Environmental Sustainability Development in Indonesia Integrating with the Green Economy: a VECM Analysis

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Abstract

This study aims to examine and analyze factors that influence sustainable environmental development in Indonesia through the Green Economy policy. The issue of sustainable development is increasingly crucial amidst increasing global emissions that threaten human safety. The green economic development model is suspected to be a development model that prioritizes economic, social, and environmental dimensions to achieve sustainable development in an integral manner. The type of data is a time series with a research period of 1992–2022. The analysis model used is the Vector Error Correction Model (VECM) to analyze the long-term and short-term relationships of the variables agriculture productivity, expected years of schooling, and renewable energy on carbon emissions. The results of the study indicate that there is no long-term relationship between the impact of the green economy, but in the short term, the variables Agriculture Productivity and Expected Years of Schooling affect carbon emissions. The results of this study emphasize the importance of a consistent green economy policy. The government and the private sector can increase investment in the renewable energy sector, allocate resources, and adopt environmentally friendly technologies. In addition, strict environmental regulations and increased education are key to building public awareness of the importance of a green economy and environmental sustainability and creating a culture and lifestyle that support environmentally friendly practices at the individual and community levels.

Keywords: Green Economy; Agriculture Productivity, Expected Years of Schooling; Renewable Energy; VECM

Introduction

Sustainable development has emerged as a critical concern, based on awareness of climate change and environmental damage. Following the 1992 United Nations (UN) Conference at Rio de Janeiro, the concept of sustainable development, as outlined in the Brundtland Report, was formally adopted. This report emphasizes that every country should use a development model that aims to meet the needs of the present without compromising the capabilities of future generations.[1] The growing awareness of the need for an economic system that prioritizes not only quantitative but also qualitative growth is becoming evident. A shift towards a new paradigm in economic development is necessary, placing social and environmental responsibility at the core of every decision. A sustainable, environmentally conscious economy offers a more inclusive approach, promoting human welfare, fostering social justice, and mitigating risks related to resource

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depletion[2]. [3] Inclusive green growth aims to offer tangible solutions, integrating financial growth, environmental sustainability, and social inclusion. The concept of green economic development has an important goal to reduce carbon emissions and minimize pollution.

At the national level, especially in Indonesia, various efforts have been made to develop policy strategies for green economic programs that are worthy of being proven in a study. This initiative is viewed as an effective means of balancing economic growth with resource efficiency, reducing carbon emissions, and enhancing the quality of life without neglecting environmental concerns. The government has adopted the green economy framework as a medium- to long-term strategy for economic transformation, which is expected to assist Indonesia in achieving the Sustainable Development Goals (SDGs). The green economy is anticipated to foster environmental sustainability while driving innovation, creating green jobs, and boosting national economic competitiveness[4].

The green economy framework established by Ministry of National Development Planning emphasizes the agricultural sector as a key element in the economic dimension of sustainable development. In alignment with this, the Food and Agriculture Organization (FAO) highlights that the world is confronting a series of crises, including those related to food, fuel, climate, and finance. Over the past few decades, 60% of global ecosystems have experienced degradation, carbon emissions have surged by 40%, water scarcity has intensified, and nearly one billion people face hunger. This underscores the growing importance of the agricultural sector in ensuring the well-being and livelihoods of people worldwide. The rise of the green economy concept as a pathway for sustainable development and poverty reduction presents not only challenges in achieving a sustainable economic transition but also in addressing distributive justice, where food security becomes a critical necessity[5]. Numerous empirical studies further validate the significant role of this framework in global food provision while shaping the quality of the environment to achieve carbon peak targets, carbon neutrality, and promote agricultural modernization[6], [7],[8].

The agricultural sector is an important pillar in providing the global food supply chain in the long term. Nations must enhance crop yields through both intensification and the expansion of agricultural land. Concentrating and intensifying food production across

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[5] FAO, "Greening The Economy With Agriculture (Gea)," *Food And Agriculture Organization Of The United Nations*, 2023, https://www.fao.org/fileadmin/user_upload/suistainability/docs/GEA__concept_note_3March_references_01.pdf.

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[7] Y Liu, Y Ouyang, and H Cai, "Evaluation of China's Agricultural Green Tfp and Its Spatiotemporal Evolution Characteristics," *The Journal of Quantitative & Technical Economics* 38, no. 5 (2021): 39.

