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Research Paper

Reinvigorating Sustainable Green Economics in Indonesia: Exploring the Nexus between Global Green Economy Index and SDG 8

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Abstract

This research investigates the correlation between the Global Green Economy Index (GGEI) and Sustainable Development Goal 8 (SDG 8) within the framework of Indonesia and highlights the importance of harmonizing environmentally sustainable economic practices with comprehensive and inclusive development. Based on 2000-2020 time-series data from key GGEI indicators, including income equality, energy efficiency, green investment attractiveness, biodiversity, and water stress, and using Granger causality tests through Python-based analysis, this study identifies the predictors of SDG 8 in Indonesia. The results show that some of the GGEI indicators have a significant influence on the achievement of SDG 8, putting into highlight some important synergies between green economic strategies and sustainable development objectives. These findings offer practical implications for policy and planning, such as promoting green investments, improving energy efficiency, and enhancing biodiversity conservation and water resource management to strengthen economic resilience and job creation. By bridging green economy metrics with SDG 8 targets, this study provides actionable recommendations for integrating environmental sustainability into Indonesia's economic strategies.

Keywords: Global Green Economy Index; SDG 8; Google Colab; Granger Causality Test.

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1. Introduction

Indonesia, as an archipelagic nation, is particularly vulnerable to the effects of climate change (ASEAN, 2024). Rising sea levels threaten coastal areas and small islands, while extreme weather events like droughts, heatwaves, and floods are becoming more frequent (Ventures, 2024). These climate impacts pose significant risks to all Indonesia's sector, in other hands, the policies and implementation in economic sectors also implicate their effect on climate change. Therefore, the transition to a green economy presents substantial economic opportunities for Indonesia. A study by Indonesia's National Development Planning Agency (Bappenas) indicates that a green economy transition could lead to GDP growth of 6.1-6.5% per year until 2050, up to 68% reduction in emissions intensity by 2045, creation of 1.8 million environmentally friendly jobs by 2030 and higher Gross National Income of up to 25-34% by 2045 (New Zealand Ministry of Foreign Affairs and Trade, 2024).

Indonesia has committed to increasing its renewable energy share to 34% of power generation by 2030 through the Just Energy Transition Partnership (JETP) (ASEAN, 2024). This initiative will mobilize $20 billion over 3-5 years to help phase out coal and invest in renewable energy infrastructure. While Indonesia has set ambitious goals, implementation remains challenging. Even though the government has integrated low carbon development and climate resilience policies into its national development plans (New Zealand Ministry of Foreign Affairs and Trade, 2024), currently, only 12% of Indonesia's energy comes from renewables, far short of its 23% target for 2025 (ASEAN, 2024). However, the country's commitment to becoming carbon neutral by 2060 and its efforts to attract green investments present significant opportunities for growth and innovation in the green economy sector.

Implementing a green economy in Indonesia can achieve net zero emissions and effectively address climate change (Qalbie & Rahmaniah, 2023). Indonesia has integrated low carbon development and climate resilience policies into its national development plans, providing a foundation for green economic growth (New Zealand Ministry of Foreign Affairs and Trade, 2024). The country has also developed a Green Economy Index (GEI) to measure progress towards a green economy (BAPPENAS, 2022). The recently launched Green Economy Index (GEI) offers a framework for measuring Indonesia's progress toward these goals by evaluating its performance across economic, social, and environmental dimensions. However, achieving these ambitious targets is fraught with challenges—ranging from financial constraints to policy implementation hurdles—that require innovative solutions and robust international cooperation.

Indonesia needs to revamp its energy infrastructure and address technical capacity issues to fully benefit from renewable energy potential. Even though Indonesia Government already applied Just Energy Transition Partnership (JETP) (ASEAN, 2024), the country's energy still heavily reliance on non-renewable sources, such as fossil fuels still dominate with around 84% of demand (BAPPENAS, 2022). Although this partnership offers crucial financial, policy, and technical support for an equitable shift to sustainable energy, the country also still faces challenges in managing regional disparities in power distribution and electrification rates (CGS, 2024). In terms of financial constraints, Indonesia needs to expand financing sources, grow local financing options, and develop new financing models. The country needs significant policy reforms, adjustments to investment priorities, and integrated cross-sectoral planning (BAPPENAS, 2022). For instance, outdated power purchase agreements (PPAs) and reliance on the state-owned electricity company (PLN) complicate funding for renewable projects, as the country also faces high verification costs and other barriers in capitalizing on international green finance opportunities (CGS, 2024).

