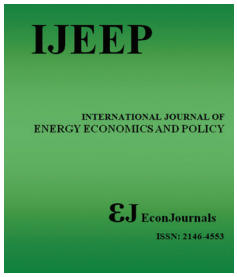


International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(3), 60-67.

Nexus Among Carbon Dioxide Emissions, Gross Domestic Product, Average Years of Schooling on Life Expectancy at Birth in Indonesia

Heru Wahyudi*, Sandra Mei Leny

Faculty of Economics and Business, University of Lampung, Bandar Lampung, Indonesia. *Email: heru.wahyudi@feb.unila.ac.id

Received: 20 October 2024 **Accepted:** 05 March 2025 **DOI:** https://doi.org/10.32479/ijeep.18197

ABSTRACT

Indonesia faces a critical challenge in balancing economic growth with environmental sustainability and improving people's welfare. As one of the countries with the largest carbon dioxide emissions in the world, increasing carbon emissions have negatively impacted environmental quality, health and life expectancy. This study aims to analyse the relationship between carbon dioxide emissions, gross domestic product and average years of schooling on life expectancy in Indonesia, with human development index (HDI) as a mediating variable. Using 12 years of data sourced from the Central Bureau of Statistics and the World Bank, this study applies a quantitative approach with Sobel test analysis to identify the direct and indirect effects of these variables through HDI. The results of the analysis show that carbon dioxide emissions have a significant negative impact on HDI, which in turn reduces life expectancy. In contrast, GDP and average years of schooling have a positive influence on HDI and life expectancy. However, the disparity in the distribution of GDP benefits and access to education between regions remains a major obstacle in improving human development equitably. This study confirms that HDI acts as an important mediator that strengthens the relationship between economic, social and environmental variables and life expectancy. The findings have significant policy implications, including the reduction of carbon emissions through sustainable strategies, increased investment in the education sector, and a more equitable redistribution of economic benefits. These evidence-based recommendations support the achievement of the sustainable development goals (SDGs) in Indonesia and make an important contribution to the development of scientific literature related to human development.

Keywords: Carbon Dioxide Emissions, Gross Domestic Product, Mean Years of Schooling, Life Expectancy, Human Development Index, Sobel Test
JEL Classifications: Q56, I15, I25, O13

1. INTRODUCTION

Indonesia is one of the developing countries with rapid economic development dynamics in recent decades. Indonesia's gross domestic product has increased significantly from USD 800 in 1990 to more than USD 4,000 in 2022. This increase represents an economic transformation driven by industrialisation, urbanisation and energy sector expansion (Rahman and Lee, 2021). However, behind this progress, there are complex challenges related to the sustainability of development, especially its impact on human well-being amid increasing carbon dioxide (CO_2) emissions (Haq et al., 2023).

As one of the largest CO_2 emitters, Indonesia's carbon emissions have more than doubled since 1990 (Wijaya et al., 2023). Based on World Bank data, Indonesia's CO_2 emissions reached more than 600 million tonnes in 2020, mostly from fossil fuel use, deforestation and peatland conversion (Putri and Anwar, 2023). This poses a serious challenge to climate change mitigation, which in turn impacts people's quality of life, including life expectancy at birth. Empirical evidence shows that CO_2 emissions contribute to reduced air quality, increased risk of chronic diseases, and reduced public health, especially in areas with limited access to health services (Yusuf et al., 2023).

Life expectancy in Indonesia has increased from 65 years in 1990 to around 73 years in 2022 (Prasetyo et al., 2023). However, disparities between regions remain a major issue. In Papua Province, life expectancy at birth is still below 65 years, while in the Special Region of Yogyakarta it has reached more than 75 years (Santoso and Firmansyah, 2022). These inequalities reflect differences in the human development index (HDI), which integrates the dimensions of education, health and income as indicators of well-being (Rahman and Hidayat, 2023).

The education factor, measured through average years of schooling, also provides an important picture. By 2022, the average years of schooling in Indonesia will reach 8.69 years, still far from the target of 12 years of compulsory education (Suryadi and Wibowo, 2023). In regions with low HDI, the average years of schooling is even lower, which exacerbates inequality in access to education and opportunities to improve welfare (Rahayu et al., 2023). Low education can affect people's ability to understand and access health information and reduce the potential for active participation in economic activities.