[8] K S Alpysbayev, Y E Gridneva, and G Sh Kaliakparova, "'Green' Economy: Realities and Prospects in Agriculture," *Проблемы Агрорынка*, no. 3 (2021): 44–50.

various regions is one of the most efficient methods to ensure global food security while also ensuring the availability of local food products, which directly influence supply chain management, food safety, and environmental quality. European Environment Agency reported, the agricultural sector significantly impacts the environment, contributing to rising carbon emissions. Environmental pressure from agriculture is evident in the depletion of natural resources. Additionally, on a global scale, agriculture contributes to climate change through GRK and a reduction in carbon sequestration within vegetation and soil[9]. Therefore, reforms and effective measures are essential to facilitate the green economy transition, promoting ambitious strategies for agricultural resource efficiency and mitigating climate change, ultimately leading to more sustainable production methods.

While the social dimension that is worth discussing is the sociology of the new era, which must be based on a holistic perception of the world, be humanistic, open to development, and free from anthropocentrism, The main idea is the synergy of seeking wisdom through the balance between nature and humans, sustainable development, ecological awareness, balance between individuals and society, equality, and fair rewards [10]. The concept of a green economy from a social perspective has also been explored by various auth The concept of green economy from a social perspective has also been developed by various authors.[11] Currently, social development is centered on the government's capability to meet various human needs through the integration of green economy to support sustainable development. [12] Viewing the green economy through a social lens highlights a range of challenges that researchers and activists need to address, as well as significant imbalances in policy direction. Consequently, policymakers bear the primary responsibility in this area, particularly through initiatives like public education and awareness campaigns that promote environmentally friendly production and consumption. Education plays a critical role in enhancing environmental awareness.

[13]The longer the expected years of schooling, the more likely individuals are to develop a stronger understanding of environmental issues, including the effects of carbon emissions. [14] A solid education can help people grasp the importance of reducing emissions and adopting sustainable environmental practices. Recognizing that education is a key driver of the green economy, policymakers should prioritize extending school years as part of a green economy strategy, which can contribute to advancing education in Indonesia[15]. Empirical studies, [16]provide concrete evidence of the crucial role education and human awareness play in reducing carbon emissions, thereby supporting

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sustainable development. Moreover, research[17] reveals that higher levels of education offer a promising pathway to addressing climate change and cutting down carbon emissions.

Climate change risks and green economic models play important roles in both economic and environmental development, drawing attention from academics and governments worldwide. From an environmental perspective, the green economy promotes sustainable production and efficient use of natural resources[18]. [19]Investing in natural capital and improving energy and resource efficiency are two major strategies to strengthen the green economy sector [20]. One of the goals of green economic development is to reduce pollution and enhance energy efficiency. While renewable energy consumption is part of the green economy agenda, its current technical limitations may prevent it from fully driving environmentally sustainable economic growth. Therefore, advancing technological innovation is critical to bridging the gap between renewable energy consumption and green economic progress.

In recent years, many researchers have investigated renewable energy as a social dimension of the green economy that can help reduce carbon emissions, such as [21], [22], [23]. Their findings indicate that renewable energy is fundamental to achieving sustainable development through the expansion of eco-friendly resources like solar power and biomass. [24] It is also widely acknowledged that investing in renewable energy offers the most effective and rapid path toward achieving the Sustainable Development Goals (SDGs). Likewise, empirical research [25] confirms that renewable energy technologies have a positive impact on sustainable development in the Middle East and North Africa (MENA), showing that renewable energy can reduce dependence on limited, non-renewable fossil fuels. By leveraging abundant renewable resources, we can secure energy sustainability for future generations.

Although the green economy concept is gaining significant attention from international and national environmental monitoring bodies, its effectiveness as an alternative approach to sustainable development remains under scrutiny. This paper aims

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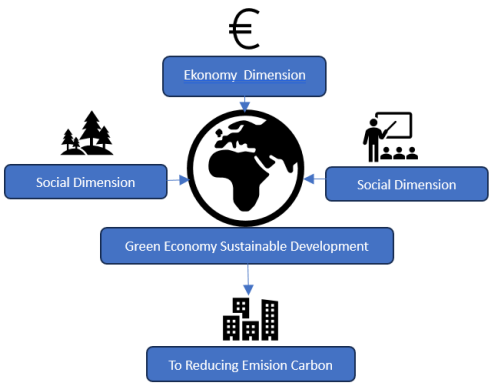
[23] Lin-Na Hao et al., "Green Growth and Low Carbon Emission in G7 Countries: How Critical the Network of Environmental Taxes, Renewable Energy and Human Capital Is?," *Science of the Total Environment* 752 (2021): 141853.

[24] Thuy Chung Phan, "Impact of Green Investments, Green Economic Growth and Renewable Energy Consumption on Environmental, Social, and Governance Practices to Achieve the Sustainable Development Goals: A Sectoral Analysis in the ASEAN Economies," *International Journal of Engineering Business Management* 16 (2024): 18479790241231724.