The need for transformation to a sustainable economic model has taken on unprecedented levels of urgency, especially with climate change that poses significant risks to ecosystems globally. This is more acute in Indonesia, as it is both a developing economy rich in natural resources and yet uniquely vulnerable to the adverse effects of climate change and depletion of these resources. In pursuing coherent economic strides with sustainable development, the nation ought to align its local aims with international ones, most particularly the SDGs. Specifically, SDG 8 focuses on "Decent Work and Economic Growth." Foster sustained economic growth per capita, increase labor productivity, spur sustainable tourism, protect labor rights, and ensure safe working conditions. The main indicators for Sustainable Development Goal 8 include GDP growth per employed person, unemployment rate, and the share of youth neither in education, employment, nor training (United Nations, 2015). These targets are in line

with Indonesia's objectives to reduce inequality, increase employment, and achieve inclusive growth while transitioning to a sustainable economy.

This study examines the role of the Global Green Economy Index (GGEI) as an ancillary tool for measuring progress toward Sustainable Development Goal 8 (SDG 8), which emphasizes decent work and economic growth. Rather than the predetermined targets and indicators developed by Bappenas, which mostly observe direct economic and employment metrics, the GGEI provides a holistic perspective by integrating environmental and social dimensions such as energy efficiency, green investment attractiveness, and biodiversity preservation (Dual Citizen, 2022). This approach aligns with theories of sustainable development, particularly the triple bottom line (Elkington, 1997), which underscores the need to balance environmental, social, and economic dimensions to have long-lasting sustainability. Adopting those three elements, GGEI captures complex interrelationships between economic growth and environmental sustainability, which might not be fully reflected in traditional SDG indicators (Meyer & Meyer, 2020).

The GGEI also responds to the emerging global narrative that puts green economic practices at the core of achieving sustainable growth. Indicators like biodiversity conservation and green investment attractiveness give a more multidimensional view of how environmental factors impact economic outcomes in Indonesia, a country highly dependent on natural resources for its economic activities (BAPPENAS, 2022). Furthermore, the GGEI provides a comparative framework that enables benchmarking of the progress made by Indonesia against global best practices, hence serving with actionable insights on how to better align policies with international sustainability standards (European Environment Agency, 2023). According to research by Lopes & Ferreira (2021), energy efficiency is one of the drivers of green industrial development, considering that improvements in energy systems can raise the productivity level of an economy while decreasing the degradation of the environment. Meanwhile, Dasgupta (2021) states that integrating biodiversity conservation into economic planning is crucial for long-term sustainability.

The paper discusses the linkage between GGEI and SDG 8, hence filling a gap in the literature that links green economic indicators to employment and productivity goals in Indonesia. In a recent publication, Lou et al. (2024) observe that low-carbon transition entails huge employment opportunities related to natural resource conservation. Similarly, the Global Green Growth Institute (2023) indicates that green investments will drive inclusive economic development. These perspectives are further supported by the findings of Ziky & El-Abdellaoui (2023), who argue that sustainable development goals can complement economic growth if policies balance resource efficiency and job creation. This linkage of GGEI and SDG 8 provides a framework that can help decision-makers identify policy priorities for Indonesia in order to accelerate its achievement of sustainable development goals.

From this background, two central questions are guided by this research: (1) What is the relationship between the GGEI and the achievement of SDG 8 in Indonesia? (2) What policies are needed to strengthen Indonesia's nexus between GGEI and SDG 8? Addressing these questions contributes to academic discourse and practical policymaking by identifying actionable pathways to integrate sustainability into Indonesia's economic strategies.

The research applies the quantitative approach of the Granger tests based on time-series data from 2000 to 2020. Thus, the methodology permits explanations of cause-and-effect relationships between the most important GGEI indicators—Income equality, biodiversity conservation, and the attractiveness of green investments on one side, and SDG 8 metrics, namely GDP growth per working person and unemployment rate, on the other. Those results are shown using ratio and interval data, comprising emissions vs. GDP, the projected percentage of biodiversity, and air quality measures. With the help of Granger, temporal analysis allows for exploring deeply the impact that GGEI indicators have on SDG 8 performance and underlines the actions that will increase policy coherence for international sustainability goals (Lou et al., 2024; Qalbie & Rahmaniah, 2023). Conversely, research can conduct time-series analysis, which is useful for discovering nonlinear relationships between economic and environmental variables using an appropriate methodological framework (Bai et al., 2015).

For instance, this will connect the dots between economic growth and sustainable development in Indonesia by providing a robust framework for integrating green economic practices into national policy. Using an integrated approach from the GGEI, this study will fill crucial knowledge gaps that will guide efforts toward driving inclusive growth, improving working conditions, and enhancing biodiversity

protection on a path to meeting global sustainability standards. These findings would address policymakers on what must be done to accelerate Indonesia's SDGs and further the resilient and equitable development of the country's green economy.