Previous research has shown that CO_2 emissions, GDP and average years of schooling have a complex relationship with life expectancy (Hossain and Chen, 2021). However, few studies have examined this relationship in depth by considering HDI as a mediator variable. The role of HDI as a multidimensional indicator may provide a more holistic understanding of how economic development and education can mitigate the negative impact of carbon emissions on quality of life (Prasetyo and Wijaya, 2022).

The urgency of this research lies in its relevance to Indonesia's development context, which currently faces the challenge of balancing economic growth, environmental protection, and improving people's welfare. Indonesia's commitment to reduce carbon emissions by 29% by 2030, as stated in the Nationally Determined Contributions (NDC), requires a strategy that is based on scientific evidence (Wardani and Pratama, 2022). However, without an in-depth understanding of the mechanisms through which carbon emissions affect welfare indicators such as life expectancy, such efforts risk losing focus and effectiveness.

In addition, this research is important to support the achievement of the sustainable development goals (SDGs), especially on goals related to health (SDG 3), quality education (SDG 4), and action on climate change (SDG 13). By exploring the role of HDI as a mediator, this research can provide strategic insights for data-driven and implementable policy formulation to reduce the negative impact of carbon emissions on human well-being.

2. LITERATUR REVIEW

2.1. Carbon Dioxide Emissions

Carbon dioxide emissions are one of the main causes of climate change that affects human health and quality of life. A study by (Wang et al., 2023) highlights the negative relationship between CO_2 emissions and life expectancy, where increasing CO_2 concentrations in the air contribute to the risk of respiratory and cardiovascular diseases. This is exacerbated in developing countries that have limited health infrastructure.

The Environmental Kuznets Curve (EKC) model provides a perspective on the non-linear relationship between economic development and environmental degradation. According to (Kuznets, 1955), in the early stages of development, carbon emissions increase with economic growth. However, at a certain income level, people begin to adopt environmentally friendly technologies that reduce the negative impact of carbon emissions (Shahbaz et al., 2022).

2.2. Gross Domestic Product (GDP)

Gross Domestic Product is a key indicator of economic and social well-being. Studies by (Liang et al., 2023) show that GDP growth is positively correlated with increased life expectancy, largely due to greater budgetary allocations to the health and education sectors. However, this positive effect is contingent on equitable income distribution (Ahmed and Khan, 2022).

In Indonesia, economic inequality remains a significant challenge. Although national GDP shows an increasing trend, disparities between regions may limit the benefits of economic growth for certain groups of people (Setiawan et al., 2023). For example, regions with low levels of development have lower life expectancy despite significant contributions to national GDP through the exploitation of natural resources (Putri and Hartono, 2022).

2.3. Mean Years of Schooling

Education acts as a catalyst in improving the quality of life. (Cheng et al., 2022) noted that higher mean years of schooling increases people's awareness of health and healthy lifestyles, which in turn leads to increased life expectancy. In addition, education also expands access to relevant information and technology to deal with health and environmental challenges.

Data in Indonesia shows that the national average years of schooling is only 8.69 years, reflecting the challenges in achieving equitable education (Sari et al., 2023). This inequality has implications for regional differences in quality of life, with rural areas generally having lower average years of schooling and shorter life expectancy compared to urban areas (Lestari and Widodo, 2022).

2.4. Human Development Index

The Human Development Index integrates three main dimensions of human well-being, namely health as a proxy variable for life expectancy, education as a proxy variable for average years of schooling and expected years of schooling, and GDP. Its role as a mediator has been widely discussed in cross-country research. (Hossain and Chen, 2021) showed that the Human Development Index can strengthen the positive relationship between GDP and quality of life, and reduce the negative impact of CO_2 emissions on human well-being.

However, in Indonesia, the disparity in Human Development Index between regions remains a major challenge. Provinces with high human development index such as DKI Jakarta and Yogyakarta show better life expectancy and average years of

schooling, while regions such as Papua and Nusa Tenggara have much lower Human Development Index values. This highlights the importance of the Human Development Index as a mediator that reflects inequality in the distribution of Development benefits (Rahmat and Prasetya, 2022).

3. RESEARCH METHODOLOGY

3.1. Scope of Research

This study analyses the effect of carbon dioxide (CO_2) emissions, gross domestic product, and average years of schooling on life expectancy at birth in Indonesia, with the human development index serving as a mediator. The study covers the period 2010-2021, which was chosen to reflect the socio-economic and environmental dynamics that have occurred in Indonesia in the last decade, including changes in environmental policies and climate change mitigation efforts. The data used in this study are sourced from the Central Bureau of Statistics and the World Bank. Methodologically, this study uses a quantitative approach using the Sobel test to test the mediating role of HDI in the influence of CO_2 emissions, GDP, and education on life expectancy.