[25] Saeed H Aldulaimi and Marwan M Abdeldayem, "Examining the Impact of Renewable Energy Technologies on Sustainability Development in the Middle East and North Africa Region," *International Journal of Engineering Business Management* 14 (2022): 18479790221110836.

to examine the impact of the green economy on carbon emissions in Indonesia. Various green economy concepts can be applied within policy frameworks to achieve sustainable development. Accordingly, this study utilizes the green economy framework developed by the Ministry of National Development Planning Agency to outline basic assumptions regarding sustainability and empirically tests these ideas. The framework is tested across multiple sectors, incorporating agricultural productivity from the economic dimension, education from the social dimension, and renewable energy from the environmental dimension. Given these considerations, assessing the conditions for the successful implementation of green economy policies that support a transition to sustainable development is critical. To enhance academic understanding, this study also integrates an Islamic perspective, offering a holistic view on effective strategies for green economy implementation. Consequently, this research provides valuable insights into aligning sustainable development goals with economic growth and Islamic principles. The research framework proposed by the author is as follows:

Figure 1.
Green Economy Concept



Source: BAPPENAS 2022 & Modified by Author

Research Methods

This study uses time series data from 1992 to 2022 and applies the Vector Error Correction Model (VECM) approach. The aim of this model is to critically analyze both the long-term and short-term relationships within the green economic development framework. The green economic indicators developed by the Ministry of National Development Planning were selected as part of a sustainable development model to address significant fluctuations in carbon emissions. High carbon emissions, particularly in Indonesia, are believed to have adverse environmental impacts. Consequently, the green economic development model, which integrates economic, social, and environmental dimensions, is expected to provide more comprehensive insights for policymaking in Indonesia.

The VECM model in this study primarily seeks to examine the relationships and effects of the economic dimension (agricultural productivity), social dimension (expected years of schooling), and environmental dimension (renewable energy) on carbon emissions (CO2 emissions). Furthermore, the VECM model is also used to analyze time series data within the framework of the Vector Autoregressive (VAR), which must be stationary at the level and first differencing to satisfy the stationarity test. As a result, the non-stationary VAR model:

$$Yt = \mu + \alpha 1\, yt-1 + \alpha 2\, yt-2 + \ldots . + \alpha_{\text{ }}pyt-_{\text{ }}p + \varepsilon t \quad (1)$$

Through this equation, the VECM equation can be formed as follows:

$$\Delta Yt = \alpha e\, t-1 + \beta 1 y \Delta\, t-1 + \beta 2 y \Delta\, t-1 + \ldots \ldots . + \beta_{\text{ }}py \Delta\, t-_{\text{ }}p + 1 + \varepsilon t \quad (2)$$

Therefore, the equation model in this study can be formed::

$$EM = \beta 0 + \beta 1 AP\, t + \beta 2 EYP\, t + \beta 3 RE + ut \quad (3)$$

The explanation of the variables used can be seen in Table 1.

Table 1
Definition Operational Variable

Variable	Notation	Proxied	Source
Emision Carbon (CO2)	EM	Sum of CO in Years	World Bank
Agriculture Productivity	AP	Total % of GDP	Our Worl in Data
Expected Years of School	EYS	Mean Years of Schooling	Our Worl in Data
Renewable Energy	RE	Share of Renewable Energy %	Our Worl in Data

Source: Computed by Author

Research Results

Stationary Test

In the VECM model, the first step taken is that each variable must meet the stationary test using the Augmented Dickey Fuller (ADF) model. Table 2 shows the results of the roots test at the level and First Difference levels.

Table 2
Stationary Test Results

Variable	Level		1 Difference	
	Statistic	Prob	Statistic	Prob
Emision Carbon (CO2)	-0.490988	0.8792	-5.051579	0.0004
Agriculture Productivity	-2.212798	0.2061	-5.768920	0.0000
Expected Years of Schooling	-0.665907	0.8405	-5.861338	0.0000
Renewable Energy	0.478664	0.9830	-5.815032	0.0000

Source: Data Processed

Lag Criteria Test

The next step after the roots/stationary test is to continue determining the lag criteria. The results can be seen in table 3, which shows the most stars as the best lag provision.

Table 3
Optimal Lag

LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-73.74625	NA	0.003726	5.758981	5.950957	5.816066
1	20.86892	154.1877*	1.12e-05*	-0.064364*	0.895515*	0.221058*
2	30.21982	12.46786	2.00e-05	0.428162	2.155944	0.941922
3	47.46709	17.88607	2.33e-05	0.335771	2.831457	1.077869
4	68.49153	15.57365	2.76e-05	-0.036409	3.227180	0.934027

Source: Data Processed

Stability Test

After conducting the lag determination test, the next step is to perform a VAR stability test to ensure that the VECM model is stable and suitable for forecasting using the Impulse Response and variance decomposition techniques. The stability criterion in this test is a modulus value less than 1, as shown in Table 4.