2. Methods

In this paper, the GGEI indicators herein referred to as Table 1 are used in evaluating the progress of SDG No. 8, which ensures decent work to promote economic growth. These dimensions include but are not limited to sectoral decarbonization, ecological health, social equity, climate change, markets, investment, environmental concerns, social issues, and governance. Each indicator was chosen because it has established relevance to sustainable economic growth, which is at the core of the goals of SDG 8. As such, income equality could mean good opportunities for decent work because of equitable wage distribution and the reduction of social disparities. Sectoral decarbonization-electricity, heat, and manufacturing-would therefore be key to the fitting of industrial growth into the energy transition. Green investment attractiveness fosters jobs and innovation in green sectors, while other indicators ensure the sustainability of resource-dependent industries like agriculture and tourism through measures of water stress and biodiversity. The linkages there show how the different GGEI indicators can combine to realize targets set out under SDG 8.

Table 1: Global Green Economic Index's Indicators

GGEI Indicators	Explanation	Source
	Climate Change & Social Equity	
GHG Emissions/GDP	GHG emissions in the context of GDP, providing insight into whether countries are decarbonizing and succeeding at producing more overall welfare (GDP) with less emissions output.	Climate Watch
GHG Emissions/ capita	GHG emissions in the context of population, providing a different perspective on whether countries are decarbonizing and succeeding at reducing the emissions output relative to their population size.	Climate Watch
Income Equality	Income equality is measured by the Gini Coefficient. The Gini Coefficient measures the degree of income equality in a country, based on household incomes.	World Bank
Gender Equality in the Workplace	To calculate Gender Equality in the Workplace, the ratio of female to male labor force participation is derived from dividing the female labor force participation rate by the male labor force participation rate and multiplying by 100.	World Bank
	Sector Decarbonization	
Buildings	Emissions produced by buildings emissions produced by buildings per GDP	Climate Watch
Electricity & Heat	Emissions produced by buildings emissions produced by electricity & heat per GDP	Climate Watch
Manufacturing & Construction	Emissions produced by buildings emissions produced by manufacturing & construction per GDP	Climate Watch
Transport	Emissions produced by buildings emissions produced by transport per GDP	Climate Watch
Waste & Resource Efficiency	Emissions produced by buildings emissions produced by waste & resource efficiency per GDP	Climate Watch
	Market & ESG Investment	
Green Investment Attractiveness	The GGEI uses IRENA installed renewable energy capacity data as a proxy for measuring the attractiveness of national markets for investment.	IRENA (International Renewable Agency)
Green Innovation	Volume of patents filed in the most recent year where data are available	WIPO (World Intellectual Property Organization
Gender Equality in Governance	Percentage of women in national parliamentary bodies to measure gender equality in governance.	World Bank
	Environmental Health	
Agriculture	Percentage of arable land that is farmed through organic methods	Research Institute for Organic Agriculture (FiBL)
Air Quality	Average Annual Population-Weighted PM2.5	Health Effects Institute
Biodiversity	Average proportion of terrestrial key biodiversity areas (KBAs) covered by protected areas	United Nations
Forests	Total forest area	Food and Agricultural Organization (FAO)
Oceans	Average proportion of marine key biodiversity areas (KBAs) covered by protected areas	UNEP-WCMC

GGEI Indicators	Explanation	Source
Water Stress	Percentage of freshwater withdrawals by all activities relative to the total freshwater available	UNESCO World Water Assessment Programme

Source: Climate Watch, 2021; World Bank Data, 2023; International Labour Organization (ILO), 2023; International Renewable Energy Agency (IRENA), 2023; World Intellectual Property Organization (WIPO), 2023; Research Institute for Organic Agriculture (FiBL), 2023 ; Health Effects Institute, 2024; Food and Agricultural Organization (FAO), 2023; UNEP-WCMC (2024); UNESCO World Water Assessment Programme, 2023.

The sources are annual reports, official publications, and others, actually published from 2000 to 2020, which have been gathered on a yearly basis with the purpose of maintaining the same temporal resolution. This actually allows for an intensive study of trends and relations for two complete decades. To fill in the gaps when the values for some years were not available in the dataset, interpolation techniques were adopted from the scikit-learn library. Smoothing was done using Python libraries such as pandas and numpy, which allow numerical computation and data transformation. Ensuring that the data was stationary-a prerequisite for time-series analysis-was checked through the Augmented Dickey-Fuller test, with necessary differencing to remove trends and ensure stationarity (Adesegun et al., 2020). The process ensures that the data will meet the required assumptions for appropriate statistical analysis. This will be an appropriate choice of the best lag, chosen based on Akaike Information Criterion and Bayesian Information Criterion, that correctly models the time dynamics and relationships.