3.2. Statistical Analysis

Statistical analysis is a systematic process that includes collecting, organizing, interpreting and presenting quantitative data using statistical techniques to identify patterns, trends and relationships in the data (Gao et al., 2023). In the context of this research, statistical analysis is used to evaluate the relationship between carbon dioxide (CO_2) emissions, gross domestic product (GDP), average years of schooling, and life expectancy at birth in Indonesia, with the human development index (HDI) acting as a mediator. This research aims to provide deeper empirical insights into the interactions between economic, social and environmental factors in Indonesia, as well as policy implications for achieving inclusive sustainable development (Sugiarto et al., 2022).

3.3. Sobel Test

Testing the mediation hypothesis can be done with a procedure developed by (Sobel, 1982) known as the Sobel test. The Sobel test is carried out by testing the strength of the indirect effect of the independent variable (X) on the dependent variable (Y) through the intervening variable (Z). The calculation of the Sobel test is as follows (Riyanto and Hatmawan, 2020):

$$Sab = \sqrt{b^2Sa + a^2Sb^2 + Sa^2Sb^2}$$

Description:
Sab: Standard Error a and b
a: Regression coefficient of the independent variable to the mediator variable
b: Regression coefficient of the mediator variable to the dependent variable
Sa: Standard Error a
Sb: Standard Error b

Then, to test the significance of the indirect effect, it is necessary to calculate the Z-count value of the ab coefficient with the following formula:

$$Z_{hitung} = \frac{ab}{Sab}$$

To test the effect of indirect variable changes, it is seen from the significance compared to the α level (5% = 0.05).

Criteria:
H_0 is rejected or Ha is accepted if the significance <0.05
H_0 is accepted or Ha is rejected if the significance >0.05.

4. RESULTS AND DISCUSSION

4.1. Statistical Analysis

Descriptive Statistical Analysis functions in descriptions that include the mean and median of a set of sorted data. In addition, this analysis includes data distribution such as maximum value, minimum value, and standard deviation value as an indicator of data distribution in the study (Jin et al., 2023).

Based on Table 1 the results of descriptive statistical analysis show significant variations among the research variables, namely carbon dioxide emissions (X1), gross domestic product (X2), average years of schooling (X3), life expectancy at birth (Y), and human development index (Z). Carbon dioxide emissions have an average of 534.09 with a range of values between 434.57 and 636.79. This variation reflects significant differences in carbon emission levels between regions and periods in Indonesia. This may reflect factors such as the level of industrialisation, environmental policies, and energy consumption patterns that vary across provinces (Setiawan et al., 2023).

GDP has an average value of 4.65, with a maximum value of 6.22 and a minimum of −2.07. Negative values in GDP indicate a significant economic contraction in some regions or periods, potentially related to global economic fluctuations, domestic policy changes, or other external factors. This variation in GDP indicates economic inequality between regions, which may affect each region's capacity to improve quality of life and human development (Rahman and Chen, 2022).

The average years of schooling was recorded at 7.94, with a maximum value of 8.54 and a minimum of 7.46. This relatively small variation suggests that despite improvements in access to education nationally, disparities in the quality of education and the distribution of education facilities remain an important issue, especially in remote or limited access areas (Mulyadi and Nugraha, 2023).

Life expectancy at birth has an average of 70.78, with a range of values between 69.81 and 71.57. This relatively narrow distribution reflects the general stability of health indicators at the national level. However, this small variation can still provide an indication of certain regions lagging behind in terms of access to health services and living standards (World Health Organization, 2023).

The HDI recorded an average value of 69.72 with a maximum value of 72.29 and a minimum of 66.53. This range indicates that

Table 1: Statistical analysis

Descriptive statistics	X1	X2	X3	Y	Z
Mean	534.0900	4.649813	7.944167	70.77750	69.71750
Median	509.1815	5.051428	7.895000	70.84000	69.86500
Maximum	636.7911	6.223854	8.540000	71.57000	72.29000
Minimum	434.5687	−2.065512	7.460000	69.81000	66.53000

Source: Data analysis results, 2024

there are disparities in human development achievements between regions. A higher HDI in a particular region may reflect success in the integration of education, economic, and health policies, while a lower HDI indicates the need for more focused policy interventions to improve quality of life (Setiawan and Kusuma, 2023). Overall, variations in GDP, carbon emissions, and average years of schooling provide a basis for exploring how these factors contribute to life expectancy at birth, either directly or through the mediation of HDI.