Table 4
Stabilitity Test Results

Root	Modulus
0.993891 - 0.038456i	0.994635
0.993891 + 0.038456i	0.994635
0.552641	0.552641
-0.447626 - 0.308359i	0.543557
-0.447626 + 0.308359i	0.543557
0.400249 - 0.319808i	0.512325
0.400249 + 0.319808i	0.512325
-0.347162	0.347162

Source: Data Processed

Cointegration Test

This study uses the Johansen cointegration test to identify a stable long-term relationship between two non-stationary variables in a time series model. The requirement is that the variables meet the cointegration test, the probability value <0.05.

Table 5
Cointegration Test Results

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob*
None *	0.856924	84.33371	47.85613	0.0000
At most 1	0.619095	33.77980	29.79707	0.0165
At most 2	0.279935	8.684468	15.49471	0.3954
At most 3	0.005588	0.145691	3.841465	0.7027

Source: Eviews Processed

Granger Causality Test

Granger causality test in the VECM model aims to determine the direction and cause-effect relationship between variables. Table 6 shows the results of the causality test with the provision of a probability value <0.05, so that a causal relationship can be considered.

Table 6
Causality Test Results

Null Hypotesis	OBS	F-Statistic	Prob
EYS does not Granger Cause AP	29	2.04048	0.1519
AP does not Granger Cause EYS		3.06471	0.0653
RE does not Granger Cause AP	29	0.76942	0.4744
AP does not Granger Cause RE		1.63227	0.2164
EM does not Granger Cause AP	29	4.57318	0.0208
AP does not Granger Cause EM		0.26709	0.7679
RE does not Granger Cause EYS	29	1.11596	0.3440
EYS does not Granger Cause RE		3.64346	0.0415
EM does not Granger Cause EYS	29	0.11125	0.8952
EYS does not Granger Cause EM		1.41036	0.2636
EM does not Granger Cause RE	29	2.66640	0.0900
RE does not Granger Cause EM		0.58595	0.5643

Source: Eviews Processed

The results of the causality test in Table 6 show a unidirectional relationship between carbon emissions and agricultural productivity., where agricultural productivity impacts carbon emissions. These findings are consistent with previous empirical studies [26]. Additionally, this research identifies a one-way relationship between expected years of schooling and renewable energy. This observation supports the conclusion from other investigations [27] that educational policies can serve as tools to promote greater use of renewable energy.

VECM Model Regression

Table 7
Long-Term and Short-Term Test Results

Variable	Coeficient	Std. Eror	t-stat	Information
		Long Run Results		
AP	0.002427	(0.00609	[0.39848]	Not Significant
EYS	-0.032328	(0.03064)	[-1.05493]	Not Significant
RE	-0.000320	(0.00588)	[-0.05443]	Not Significant
		Short Run Results		

[26] Kingsley Appiah, Jianguo Du, and John Poku, "Causal Relationship between Agricultural Production and Carbon Dioxide Emissions in Selected Emerging Economies," *Environmental Science and Pollution Research* 25 (2018): 24764–77.
[27] Gamze Sart et al., "Impact of Educational Attainment on Renewable Energy Use: Evidence from Emerging Market Economies," *Energies* 15, no. 7 (2022): 2695.

CointEq1	-2.829998	(0.76136)	[-3.71704]	
D (AP (-1))	0.000417	(0.00700)	[0.05954]	Not Significant
D (AP (-2))	-0.492891	(0.23324)	[-2.11321]	Significant
D (EYS (-1))	-0.073179	(0.05261)	[-1.39085]	Not Significant
D (EYS (-2))	-1.342930	- (0.31857)	[-4.21545]	Significant
D (RE (-1))	0.001011	(0.01235)	[0.08187]	Not Significant
D (RE (-2))	-0.051633	(0.34390)	[-0.15014]	Not Significant
C	0.003229	(0.00656)	[0.49216]	

Source: Eviews Processed

Based on the results of the study in Table 7, regarding the long-term influence of agricultural productivity, expected years of schooling, and renewable energy on carbon emissions in Indonesia, no long-term relationship was found. The first analysis starts with the agricultural productivity variable, which shows a negative and insignificant coefficient value. This finding indicates that a 1% increase in the agricultural sector will cause a decrease in carbon emissions of 0.002. In this study, although it did not show significant results, several external factors that can be identified, such as environmental conditions in various regions, can cause inconclusive results. Therefore, the author emphasizes that the concept of a green economy involving agricultural productivity has a long-term impact if the agricultural model practiced is sustainable is more efficient and supports environmentally friendly technology. The study [28] affirms that one of the more practical modern agricultural models that mitigates the risk of carbon emissions is to apply efficient irrigation methods and plant more productive crop varieties. Analysis [29] reveals that reducing agricultural carbon emissions is increasingly important today. This sector cannot be eliminated from prevention. Therefore, the agricultural model must be evaluated to continue to contribute to the country's economic development while reducing carbon emissions. Thus, improving agricultural infrastructure, developing human resources, and developing research and investment in agriculture are the right solutions to support sustainable development through the agricultural sector.