Figure 1. The Granger causality test is an appropriate choice in this research because it would consider whether the past values of the GGEI indicators could be used to predict changes in SDG 8, given that this research will be done in a time-series environment. Granger causality can find a time-related link in sustainable development studies, which has been proven through research (Rosół et al., 2022). In this respect, The Granger causality relationship between indicators of GGEI and SDG 8 is determined using the Python library of statsmodels. This will help in understanding which indicators predict progress in economic growth and decent jobs. Such nonlinear causality tests, performed using techniques like neural networks, enhance this further. This is particularly useful when the relationships are complicated and the data size is large, according to (Krishna & Guo, 2008), and (Bai et al. 2015).

These are all done on a shared platform of Google Colab, allowing for the effect of efficiency in processing and representation of data. In this regard, Matplotlib and seaborn should be applied for the constructive visualizations of trends and relations of variables. This approach ensures the outcome of the study is statistically strong and applicable in real life. It aligns with previous studies on SDGs and their measurements using advanced econometric methods (Liu & Gao, 2019; Yesuf et al., 2023).

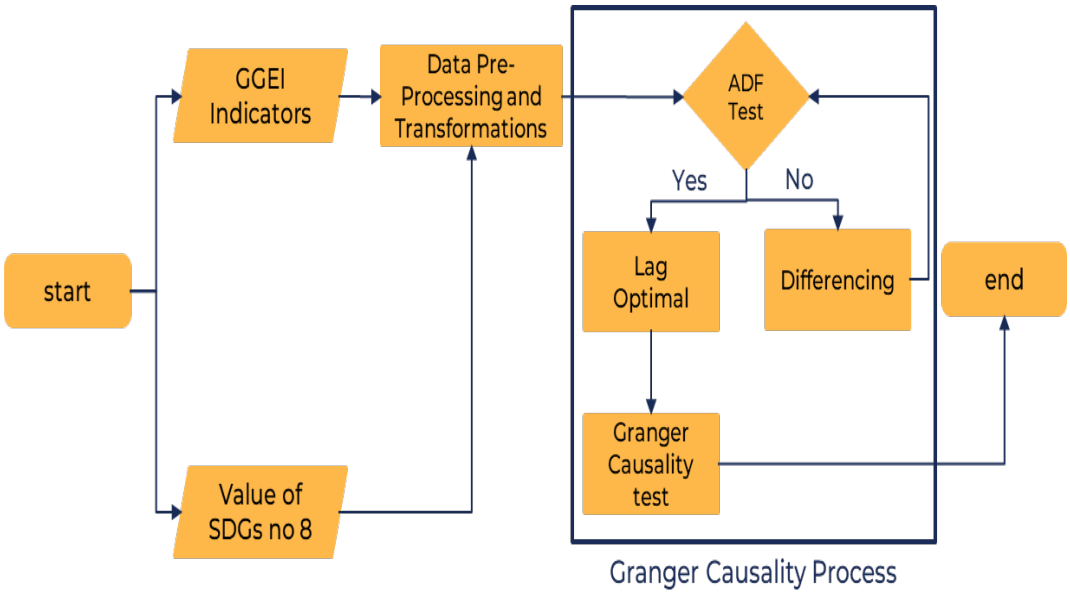

Figure 1. Research Flow chart
Source: Authors, 2024

3. Results and Discussions

3.1 Indonesia's position in the GGEI and achievement of SDG 8

The GGEI and SDG 8 are associated yet interlinked frameworks that draw on the juncture at which economic growth and environmental sustainability meet. It is here that, especially, SDG 8 makes efforts to achieve higher, inclusive, and sustainable economic growth, decent work, and full and productive employment. On the other hand, GGEI assesses the performance of the country in regard to integrating green economic practices, such as renewable energy development, biodiversity conservation, and green investment. For Indonesia, these frameworks are indispensable because the country faces a dual challenge: it has to maintain economic growth while mitigating environmental degradation.