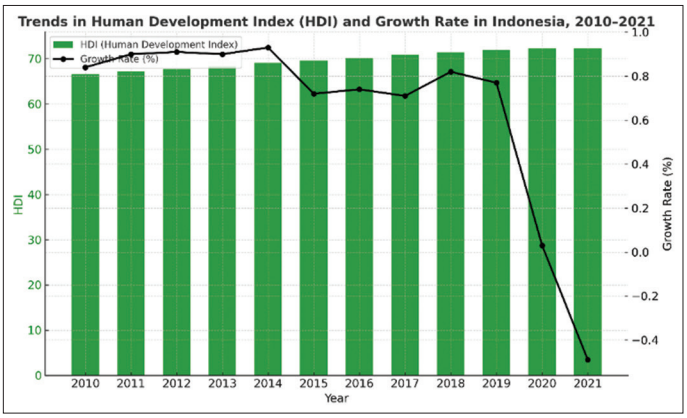
Figure 1 shows the trend of the human development index and its growth rate in Indonesia over the period 2010-2021. Overall, while Indonesia experienced a consistent increase in HDI, the rate of growth was uneven across regions. Several factors, such as unequal distribution of resources, limited access to education and healthcare, and the impact of increased carbon emissions, have contributed to fluctuations in HDI growth.

Based on Figure 1, it can be seen that while Indonesia's human development index (HDI) has increased from 66.53 in 2010 to 72.29 in 2021, there have been significant fluctuations in its growth rate, especially in recent years. The decline in the HDI growth rate, seen in 2019-2021, can be explained by considering factors such as inequality in resource distribution, disparities in access to education and healthcare, and increased carbon emissions affecting people's quality of life.

These fluctuations in growth reflect the huge challenges in human development that are not only influenced by economic growth, but also by interrelated social and environmental factors. For example, despite Indonesia's steady increase in GDP, economic inequality between regions remains a major issue, leading to disparities in HDI achievement. Regions with higher economic growth, such as Jakarta and Bali, show better HDI compared to underdeveloped regions, such as Papua and Maluku, which are still struggling to improve the quality of life of their people. This suggests that despite progress at the macroeconomic level, the distribution of development benefits remains highly uneven at the micro level (Fankhauser and Kallbekken, 2022).

In addition, increasing carbon dioxide emissions, mostly from fossil fuel use and deforestation, contribute to fluctuations in HDI. Air pollution resulting from carbon emissions not only impacts health, but can also hinder people's ability to access quality education and employment (Andrian et al., 2024). Therefore, despite the improvement in the overall HDI, inequality and the negative impacts of carbon emissions hinder the potential for sustainable human development.

Figure 1: Trends in Human Development Index (HDI) and Growth Rate in Indonesia 2010 - 2021



Source: Central bureau of statistics, 2024

4.2. Mediation Analysis of HDI in the Relationship between Carbon Emissions and Life Expectancy in Indonesia

Based on Table 2, it is found that the human development index (HDI) variable acts as a significant mediator in the relationship between carbon dioxide emissions (X1) and life expectancy at birth (Y). The analysis shows that the direct path coefficient from X1 to Z is negative −0.000514, indicating that an increase in carbon dioxide emissions tends to decrease HDI. This is consistent with the sustainable development theory, which states that economic activities that produce high carbon emissions can damage the environment and the quality of human life, thus negatively impacting the dimensions of education, health and living standards, which are reflected in HDI. Furthermore, the path coefficient from Z to Y is positive at 0.380435 which indicates that an increase in HDI significantly contributes to an increase in life expectancy. This finding is consistent with human capital theory, which emphasises the importance of education and health as key assets in improving productivity and quality of life, including life expectancy (Becker, 1993).

The Sobel test statistic value of −2.58883484 and P = 0.00963 confirm that this mediation relationship is significant at the 95% confidence level. With a P-value smaller than 0.05, it can be concluded that the mediation path through HDI (Z) has a real contribution to the relationship between carbon dioxide emissions and life expectancy. In addition, the standard error value of 0.00007553 indicates a high level of accuracy in the estimation of the mediation parameters, which supports the stability of the analysis results.