The next finding, expected years of schooling, shows a negative and insignificant coefficient value. This shows that an increase in average education or length of schooling of 1% will reduce the emission level by -0.03. Despite the insignificant results in this study, the author emphasizes raising awareness about maintaining environmental quality is a way to instill an ecology-based strengthening paradigm within the community. Therefore, if a region is aware of the impact of environmental damage, it will still be difficult to achieve the target of sustainable environmental development. This dynamic will create free riders, as expressed by [30], who emphasize the importance of integral community involvement in understanding the impact of carbon emissions that result in

[28] Poolad Karimi et al., "Reducing Carbon Emissions through Improved Irrigation and Groundwater Management: A Case Study from Iran," *Agricultural Water Management* 108 (2012): 52–60.

[29] Huan Yang, Xiaoxuan Wang, and Peng Bin, "Agriculture Carbon-Emission Reduction and Changing Factors behind Agricultural Eco-Efficiency Growth in China," *Journal of Cleaner Production* 334 (2022): 130193.

[30] P.R Shukla et al., *Summary for Policymakers in Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the IPCC, Climate Change 2022 - Mitigation of Climate Change*, 2023, https://www.cambridge.org/core/books/climate-change-2022-mitigation-of-climate-change/summary-for-policymakers/ABC31CEA863CB6AD8FEB6911A872B321.

environmental risks. In addition, this finding is in line with the investigation [31] in Pakistan, who discovered the fact that education is human capital to help reduce carbon emissions in the country. The government must formulate comprehensive policies or strategies by increasing human capital in the form of education and a concrete understanding of environmental development. An environmental observer [32] stated that public understanding of the risks of environmental degradation is an important component of mitigating environmental risks. Thus, the results of this observation emphasize the importance of a comprehensive public understanding of the impact of carbon emissions on the long-term sustainability of the earth. Sustainable development is a long-term target; therefore, the policies that are carried out must be able to be implemented consistently.

The next crucial discussion is the use of renewable energy, which shows insignificant negative results. This is confirmed by a 1% increase in the use of renewable energy, which reduces carbon emissions by -0.003. Therefore, although this study has not shown significant results in the long term, various factors must be considered in determining whether the evaluation of the pattern of renewable energy use as part of the green economy policy still requires seriousness from the government. This step must be supported by very large allocations and resources to obtain long-term benefits. This relationship is in line with the rebound effect theory popularized by [33], which states that transforming the use of renewable energy initially requires very large investments. Still, the impact that will be obtained is better and provides integral development sustainability. In addition, the phenomenon of the use of renewable energy always invites critical debate from environmental and economic observers. The faction that supports sustainable development will prioritize the movement to reduce dependence on fossil fuels, which results in exploitative actions on natural resources [34]. Meanwhile, the opponents will highlight the green-inflation phenomenon that drives the increase in goods and services related to environmentally friendly production and distribution processes, emerging as an impact of environmental observer pressure to move towards a green economic transition [35].

Meanwhile, this study also reveals a short-term effect on the agricultural productivity variable. This finding shows a negative and significant coefficient value. Therefore, every increase in the agricultural sector will reduce carbon emissions by -0.49 in the short term. Therefore, this study confirms the research study [36] that the agricultural sector must receive attention from the government through modern-based agricultural policies. One effective step is training and education, as well as support for resource allocation to farmers so that they can implement environmentally friendly agricultural patterns. Observations [37] reveal that agriculture based on modern technology can reduce

[31] Sadia Bano et al., "Identifying the Impacts of Human Capital on Carbon Emissions in Pakistan," *Journal of Cleaner Production* 183 (2018): 1082–92.
[32] Michael E Porter, "Michael Porter on Competition," *The Antitrust Bulletin* 44, no. 4 (1999): 841–80.
[33] William S Jevons, "The Theory Of," *Political Economy*, 1871.
[34] Muhammad Atif Nawaz et al., "Trilemma Association of Energy Consumption, Carbon Emission, and Economic Growth of BRICS and OECD Regions: Quantile Regression Estimation," *Environmental Science and Pollution Research* 28 (2021): 16014–28.
[35] Gyöngyi Vörösmarty and Imre Dobos, "Green Purchasing Frameworks Considering Firm Size: A Multicollinearity Analysis Using Variance Inflation Factor," in *Supply Chain Forum: An International Journal*, vol. 21 (Taylor & Francis, 2020), 290–301.
[36] Ehsan Elahi, Zainab Khalid, and Zhixin Zhang, "Understanding Farmers' Intention and Willingness to Install Renewable Energy Technology: A Solution to Reduce the Environmental Emissions of Agriculture," *Applied Energy* 309 (2022): 118459.
[37] Asif Raihan and Almagul Tuspekova, "Dynamic Impacts of Economic Growth, Energy Use, Urbanization, Agricultural Productivity, and Forested Area on Carbon Emissions: New Insights