Indonesia's economy heavily depends on natural resources, making it highly vulnerable to climate risks and resource depletion. With a GGEI score of just 0.37, Indonesia ranks low among countries, reflecting substantial gaps in its transition to a green economy (Dual Citizen, 2022). Key issues include deforestation, water stress, and limited investments in renewable energy infrastructure. This is well-illustrated by Indonesia, whose greenhouse gas emissions are dominated by deforestation, while only 12% of its energy comes from renewable sources-considerably below the global average of 29% (International Energy Agency, 2023). In turn, despite these difficulties, the score of Indonesia for SDG 8 went up to 75.91 (Figure 2), pointing to the progress in GDP per capita, which has grown by 5.3% from the year 2001 to 2022 (Republic of Indonesia, 2024). However, the SDG 8.1 target for low-middle income countries of 7% GDP growth (BAPPENAS, 2024) remains unmet, highlighting the need for enhanced policy alignment.

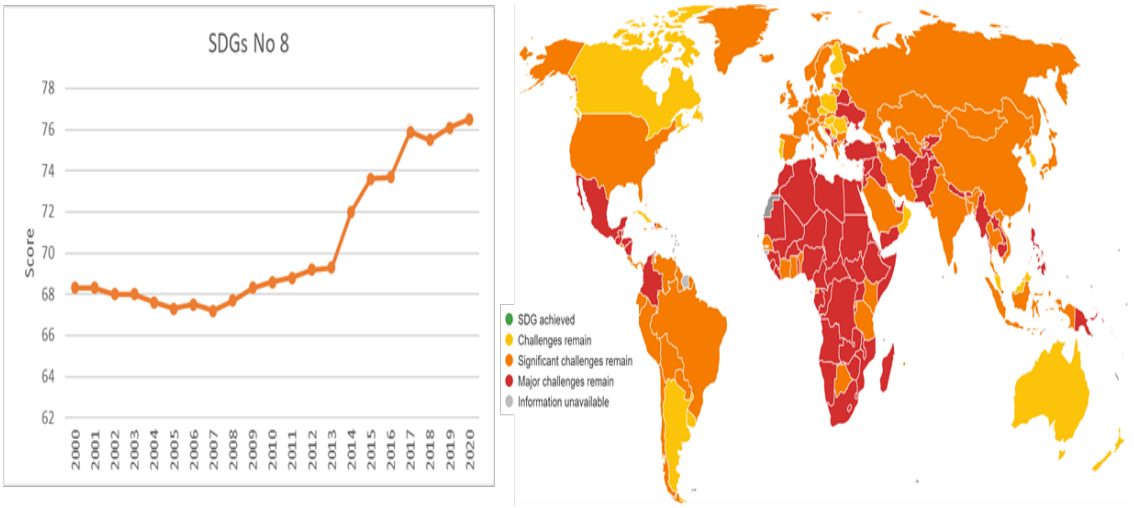

Figure 2. Indonesia's SDG 8 value and its classification (Sachs, et al., 2024)

SDG 8 is core to increasing Indonesia's economic resilience through decent work, with a premium on improving labor productivity. Indonesia has some structural problems, including premature deindustrialization, whereby the contribution of the manufacturing sector to GDP fell from 27.4% in 2005 to 18.3% in 2022 (BAPPENAS, 2023). Meanwhile, informal employment remains high, with over 57% of the workforce engaged in low-productivity sectors such as agriculture and traditional services (International Labour Organization, 2023). Integrating GGEI insights, such as promoting green investments and fostering a circular economy, could create higher-quality, sustainable jobs while addressing economic inequalities (Global Green Growth Institute, 2023).

The progress of reaching SDGs, including SDG 8, has been very slow; the global sustain index increased from only 64% in 2015 to 67% by mid-2022 (Sachs et al., 2024). Indonesia's low ranking in the GGEI indicates its need to benchmark against global best practices. For instance, economies like Germany and Denmark that take the lead in renewable energy investments and circular economy policies show high performances across both GGEI and SDG 8 indicators. They have already implemented policies like tax incentives for the green industry and the enforcement of mandatory sustainability reporting for

corporations (European Environment Agency, 2023). With these same approaches, Indonesia would be able to quickly advance its green economic transformation and competitiveness in the global economy.

The amalgamation of the GGEI and SDG 8 is essential for tackling socio-economic disparities in Indonesia. The Gini coefficient indicative of income inequality in the nation is notably elevated, maintaining a level near 0.384 in 2022 (World Bank Data, 2023), which suggests ongoing imbalances in wealth allocation. Furthermore, gender disparity remains evident, as female participation in the labor force is merely 53.4%, whereas male participation stands at 81.2% (ILO, 2023). Kreinin & Aigner (2022) argue that aligning SDG 8 with strong sustainability principles can promote equitable economic policies that reduce these disparities. Encouraging inclusive green investments, such as community-based renewable energy projects, could provide opportunities for marginalized groups to benefit from the green transition.