Theoretically, these results are also in line with the epidemiological transition theory, which explains that increasing carbon dioxide emissions contribute to air pollution that affects disease patterns in society. Air pollution can increase the prevalence of chronic diseases such as respiratory and cardiovascular diseases, ultimately reducing life expectancy (Guhathakurta et al., 2023). However, the role of HDI as a mediator suggests that better education (average years of schooling) and higher quality of life can mitigate these negative impacts. This confirms the importance of the human development dimension in mitigating environmental impacts on public health.

Table 2: Sobel Test Results to Test the Mediating Role of Human Development Index in the Relationship between Carbon Emissions and Life Expectancy in Indonesia

Descriptive statistics		Test statistic	Std. Error	p-value
-0.00045	Sobel test	-2.5888348	0.0000755	0.0096301
0.380435	Aroian test	2.58778259	0.0000755	0.0096595
0.000198	Goodman test	2.58988883	0.0000755	0.0096007
0.010880	Reset all		Calculate	

Source: Data analysis results, 2024

Overall, these results emphasize that carbon dioxide emissions not only have an indirect impact through lower HDI, but also a direct impact on life expectancy through environmental damage (Wahyudi et al., 2024). Therefore, based on the theory of sustainable development, policies to reduce carbon emissions are very important to support better human development. This research provides insight that improving the quality of education, health and living standards can be an effective strategy to overcome the challenges posed by carbon emissions in Indonesia.

4.3. Mediation Analysis of HDI in the Relationship between GDP and Life Expectancy in Indonesia

Table 3 presents the results of the Sobel test analysis to test the mediating role of the human development index in the relationship between gross domestic product and life expectancy in Indonesia over the period 2010-2021. The results of this analysis aim to evaluate whether GDP has a significant effect on life expectancy through HDI as a mediator.

The path coefficient between GDP and HDI is 0.034635 with a P = 0.0000, which indicates a positive and statistically significant relationship. This finding indicates that an increase in GDP directly increases HDI values. In Indonesia, an increase in GDP reflects a greater availability of resources to improve the quality of education, health, and economic services, which are the main dimensions in measuring HDI. Increased GDP consistently contributes to higher quality human development reflecting the government's increased fiscal capacity to fund multidimensional development programmes, such as investment in the education sector through the smart Indonesia programme (PIP) and improved access to health services through the National Health Insurance (JKN). This is in line with the human capital development theory which emphasises that an increase in a country's income can directly improve the welfare of its people through investment in the social sector and human development (Roy et al., 2021). Thus, economic growth as measured by GDP plays an important role in supporting human development.

Furthermore, the path between HDI and Life Expectancy has a coefficient of 0.380435 with a P = 0.0000, which indicates it is statistically significant. This finding suggests that HDI has a positive influence on life expectancy. The human development index, which involves indicators such as education, health, and decent living standards, plays an important role in improving people's quality of life. During the study period, life expectancy in Indonesia increased from 69.8 years in 2010 to 71.7 years in 2021. This increase can be explained by several phenomena, such as the success of the national immunization programme, improved nutrition, and better access to health facilities. In the human development theory developed by Amartya Sen, an increase in HDI not only reflects the quality of life of individuals, but also strengthens the capability to contribute to economic and social development (Sen, 1999). This relationship suggests that human development is an important component in supporting the extension of life expectancy.

Table 3: Sobel test results as test of the mediating role of human development index in the relationship between gdp and life expectancy in Indonesia

Input		Test statistic	Std. Error	p-value
0.034635	Sobel test	10.636282	0.00123881	0.00000
0.380435	Aroian test	10.632337	0.00123927	0.00000
0.003102	Goodman test	10.640231	0.00123835	0.00000
0.010880	Reset all		Calculate	

Source: Data analysis results, 2024

The resulting Sobel statistic is 10.636282, with a low standard error value (0.00123881) and a P = 0.0000, which indicates that HDI significantly mediates the relationship between GDP and life expectancy. This means that the effect of GDP on life expectancy is not only direct, but also amplified through the role of HDI as a mediator. Logically, an increase in GDP provides fiscal space for the government to allocate funds to strategic sectors that contribute directly to increasing HDI, such as education and health. In this context, human development becomes a key mechanism that strengthens the impact of economic growth on increasing life expectancy.

A deeper analysis reveals that this positive relationship between GDP, HDI, and Life Expectancy is also supported by regional dynamics in Indonesia. Regions with high GDP contributions, such as Java and Sumatra, show higher HDI and Life Expectancy compared to eastern Indonesia, which still faces challenges in human development. These regional differences suggest the importance of redistribution policies to ensure equitable distribution of economic development benefits across regions (Leiwakabessy and Amaluddin, 2020).