carbon emissions. Therefore, farmers need to adopt modern agricultural models based on low-carbon technology and gradually abandon conventional agriculture, which has been identified as a contributor to carbon emissions, with support from the Ministry of Agriculture.

Likewise, Islam emphasizes the importance of agricultural practices to maintain interaction with nature. In carrying out economic activities in the form of farming activities, humans should consider what already exists in nature and be responsible for every decision. On this basis, Islamic economics emerged as a theoretical construction of an economic activity that provides sustainable solutions[38]. In addition, [39]research reveals that Islam places great emphasis on environmental sustainability as a target for sustainable development. Therefore, the Islamic paradigm, emphasizing the sustainable use of agricultural resources, must be based on production methods that maintain synergy between flora, fauna, and biodiversity. Ecological teachings originating from Islam have been manifested in various increasingly popular environmental movements. An economic development model that encourages a self-sustaining agricultural sector [40].

Further analysis revealed that expected years of schooling as a social dimension of the green economy framework showed a negative impact and significant coefficient value. This fact shows that, in the short term, a 1% increase in education will reduce carbon emissions by -1.34. This finding is in line with research [41] showing that education programs implemented on a large scale have the potential to reduce carbon emissions. Therefore, solutions to climate problems or increased carbon emissions that threaten environmental development targets must focus on mitigation and adaptation steps that encourage people to have information and environmental awareness education [42]. This movement has also become a major concern for the United Nations Educational, Scientific, and Cultural Organization (UNESCO) monitoring agency, which emphasizes educational efforts in responding to climate change [43]. Therefore, Islam emphasizes the urgency of environmental education, which aims to form patterns of community behavior that are aware of environmental problems. Environmental education is a fundamental teaching of Islam. The word of Allah SWT, QS. Ar-Rum verse 41, says that it has been seen that environmental damage that has occurred on earth is caused by human actions [44]. From the results of this observation, the author emphasizes that the concept of a green economy that combines the average length of time people have been educated plays a very important role in realizing sustainable development. The phenomenon of environmental degradation caused by carbon emissions threatens the safety of the global

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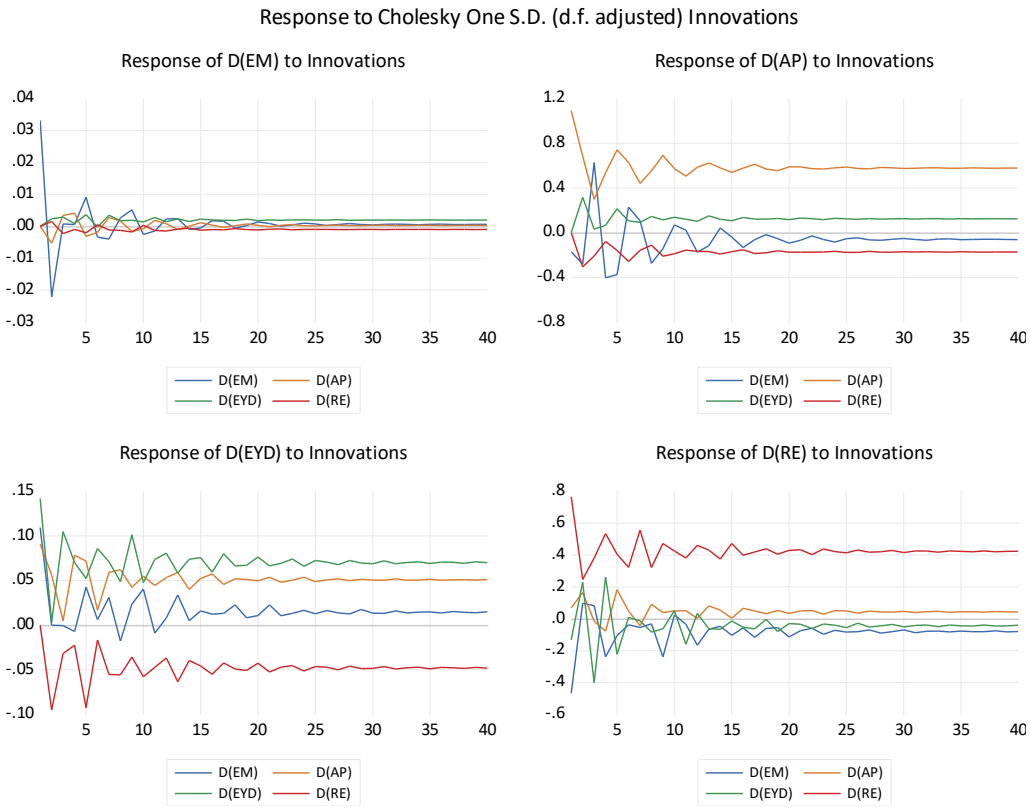
community. Therefore, a major warning from the UN Secretary-General, Antonio Gutteres, must be a joint evaluation that the world is in the grip of global warming due to human actions themselves. Nature is under great pressure, so mitigation steps are needed to maintain biodiversity [45].