In Indonesia, the country stands currently as the sixth largest emitter in the world, accounting for 3.11% of the world's total. According to Climate Watch (2021), the commitments of the government to such reductions have equally been made via low-carbon development by 1.63 GtCO2e by 2030 and 540 MtCO2e by 2050. Current progress, however, remains slow-with renewable energy comprising only a fraction of the energy mix and green infrastructure investment lagging. According to the Global Green Growth Institute in 2023, green investments can spur inclusive development on the one hand and reduce emissions on the other. For instance, developing Indonesia's geothermal and solar energy could contribute to lowering carbon emissions and creating more employment opportunities.

GGEI and SDG 8 have the potential to induce crucial transformative change if integrated into Indonesia's national strategies. This present analysis also stands to act as an excellent reference point for Indonesia's National Long-Term Development Plan 2025-2045, with emphasis on green industrialization, investments in renewable energy, and equitable labour practices. Enhancing Indonesia's GGEI Score: The country's ranking will also increase its ability to attract international green investments, crucial for financing wide-ranging sustainability projects. The insights gained from this integration may likewise function as a framework for additional developing countries aiming to realize sustainable development within a swiftly evolving global economic context (Kreinin & Aigner, 2022; Global Green Growth Institute, 2023).

3.2 Causality of GGEI and SDG 8

The relationship between the GGEI and SDG 8 suggests a possible correlation, although it is important to note that correlation only describes the relationship between two variables and does not prove that one variable causes change in the other (Dörgő et al., 2018; Ziky & El-Abdellaoui, 2023). It is crucial to acknowledge that a mere correlation does not necessarily imply causality. Variables that exhibit a correlation may not necessarily be causally linked, and thus, a correlation does not necessarily provide evidence of a causal relationship. In the event of a significant correlation, further investigation is required to ascertain whether alterations in one variable exert an influence on the other (Tusmar & Mora, 2015).

In this study, time series analysis is employed to ascertain whether GGEI indicators exert an influence on SDG 8 values. The Granger causality test, introduced by Granger (1969), is used to measure the extent that one variable can predict another. The principle of time series analysis is the understanding about how data are generated (DGP) because, if we deal with non-stationary time series namely, ARIMA cannot be applied to estimate and forecast correctly. A series is said to be stationary when its statistical properties (e.g. the mean and variance) do not fluctuate over time (Granger & Newbold, 1974). To test for stationarity, we use the Augmented Dickey — Fuller (ADF) Test which identifies unit roots (Dickey & Fuller 1981). In spite of the high power, it enjoys against most alternative hypotheses, Agiakloglou & Newbold (1992) warn that trend- stationary series with structural breaks can result in rejection by ADF.

The ADF test results for this study indicate that only GHG emissions per capita and biodiversity are stationary. As illustrated in Table 3, a negative ADF statistic value provides evidence that the data are stationary. However, the magnitude of this negative value has implications for the strength of the evidence. In the event that the ADF value is increasingly negative, yet the p-value remains above 0.05, the data is still deemed to be non-stationary. Accordingly, indicators other than GHG emissions per capita and biodiversity necessitate differencing to attain stationarity.

Following the initial differencing process (Figure 3), the following indicators achieved stationarity: GHG Emissions/GDP, Gender Equality in the Workplace, Electricity and Heat, Transport, Green Investment Attractiveness, and Gender Equality in Governance. Moreover, in the second differencing, indicators such as Waste & Resource Efficiency, Air Quality, and Water Stress were found to have achieved stationarity. The third differencing resulted in the attainment of stationarity for additional indicators, including Income Equality, Buildings, and Oceans.

However, despite the application of differencing up to three times, the Manufacturing & Construction and Green Innovation indicators only reached stationarity after differencing six times. This indicates the presence of a strong trend or seasonal pattern in both indicators. While the repeated differencing process may result in a reduction of information from the original data, the graphical patterns of these two indicators still demonstrate alignment with the original data, allowing for their continued utilisation in subsequent analysis.