The significance of this study is supported by the results of additional tests such as the Aroian test and Goodman test, which provide consistent results. In other words, an increase in GDP not only has a direct impact on life expectancy but also has an indirect effect through strengthening HDI. Overall, these results underscore the importance of HDI as a mediator that strengthens the relationship between economic growth and life expectancy. Within the study period, an increase in GDP contributed significantly to human development as reflected in HDI, which in turn led to an increase in people's life expectancy.

4.4. Mediation Analysis of HDI in the Relationship between Mean Years of Schooling and Life Expectancy in Indonesia

Table 4 presents the Sobel test results to test the mediating role of the human development index in the relationship between average

Table 3: Sobel test results as test of the mediating role of human development index in the relationship between mean years of schooling and life expectancy in Indonesia

Input		Test statistic	Std. Error	p-value
0.750586	Sobel test	10.007874	0.02853245	0.00000
0.380435	Aroian test	10.004119	0.02854316	0.00000
0.071862	Goodman test	10.011633	0.02852174	0.00000
0.010880	Reset all		Calculate	

Source: Data analysis results, 2024

years of schooling and life expectancy in Indonesia over the period 2010-2021. This study aims to explore how education, represented by average years of schooling, can affect life expectancy directly or indirectly through HDI.

The results of the analysis show that the path between average years of schooling and HDI has a coefficient of 0.750586 with a P = 0.0000, which is statistically significant. This finding reflects that increasing average years of schooling makes a significant positive contribution to HDI. Logically, better education gives people the ability to access knowledge, improve life skills, and make better decisions regarding health, nutrition, and the environment (Setyadi et al., 2023). Education also increases individuals' economic opportunities, which can support access to quality health services. In the human capital theory developed by Becker in 1964, education is seen as an investment in the development of skills and abilities that generate long-term economic and social benefits. Higher education allows individuals to acquire knowledge, improve skills and understand how to live a healthier life. In Indonesia, programs such as the 12-year compulsory education and the smart indonesia card (KIP) are strategic policies that support increased access to education, contributing directly to the increase in HDI.

Furthermore, the path between HDI and Life Expectancy shows a coefficient of 0.380435 with a P = 0.0000, which is also statistically significant. These results confirm that HDI, which includes the dimensions of education, health, and income, plays an important role in improving quality of life and extending life expectancy. This is consistent with the social determinants of health theory, which states that education, economic and social environmental factors collectively influence health status and life expectancy (Marmot and Wilkinson, 2006). The education dimension of HDI acts as a foundation that enables people to understand and access health services, lead a healthy lifestyle, and reduce their risk of chronic diseases. For example, individuals with higher education levels tend to have better awareness of the importance of immunization, nutrition, exercise, and early treatment, which contribute to improved health and life expectancy.

The Sobel statistic of 10.00787431, with a standard error of 0.02853245 and a P = 0.0000, indicates that the mediating effect of HDI in the relationship between average years of schooling and life expectancy is significant. Additional tests, such as Aroian and Goodman, provide consistent results, further strengthening the conclusion that HDI mediates this relationship. According to the theory of human development by (Sen, 1999), education is an important component that expands the capabilities of individuals to lead meaningful and productive lives. Education also provides access to better economic opportunities, enabling individuals to earn an income that supports access to quality healthcare, health insurance and healthy lifestyles.

During the study period, Indonesia experienced an increase in average years of schooling from 7.4 years in 2010 to 8.7 years in 2021. This increase was accompanied by an increase in the HDI from 66.53 in 2010 to 72.29 in 2021, as well as an increase in life expectancy from 69.8 years to 71.7 years in the same period (BPS, 2021). However, there are challenges in the form of significant regional disparities. Underdeveloped regions such as Papua and Nusa Tenggara tend to have lower access to education than developed regions such as Java and Bali. This suggests the need for more targeted policies to address regional education disparities, so that all communities can enjoy the benefits of human development equally.

This phenomenon underscores the importance of education as an instrument of social transformation that can support sustainable development. Education not only serves as a tool to improve individual skills but also as a key pillar in driving improvements in the quality of life (UNDP, 2023). The implications of this study confirm that investment in education should be followed by the strengthening of sustainable public health programs. Education integrated with the health and economic sectors can create synergies that result in long-term impacts on improving quality of life and achieving sustainable development goals (SDGs) (World Health Organization, 2023). This approach provides a foundation for Indonesia to promote holistic human development, accelerate social progress, and improve economic competitiveness globally.