IRF and IFD

The next analysis is related to the impulse response to observe the influence of shocks from one variable to another or the variable itself. Thus, the impulse response will provide a visual depiction of the relationship between the magnitude of the influence between the variables and the estimated period to reach a stable direction. The results of the response analysis can be observed as follows:

Figure 2
Impulse Response



Source: Data Processed

In the initial analysis, starting with the IRF graph for the carbon emission variable in response to shocks from the other three variables, the first period exhibited a negative response, reaching -0.02. However, from the tenth period onward, the response began to stabilize. This suggests the importance of support from green economic policies, drawn from the three indicators, to to effectively reduce the increase in carbon emissions in the long term.

Next, the analysis focuses on the response of agricultural productivity to shocks from the other three variables, as well as to itself. While the results showed a positive response at the beginning, the trend began to stabilize around the 20th period. In contrast, the response to carbon emissions showed negative results in the early period. This indicates that to curb rising carbon emissions, policies focused on green economy

[45] Barbara H. Lange, "A Message from the Executive Director," *SMPTE Motion Imaging Journal* 130, no. 2 (2021): 6, https://doi.org/10.5594/JMI.2021.3057266.

development through agriculture must adopt environmentally friendly technologies and include emission testing as an essential requirement. This should serve as a key consideration to ensure that increased agricultural productivity not only contributes to economic growth but also promotes environmental sustainability.

In the next analysis, the response of the expected years of schooling variable revealed a significant positive shock from the early period, with a more stable direction emerging around the 25th period and continuing through to the final period. This finding highlights that a green economic development model, which incorporates the social dimension (expected years of schooling), can contribute to long-term sustainable development. However, consistent policy implementation is essential. Education plays a crucial role in fostering sustainable development by encouraging individuals to adopt more eco-friendly resource use patterns, a fundamental component of sustainability. With the ongoing rise in carbon emissions posing an increasing concern, a well-structured research and policy framework is needed to develop strategies that mitigate these risks. Education is a key tool in addressing environmental degradation, yet current economic practices often prioritize development that exploits natural resources over environmental sustainability.

Meanwhile, the response of the renewable energy variable initially showed positive values, with a negative influence from the carbon emission variable. By the 25th period, the response began to stabilize, continuing through the final period. These results align with theoretical assumptions that increased use of renewable energy is likely to reduce carbon emissions. One of the critical challenges of the 21st century is the economic development model, which relies heavily on industrial activities fueled by fossil energy, leading to resource depletion and higher carbon emissions. This issue has been a focal point for the International Energy Agency (IEA), which urges stakeholders to prioritize the use of renewable energy sources.

Table 8
Variance Decomposition Emisi Karbon

Response of D(EM): Period	D(EM)	D(AP)	D(EYS)	D(RE)
1	0.033155	0.000000	0.000000	0.000000
2	-0.022062	-0.005248	0.002344	0.001466
3	0.000748	0.003413	0.002894	-0.002270
4	0.000529	0.004113	0.000845	-0.000993
5	0.009159	-0.003151	0.003639	-0.002038
6	-0.003357	-0.001825	-0.000301	0.000470
7	-0.004022	0.002744	0.003435	-0.001165
8	0.002638	0.001602	0.001776	-0.001287
9	0.005166	-0.001581	0.001898	-0.001792
10	-0.002568	-0.000785	0.001379	0.000277

Source: Data Processed

The explanation of Table 8, which details the variance decomposition of carbon emissions, shows a contribution of approximately 0.03% in the first period. Furthermore, in the short-term period (3rd), the largest shock is observed, reaching around 0.000748. However, in the long term, it begins to show a fluctuating decline, accompanied by other variables.

