in Indonesia.

Varian Decomposition (VD)

This test was conducted to determine the extent to which each variable contributes to other variables (Winarno, 2015). Unlike IRF, which illustrates the impact of a shock, the VD test highlights the importance of each variable within the VAR/VECM model in response to a shock, indicating how strongly one variable influences others (Table 9).

Based on the VD test results above, it can be explained that the variable predicted to contribute the most to poverty over the next 10 years is poverty itself, with an average annual contribution of 97.62 percent. This is followed by the contribution of HDI at 1.39 percent, economic growth at 0.21 percent, and environmental quality at 0.76 percent. While poverty will continue to provide the largest contribution on average each month over the next 10 years, its contribution will decrease slightly each year, in

contrast to HDI, economic growth, and environmental quality, whose contributions will gradually increase over time.

Table 9. Variance Decomposition test results

Variance Decomposition of D(PVRTY):					
Period	**S.E.**	**D(PVRTY)**	**D(HDI)**	**D(GDRP)**	**D(EQI)**
1	0.233477	100.0000	0.000000	0.000000	0.000000
2	0.30244	99.19293	0.151941	0.122685	0.532441
3	0.302825	98.98269	0.276655	0.133142	0.607512
4	0.30523	97.51512	1.72578	0.143742	0.615356
5	0.305735	97.30117	1.741985	0.149463	0.807379
6	0.306504	96.95102	1.907047	0.295492	0.846438
7	0.306838	96.91766	1.90846	0.294917	0.87896
8	0.307896	96.71337	1.933039	0.293495	1.060096
9	0.308293	96.46641	2.069777	0.361973	1.101842
10	0.308688	96.25254	2.208132	0.361986	1.177344

Discussion

The relationship between human development and poverty

The results indicate that the human development index and poverty do not have a two-way causal relationship, as shown by the probability value being greater than the 5 percent alpha level. However, in the P-VECM model, the long-term relationship shows that the human development index has a negative coefficient and a significant effect on poverty. In the short term, it also exhibits a significant negative relationship in lags 1 and 2, although in lags 3 and 4, it has no significant effect on poverty. This suggests that the human development index is negatively correlated with poverty in both the long and short term. In other words, improvements in human development—reflected in components such as a long and healthy life, increased knowledge, and a decent standard of living—lead to a reduction in poverty in Indonesia.

These findings are consistent with research by Trisno et al. (2021), which found that the human development index and poverty have a negative correlation and a significant impact. The shift in the development paradigm from a state-centric approach to one that emphasizes the role of society cannot be realized if poverty levels remain high. This is because poor individuals are often preoccupied with meeting their basic needs, leaving them less inclined to engage in activities unrelated to survival. The research highlights that a higher population of poor individuals tends to lower human development, as poverty restricts purchasing power.

When individuals are not poor, they are better able to meet their basic needs, such as food, education, and health services. Poor people, once provided with opportunities to continue their education and access healthcare, can improve their overall quality of life. This, in turn, enhances the human development index. Although indirect, increasing the human development index through education and healthcare for people experiencing poverty has a positive impact on employment opportunities, productivity, and income, helping to break the cycle of poverty (Mirza, 2012; Putra & Anis, 2022).

This aligns with the goals of the SDGs, particularly Goal 1: No Poverty, which aims to eradicate poverty in all its forms by 2030. One of the targets is to build resilience among people experiencing poverty and those in vulnerable situations by reducing their exposure to climate-related extreme events and economic, social, environmental, and disaster-related shocks. The analysis in this study strengthens these

findings by mapping the achievement of the SDGs across regions using Cartesian diagram mapping (Figure 2).