5. CONCLUSION

This research makes a significant contribution to understanding the determinants of life expectancy in Indonesia through a multidimensional analysis involving carbon dioxide emissions, gross domestic product, and average years of schooling, with the human development index (HDI) as a mediator. The results of the analysis show that an increase in carbon dioxide emissions contributes to a decrease in HDI, which in turn negatively impacts life expectancy. In contrast, an increase in GDP consistently shows a positive influence on HDI and life expectancy, although the disparity in the distribution of benefits between regions is a challenge that needs to be addressed through effective redistribution policies. Average years of schooling was found to have a significant effect in increasing HDI, confirming its role as an important determinant in improving quality of life through increased access to education and health. The role of HDI as a mediator shows that a multidimensional approach is needed to understand the complexity of the relationship between these variables and their impact on life expectancy. This research recommends the implementation of integrated policies, including reducing carbon emissions, increasing investment in education, and equitable distribution of economic development benefits to

strengthen HDI and improve people's welfare in a sustainable manner. This conclusion not only contributes to the development of scientific literature but also offers strategic insights for policy makers in supporting the achievement of the sustainable development goals (SDGs) in Indonesia.

REFERENCES

Ahmed, S., Khan, T. (2022), Income inequality, GDP growth, and health outcomes: A comparative study in developing countries. International Journal of Development Economics, 14(3), 245-262.

Andrian, T., Wahyudi, H., Leny, S.M. (2024), Strategies to achieve net zero emissions 2060 with CSR disclosure. International Journal of Energy Economics and Policy, 4(6), 574-579.

Becker, G.S. (1993), Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education. Chicago: University of Chicago Press.

BPS. (2021), Statistik Pendidikan dan Kesejahteraan Sosial di Indonesia. Badan Pusat Statistik. Available from https://www.bps.go.id

Cheng, T., Liu, H., Zhang, Y. (2022), The role of education in improving life expectancy: Evidence from longitudinal studies. Journal of Public Health Research, 11(3), 456-470.

Fankhauser, S., Kallbekken, S. (2022), Green finance and sustainable development in Indonesia. Asian Development Bank Reports, 12(3), 201-214.

Gao, Z., Liu, Y., Chen, X. (2023), Statistical analysis in development economics: Methods and applications. Journal of Economic Analysis, 50(1), 123-139.

Guhathakurta, A., Smith, J. L., Wang, Y., & Martinez, R. (2023), The impact of air pollution on health and life expectancy: A global perspective. Environmental Health Perspectives, 131(7), 089503.

Haq, M., Li, X., Zhao, R. (2023), CO_2 emissions and human health: The mediating role of environmental quality in developing economies. Ecological Economics, 194, 107342.

Hossain, M., Chen, L. (2021), Human Development Index as a mediator in the relationship between GDP and life expectancy: A global perspective. World Development, 139, 105312.

Jin, L., Wang, H., Zhao, Y. (2023), Descriptive statistical methods and their application in economic research. Journal of Economic Statistics, 42(3), 123-137.

Kuznets, S. (1955), Economic growth and income inequality. The American Economic Review, 45(1), 1-28.

Lestari, A., Widodo, B. (2022), The rural-urban divide in educational attainment and life expectancy: Evidence from Indonesia. Development Studies Quarterly, 18(4), 456-472.

Leiwakabessy, E., & Amaluddin, A. (2020), A modified human development index, democracy and economic growth in Indonesia. Humanities & Social Sciences Reviews, 8(2), 732-743.

Liang, J., Zhou, X., Wang, Y. (2023), Economic growth and life expectancy: Exploring the role of public spending in emerging economies. Journal of Economic Policy Research, 11(2), 345-360.

Marmot, M., Wilkinson, R.G. (2006), Social Determinants of Health. Oxford: Oxford University Press.

Mulyadi, T., Nugraha, A. (2023), Educational disparities and human development in Indonesia: Challenges and opportunities. Journal of Indonesian Education, 39(2), 88-102.

Prasetyo, H., Wijaya, T. (2022), The impact of economic and educational factors on human development: A mediation analysis in Indonesia. Development Policy Review, 40(2), 125-139.

Prasetyo, H., Wijaya, T., Rahayu, D. (2023), Life expectancy trends and regional disparities in Indonesia: A longitudinal analysis. Journal of Population Studies, 35(1), 120-135.