Table 2: Augmented Dickey-Fuller (ADF) unit root test

GGEI Indicators	ADF t-Statistics	p-value	Level of Difference
GHG Emissions/GDP	-8.942	9.181456540885354e-15	1
GHG Emissions/capita	-4.066	0.001	0
Income Equality	-5.676	8.664755747616673e-07	3
Gender Equality in the Workplace	-4.082	0.001	1
Buildings	-11.295	1.3481247330372438e-20	3
Electricity & Heat	-4.674	9.391005569662365e-05	1
Manufacturing & Construction	-25.324	0.0	6
Transport	-3.818	0.002	1
Waste & Resource Efficiency	-9.252	1.4771735101953484e-15	2
Green Investment Attractiveness	-5.462	2.5053232612285722e-06	1
Green Innovation	-3.807	0.002	6
Gender Equality in Governance	-4.847	4.4061468579075305e-05	1
Air Quality	-8.489	1.3259289056594605e-13	2
Biodiversity	-9.292	1.1728524000587546e-15	0
Oceans	-17.208	6.395411459622168e-30	3
Water Stress	-4.286	0.00046	2

p-value: a probability value that indicates how strong the evidence is to reject H0.
If the p-value is smaller than the significance level (0.05), then reject H0 and conclude that the data is stationary.

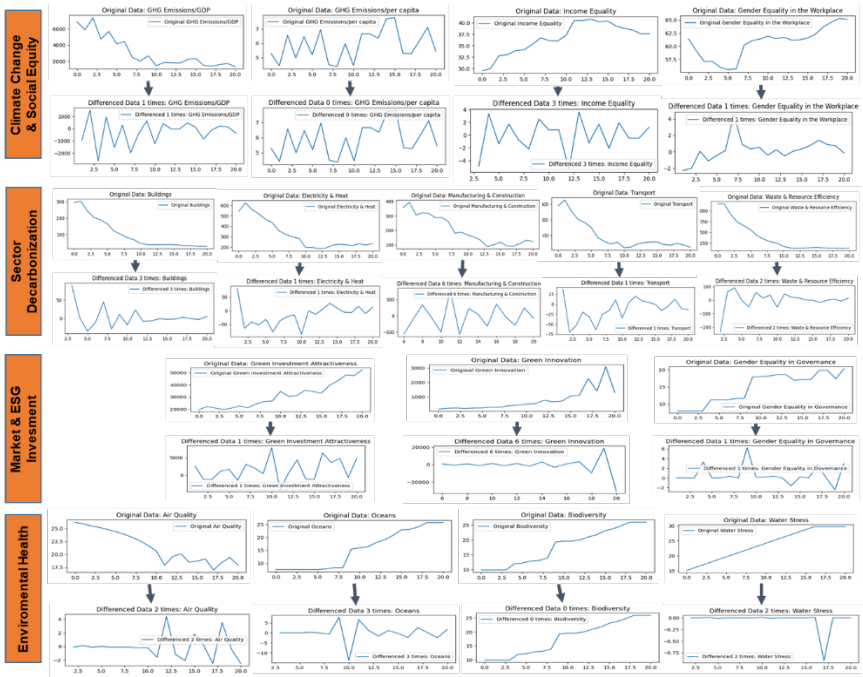

Figure 3. Differencing Data
Source: Authors, 2024

These criteria include, inter alia, the Hannan-Quinn Information Criterion (HQIC), Bayesian Information Criterion (BIC) and Akaike's Information Criterion (AIC). AIC score is a composed of the

complexity cost (the number of parameters in model) and model fit, that this are best describes as how well stats your data points with given dimensions. Similarly, BIC also calculates a value that combines the likelihood and complexity penalty, albeit with a greater penalty on BIC than on AIC. HQIC also calculates a value that combines likelihood and complexity penalties, but with a penalty on HQIC that is between that of AIC and BIC. The optimal lag length is determined from the VAR equation with the smallest AIC value (Roman & Kartiko, 2020).

As evidenced by the results presented in Table 3, the determination of the optimal lag length through the application of AIC, BIC, and HQIC yields nearly identical outcomes. In accordance with the aforementioned assertion that the determination of the optimal lag is based on the lowest AIC value, the longest optimal lag is identified for the Market and ESG Investment variables, followed by the Climate & Social Equity and Environmental Health variables. Conversely, the Decarbonization variable exhibits the shortest lag. In accordance with the findings of Liu and Gao (2019), the decarbonization variable exerts the most immediate influence on SDG 8, whereas the market and ESG investment variable demonstrates the longest lag in its impact.