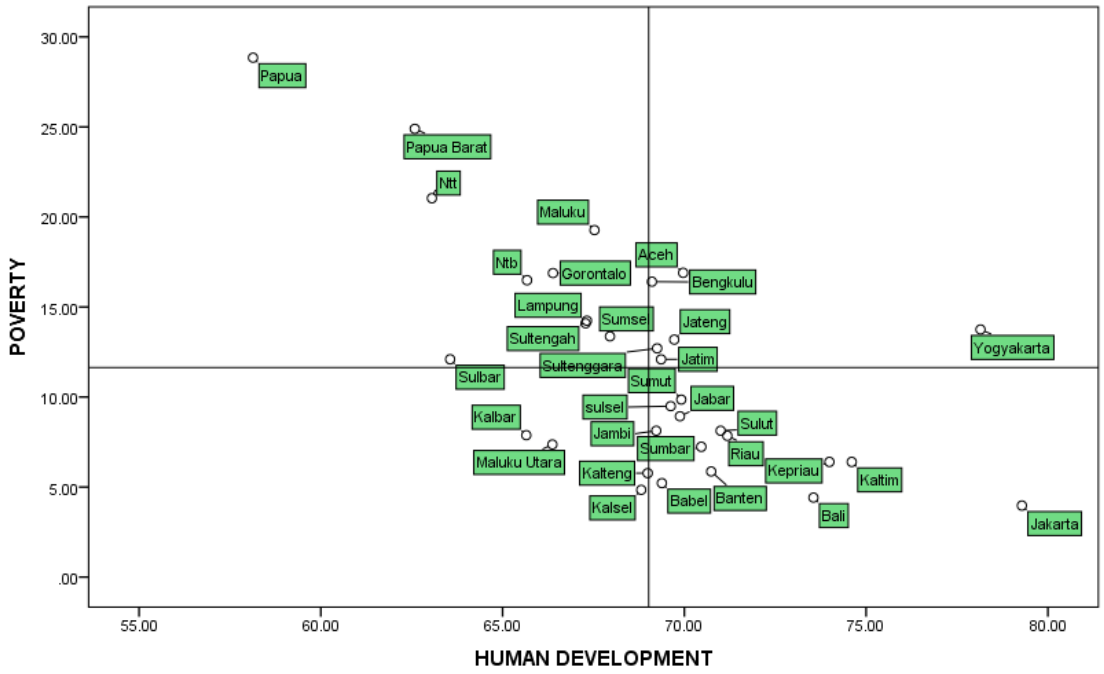

Figure 2. Opportunities to achieve SDGs through human development and poverty in Indonesia

Based on a 10-year analysis using a Cartesian diagram, it is clear that regions with high poverty levels tend to have low human development indices. For instance, Papua has an average poverty rate of 28.8 percent and a HDI of 58.13. West Papua has an average poverty rate of 24.89 percent with an HDI of 62.58, and East Nusa Tenggara also reflects similar trends. In contrast, regions with low poverty levels and high human development indices, such as Jakarta, East Kalimantan, Bali, and the Riau Islands, show strong potential for realizing the SDGs. These provinces demonstrate that human development is a critical indicator in measuring success in poverty alleviation efforts and that the HDI can help determine a region or country's development ranking.

In conclusion, the HDI reflects several key dimensions, such as long and healthy lives, enabling individuals to work longer and contribute more to the economy. Moreover, higher education increases employment opportunities and creativity, boosting income levels and, in turn, enhancing purchasing power. Increased income allows for greater consumption, enabling individuals to meet their needs and escape poverty. Therefore, improving HDI can significantly reduce poverty (Diniati & Permana, 2024).

The relationship between economic growth and poverty

The Granger causality test results indicate that there is no two-way causal relationship between economic growth and poverty, as the probability value is greater than the 5 percent alpha level. In both the long-term and short-term analysis using the P-VECM model, economic growth has no significant effect on poverty, as shown by the t-statistic being larger than the critical t-table value. This suggests that in the near future, economic growth alone will not be a key factor in alleviating poverty.

These findings are consistent with research by Elviani et al. (2018), which also found that economic growth does not have a significant impact on poverty reduction.

According to Todaro & Smith (2014), growth should, in theory, reduce poverty based on the "trickle-down theory." However, when increased employment opportunities do not accompany economic growth, it can lead to income inequality, where economic growth is coupled with rising poverty.

In this study, it is observed that while economic growth occurs, it is often accompanied by an increase in poverty, though this effect is not substantial. Economic growth, typically measured by the growth of Gross Domestic Product (GDP), reflects an increase in the production of goods and services in a region. However, economic growth alone is insufficient for poverty reduction. For growth to effectively alleviate poverty and reduce unemployment, it must be complemented by deliberate policies aimed at redistributing income. These policies should focus on sectors that directly impact people experiencing poverty, such as agriculture, and invest more in human capital.

Moreover, economic development strategies must prioritize quality growth that empowers local communities to participate as active agents in development. With technological advancements reducing labor demand, it is essential to ensure that growth is accompanied by job creation. Without such initiatives, economic growth could exacerbate income inequality, as income generated by growth will primarily benefit wealthier segments of society, leaving the poor behind (Elviani et al., 2018).

One of the reasons why economic growth does not significantly reduce poverty in Indonesia, either in the short or long term, is the quality of the growth itself. Not all forms of economic growth lead to poverty reduction. For instance, if growth is concentrated in capital-intensive and high-tech sectors, the benefits may not be widely distributed, particularly to people experiencing poverty (Sumargo & Haida, 2020).