Putri, A., Hartono, D. (2022), Regional disparities and economic growth in Indonesia: Implications for human development. Journal of Development Studies, 39(4), 587-603.

Putri, S., Anwar, H. (2023), Carbon emissions and deforestation in Southeast Asia: A case study of Indonesia. Environmental Research Letters, 18(2), 020123.

Rahayu, L., Sugiarto, D., Permana, T. (2023), The role of education in reducing inequality: Insights from Indonesia. Journal of Social Policy Studies, 42(3), 345-360.

Rahman, F., Chen, L. (2022), Economic fluctuations and GDP performance in developing countries: A case study of Indonesia. Journal of Economic Development, 28(4), 156-172.

Rahman, F., Hidayat, R. (2023), Human Development Index as a predictor of life expectancy in developing economies: A case study of Indonesia. Global Health Perspectives, 11(3), 356-372.

Rahman, M., Lee, J. (2021), Economic transformation and environmental sustainability in developing countries. Journal of Environmental Management, 284, 112031.

Rahmat, A., Prasetya, R. (2022), Human Development Index disparities in Indonesia: Challenges and policy implications. Journal of Regional Studies, 18(3), 275-290.

Riyanto, Y., Hatmawan, M. (2020), Statistical methods for research: A comprehensive guide to Sobel Test and beyond. Journal of Statistical Studies, 13(2), 99-115.

Roy, M., Chen, L., & Kumar, S. (2021), Impact of GDP and poverty on Human Development Index in Indonesia. Journal of Development Economics, 40(1), 128-142.

Santoso, R., Firmansyah, A. (2022), Human development and life expectancy disparities in Eastern Indonesia: Policy implications. Development Policy Review, 40(2), e12560.

Sari, D., Prasetya, R., Hidayah, L. (2023), Education disparity and its impact on regional development in Indonesia. Journal of Education and Development, 14(2), 245-259.

Sen, A. (1999), Development as Freedom. Oxford: Oxford University Press.

Setiawan, B., Rahardjo, F., Kusuma, T. (2023), Economic inequality and its effects on life expectancy in Indonesia: A spatial analysis. Economic Development Journal, 15(2), 312-327.

Setiawan, B., Wibowo, R., Kusuma, T. (2023), Regional disparities in carbon emissions and economic development in Indonesia. Journal of Environmental Economics, 45(3), 210-225.

Setyadi, A., & Lestari, D. (2023), Improving human development in Indonesia: Education, health, and economic dimensions. International Journal of Development Studies, 16(4), 201-215

Shahbaz, M., Balsalobre-Lorente, D., Sinha, A. (2022), Analyzing the role of renewable energy and technology in reducing carbon emissions: Evidence from EKC framework. Renewable Energy, 185, 1231-1243.

Sobel, M.E. (1982), Asymptotic confidence intervals for indirect effects in structural equation models. Sociological Methodology, 13, 290-312.

Sugiarto, D., Wibowo, R., Prasetya, A. (2022), Assessing the role of human development in sustainable growth: Evidence from Indonesia. Global Development Studies, 18(4), 340-355.

Suryadi, R., Wibowo, H. (2023), The long-term impact of education on human development indicators in Indonesia. Asian Development Journal, 11(2), 215-229.

UNDP. (2023), Human Development Report: Indonesia's Progress and Challenges. United Nations Development Programme. Available from: https://www.undp.org

Wahyudi, H., Leny, S.M., Sutarto. (2024), CSR Index of energy sector companies in Indonesia. International Journal of Energy Economics and Policy, 14(6), 40-45.

Wang, Y., Li, X., Zhao, R. (2023), The effects of air pollution on public

health and life expectancy: A global analysis. Environmental Science and Policy, 145, 324-339.

Wardani, F., Pratama, T. (2022), Nationally Determined Contributions and climate action strategies in Indonesia: Challenges and opportunities. Climate Policy Review, 12(3), 312-327.

Wijaya, R., Hidayat, M., Zain, A. (2023), The dynamics of CO_2 emissions and energy consumption in developing economies: Evidence from Indonesia. Energy Policy, 175, 113412.

World Health Organization. (2023), Health Disparities and the Role of Public Health Services in Indonesia. Available from: https://www.who.int/countries/id

Yusuf, M., Siregar, P., Amalia, R. (2023), Environmental degradation and its implications for public health: Insights from Indonesia. Health and Environment Journal, 29(4), 459-470.