Table 9
Variance Decomposition Agriculture Productivity

Response of D(AP): Period	D(EM)	D(AP)	D(EYS)	D(RE)
1	-0.170111	1.091367	0.000000	0.000000
2	-0.281903	0.684344	0.317004	-0.305949
3	0.627776	0.298758	0.031943	-0.208981
4	-0.403299	0.536574	0.065324	-0.078093
5	-0.375261	0.740804	0.213285	-0.158068
6	0.228131	0.628245	0.105084	-0.258233
7	0.106236	0.440470	0.092302	-0.157528
8	-0.273036	0.552363	0.144837	-0.111401
9	-0.144546	0.691261	0.114671	-0.209772
10	0.068481	0.573634	0.136938	-0.189243

Source: Data Processed

Further analysis of the Forecast Error Variance Decomposition presented in Table 9 highlights the impact of agricultural productivity over 10 periods. In the short term, such as in the 5th period, the largest shock was observed, reaching approximately 0.74%. However, by the 10th period, the shock had decreased to around 0.57%. Meanwhile, the expected years of schooling variable showed an increase in the final period, reaching 0.13%.

Table 10
Variance Decomposition Expected Yeas of Schooling

Response of D(EYS): Period	D(EM)	D(AP)	D(EYS)	D(RE)
1	0.109329	0.090765	0.141806	0.000000
2	3.45E-05	0.056278	0.003440	-0.094918
3	-0.000555	0.004975	0.104616	-0.031749
4	-0.007071	0.078347	0.070134	-0.022393
5	0.042571	0.071759	0.052222	-0.092206
6	0.006246	0.016535	0.085805	-0.016549
7	0.031139	0.059183	0.070973	-0.055139
8	-0.017578	0.062041	0.048744	-0.055580
9	0.023699	0.042440	0.101289	-0.035650
10	0.040462	0.054827	0.047495	-0.057717

Source: Data Processed

Further discussion can be observed in Table 10, which displays the results of the shock of the expected years of schooling variable. In the short term (period 3), it experienced a very large shock of around 0.10%. However, in the long term, it experienced a decline even though it was fluctuating, as evidenced by the variance decomposition value of 0.04%.

Table 8
Variance Decomposition IKLH

Response of D(RE): Period	D(EM)	D(AP)	D(EYS)	D(RE)
1	6.145832	0.000000	0.000000	0.000000
2	0.006987	3.381415	0.725717	-1.243038
3	2.651628	0.862911	-0.526196	-0.918643
4	3.868375	0.462917	1.888116	-0.166861
5	2.204441	1.540625	-0.237806	-0.268804
6	1.754094	2.374018	-0.299491	-1.387085
7	2.844007	0.723472	1.247004	-0.616244
8	3.618834	0.455293	0.685240	0.113954
9	1.727280	2.404982	-0.352645	-0.955597
10	1.932585	1.711645	0.320821	-1.202570

Source: Data Processed

The results of the variance decomposition analysis of the renewable energy variable show fluctuating shocks from the beginning of the period to the last period. If observed in detail, the largest shock is in the 2nd period, which reaches -1.24%. but in the long term, it begins to experience a significant decline.

Conclusion

This study investigates the relationship between sustainable development in Indonesia by incorporating the green economy framework developed by Ministry_of_Development_PlanningMinistry of National Development Planning and utilizing vector error correction model (VECM) analysis. The analysis did not find any long-term impact of economic, social, and environmental dimensions on carbon emissions in Indonesia. However, in the short term, agricultural productivity as an economic factor and estimated years of schooling as a social dimension did affect carbon emissions. On the other hand, the environmental dimension, which involves renewable energy, did not have a significant impact on carbon emissions during the study period.

This finding underscores that transitioning to a green economic development model, which requires substantial financial investment, demands a strong commitment from policymakers in Indonesia. The phenomenon of “Green Inflation” that drives the transition to environmentally friendly practices, for example, urges countries to adopt renewable energy and reduce the use of fossil fuels seriously. Such a shift requires significant financial policies and support from various stakeholders to achieve green growth and sustainable development. In line with this, the theory of energy transition, or the rebound effect popularized by Jevon, highlights the initial need for substantial

resources, but the transition can have positive impacts on both the economy and the environment.

From an Islamic perspective, the concept of SDGs and a green economy aligns closely with the principle of Maqashid Sharia. Islam emphasizes the importance of balancing human needs with environmental sustainability, as reflected in the concept of "caliphate," which stresses the responsibility of humankind to protect nature and its resources. Similarly, the principle of "Mizan" underscores the necessity for fair and non-exploitative use of natural resources. Thus, the integration of sustainable development through a green economy model not only aligns with Indonesia's development goals but also reflects Islamic values by promoting environmental stewardship as a trust from God.

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