Income distribution is a crucial factor in eradicating poverty. If economic growth is not paired with a more equitable distribution of income, inequality could worsen. If only a small fraction of wealthy individuals benefit from economic growth, poverty alleviation will be limited, even if the economy grows overall (Ferreira et al., 2023). Therefore, government intervention through redistributive policies such as investments in education, health, and infrastructure is essential to amplify the positive effects of economic growth on poverty reduction. Without these policies, the impact of growth on poverty may be minimal (Saidi et al., 2023; Yu & Huang, 2021).

Based on a 10-year analysis using a Cartesian diagram (Figure 3), it is clear that regions with high economic growth are also often regions with high poverty levels. For example, East Java, Central Java, and South Sumatra are areas where high economic growth has not led to significant poverty reduction. This suggests the presence of high inequality in these regions, contradicting Kuznets' theory, which posits that, in the long run, high economic growth reduces inequality. Moreover, Hischman's Trickle-Down Effect is not evident in these areas.

Conversely, regions with the potential to successfully achieve the SDGs in Indonesia include DKI Jakarta, West Java, East Kalimantan, North Sumatra, Riau, and Banten. These provinces have relatively lower poverty rates and higher economic growth. On the other hand, provinces such as Papua, West Papua, East Nusa Tenggara, Maluku, Gorontalo, Aceh, Bengkulu, and Lampung, which experience both high poverty and low economic growth, highlight the fact that economic growth has not been successful in reducing poverty in these regions. This indicates that growth is not evenly distributed across society, benefitting primarily the upper and middle classes while leaving the lower-income groups, including people experiencing poverty, without

significant improvements in their economic situation. This uneven distribution of the benefits of growth contributes to the slow pace of poverty reduction.

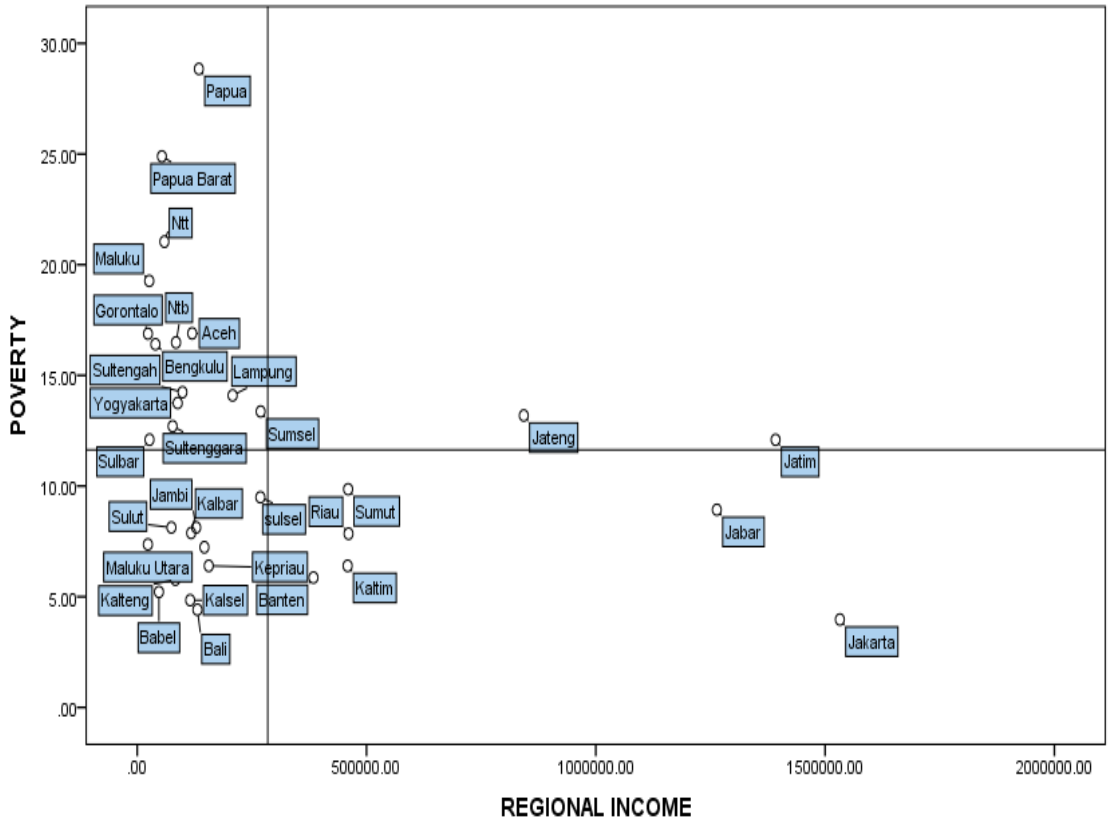

Figure 3. Opportunities to achieve through economic growth and poverty in Indonesia

The relationship between environmental quality and poverty

The results of the Granger causality test presented above indicate that environmental quality and poverty do not have a two-way causality relationship, as the probability value is greater than the 5% alpha level. Moreover, the P-VECM model suggests that both long-term relationships lack a significant influence. During the analysis period in Indonesia, no significant relationship between environmental quality and poverty was observed. This condition is believed to be due to shrinking natural resources, diminishing land ownership resulting from land conversion, and environmental protection regulations that the government is firmly enforcing. However, in the short term, across all lags from 1 to 4, there is a negative coefficient, indicating a significant effect between the environmental quality index and poverty. This implies that when environmental quality—such as clean water, air quality, and effective land cover—improves, poverty levels decrease.

The test results further reveal that the environmental quality index is negatively but insignificantly related to poverty. Research by Amponsah et al. (2023) also demonstrates a negative and insignificant impact of poverty incidence on the environmental quality index. The study suggests that the higher the poverty rate, the worse the environmental quality in that region. Long-term environmental degradation and poverty lead to numerous issues, including environmental damage and health problems. Poverty forces individuals to resort to extreme measures to meet their basic

needs, which may include illegal activities like logging, contributing to environmental destruction.

Poverty and environmental degradation are negatively correlated and mutually influence each other. Environmental damage can exacerbate poverty, and poverty can further deteriorate the environment, creating a vicious cycle. As this cycle persists, poverty worsens, and environmental conditions continue to decline. Over time, this situation becomes chronic, with poverty levels intensifying from poor to very poor, mirroring the escalating environmental damage. This is characterized by human activities that exceed the natural carrying capacity. Poor people often rely on excessive exploitation of natural resources for survival, which leads to environmental degradation (Finanda & Gunarto, 2021). Poor households in Indonesia typically depend on firewood from forests or gardens for fuel, which negatively impacts EQI. Several mappings support these findings by examining the achievement of SDGs across regions using Cartesian diagram mapping (Figure 4).

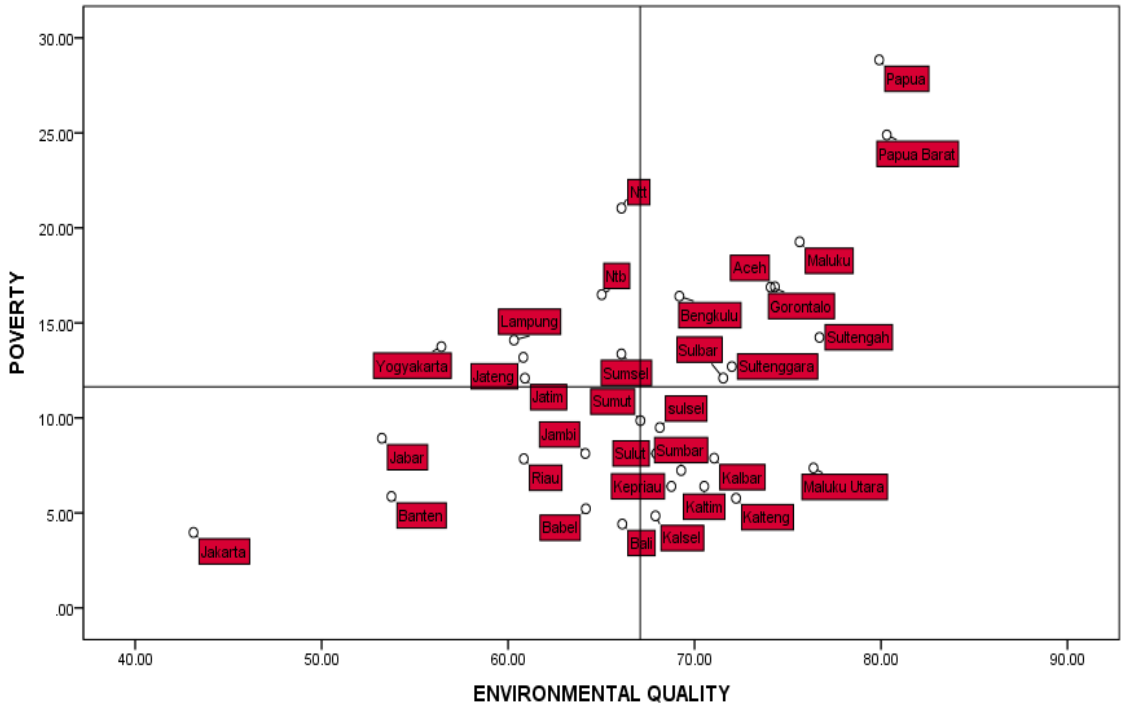

Figure 4. Opportunities to achieve SDGs through environmental quality and poverty in Indonesia

Figure 4 illustrates a Cartesian diagram analysis of four quadrants based on data over an average of 10 years. This analysis supports the short-term results, which demonstrate a significant negative correlation between the environmental quality index and poverty. Regions such as North Maluku, much of Kalimantan, West Sumatra, South Sulawesi, and the Riau Islands show a high level of environmental quality coupled with a low level of poverty. These regions present great potential as areas with an even and balanced achievement of SDGs.

Conversely, regions such as Papua, West Papua, Maluku, Aceh, Gorontalo, Central Sulawesi, Bengkulu, Southeast Sulawesi, and West Sulawesi exhibit high levels of environmental quality, which are comfortable and acceptable to the community but also have high poverty rates. These areas rely heavily on the excessive use of natural resources, exceeding the carrying capacity of the environment.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This research examined the concept of sustainable development (SDGs) by considering three key aspects: the human development index (social), economic growth (economic), and the environmental quality index (environmental) in the context of reducing poverty in Indonesia, using the Panel Vector Error Correction Model (PVECM). The results showed that there is no one-way or two-way causal relationship between these variables, as indicated by the Granger causality test. In the long term, only the human development index has a significant and negative relationship with poverty. In contrast, economic growth and the environmental quality index do not exhibit a significant long-term impact on poverty levels in Indonesia.

In the short term, the human development index has a significant and negative effect on poverty alleviation. As poverty decreases, basic needs such as food, education, and healthcare are more accessible, improving the quality of life. This improvement, in turn, raises the human development index as people gain access to education, healthcare, sanitation, and clean water. Although the human development index may not have an immediate direct impact, improving education and healthcare for poor populations increases employment opportunities and productivity, leading to higher incomes and ultimately helping people escape poverty.

Conversely, the short-term relationship between economic growth and poverty is less tangible. The analysis indicates that economic growth does not necessarily reduce poverty; in some cases, it may even have a positive effect on poverty. Economic growth reflects increased production of goods and services. However, for economic growth to be an effective tool in poverty reduction, it must be accompanied by policies aimed at redistributing income and investing in human capital.

Poverty and environmental quality have a significant short-term relationship, with improvements in environmental conditions leading to faster poverty reduction. The analysis suggests that enhancing environmental quality, such as access to clean water, better air quality, and more effective land use, can significantly reduce poverty. While the specific mechanisms were not examined in this study, higher agricultural productivity and improved environmental services likely contribute to this relationship. Further research is needed better to understand these channels and their impact on poverty reduction.

Recommendations

To effectively reduce poverty through human development, the focus should be on increasing access to education and healthcare for all levels of society. This includes improving the quality of education and expanding skills training programs to enhance employment opportunities. In addition, expanding access to affordable healthcare, promoting good health and nutrition, and implementing social safety nets, such as health insurance and cash assistance for vulnerable groups, are essential to improving the quality of life and alleviating poverty.

In terms of economic growth, it is essential to implement inclusive strategies that benefit all levels of society. This includes investing in infrastructure development in remote and impoverished areas to improve connectivity and access to markets, education, and healthcare services. Such efforts can reduce income inequality and increase productivity. Furthermore, policies should focus on progressive taxation and income redistribution to ensure that the benefits of economic growth reach the poorest

segments of the population. Economic diversification is also crucial, with a need to develop various sectors such as manufacturing, technology, and tourism to reduce reliance on the primary sector. Finally, green economic policies should be adopted, promoting sustainable development through investment in renewable energy and responsible management of natural resources.

Environmental quality plays a vital role in poverty reduction, particularly in rural areas where agricultural productivity and environmental services are critical for livelihoods. Improving environmental quality, such as through better land management, water conservation, and air quality improvements, can have a direct impact on poverty reduction. Therefore, policies should aim to preserve and enhance the natural environment while supporting the livelihoods of poor communities, ensuring that environmental sustainability is integrated into poverty alleviation strategies.

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