Table 3: Lag Length Test Results

GGEI Indicators	AIC	BIC	HQIC	Lag Optimal
GHG Emissions/GDP	285.807	290.259	286.421	3
GHG Emissions/capita	62.569	66.694	63.183	3 (AIC)/ 2 (BIC)
Income Equality	57.841	62.293	58.455	3
Gender Equality in the Workplace	63.919	68.371	64.533	3
Buildings	137.762	141.540	138.402	2
Electricity & Heat	178.955	182.732	179.594	2
Manufacturing & Construction	183.543	187.321	184.183	2
Transport	163.627	167.405	164.267	2
Waste & Resource Efficiency	178.663	182.441	179.303	2
Green Investment Attractiveness	327.649	348.488	344.650	4
Green Innovation	243.203	248.202	243.700	4
Gender Equality in Governance	77.806	82.806	78.303	4
Air Quality	57.527	61.979	58.141	3
Biodiversity	66.463	70.915	67.077	3
Oceans	78.866	83.318	79.480	3
Water Stress	-2.103	1.674	-1.463	2

Source: Authors, 2024

The findings from the Granger Causality test, as outlined in Table 4, reveal significant causal connections between various GGEI indicators and the attainment of SDG 8. The indicators of Income Equality (p-value = 0.024), Electricity & Heat (p-value = 0.047), Manufacturing & Construction (p-value = 0.005), Green Investment Attractiveness (p-value = 0.028), Biodiversity (p-value = 0.030), Oceans (p-value = 0.014), and Water Stress (p-value = 0.039) exhibit a predictive effect on the outcomes related to SDG 8. These findings show the crucially important contribution that integrated social, environmental, and economic policy makes to achieving sustainable growth with decent work.

Green Investment Attractiveness indicates that a greater regulatory framework attracts green finance in the form of green bonds or ESG thematic investment, among others, that catalyzes employment opportunities and innovations within the renewable energy and ecofriendly industry (Sugiawan & Managi, 2019; Meyer & Meyer, 2020). In a similar vein, Income Equality underscores the importance of fair wage allocation and the provision of quality employment opportunities, necessitating the implementation of vocational training initiatives and equitable regional minimum wage standards to mitigate economic inequalities (Kreinin & Aigner, 2022). The causal relationships associated with Electricity & Heat and Manufacturing & Construction suggest that the decarbonization of these sectors is critical, as the adoption of energy-efficient methodologies and clean technologies can decrease emissions while simultaneously enhancing economic resilience (Lopes & Ferreira, 2021).

Biodiversity and oceans are so fundamental that conservation, particularly with extending programs for marine protected areas, introducing sustainable fisheries, and reforestation policies, should all balance economic growth with resource preservation. Lastly, the impact of Water Stress demonstrates that water availability critically influences economic productivity, particularly in agriculture and industry, making investments in smart irrigation, urban rainwater harvesting, and wastewater recycling essential

for resource efficiency (Bai et al., 2015). Collectively, these results emphasize the importance of aligning social, environmental, and economic policies to advance Indonesia's progress toward SDG 8 while ensuring long-term sustainability and inclusivity.

Table 4: Granger Causality between GGEI's Indicators and SDG 8

Null Hypothesis	F-statistic	p-value	description
GHG Emissions/GDP	3.7950	0.068	Rejected
GHG Emissions/capita	0.0960	0.760	Rejected
Income Equality	6.1285	0.024	Accepted
Gender Equality in the Workplace	1.2453	0.280	Rejected
Buildings	3.8253	0.067	Rejected
Electricity & Heat	4.5558	0.047	Accepted
Manufacturing & Construction	10.2583	0.005	Accepted
Transport	2.5590	0.128	Rejected
Waste & Resource Efficiency	3.5150	0.078	Rejected
Green Investment Attractiveness	5.7077	0.028	Accepted
Green Innovation	0.8437	0.371	Rejected
Gender Equality in Governance	2.8795	0.107	Rejected
Air Quality	3.0347	0.099	Rejected
Biodiversity	5.5933	0.030	Accepted
Oceans	7.3735	0.014	Accepted
Water Stress	7.6563	0.013	Accepted

Source: Authors, 2024

3.3 GGEI Factors and Its Implication to Indonesian Policies

According to Granger causality statistical analysis result, its revealed that significant causal relationships in which not all Global Green Economy Index (GGEI) indicators significantly influence SDG 8 in Indonesia, these several indicators are comprises of *Income Equality, Electricity & Heat, Manufacturing & Construction, Green Investment Attractiveness, Biodiversity, Oceans and Water Stress*. As these indicators aforementioned have significant casual relationship, doesn't mean the others are not important factors or indicators. Those which have a p-value close to 0 mean that they need to be prioritized or tackled soon in achieving SDG 8; meanwhile, those which have a p-value close to 1 potentially will be put on the long-term program.

The paper finding has important implications for green economy policies in Indonesia, even though there's still room for improvement in reaching SDG8. For instance, the causal relationship between income equality and SDG 8 underscores the importance of inclusive economic growth, as Indonesia has made progress in reducing inequality, with the Gini coefficient decreasing from 0.41 in 2011 to 0.38 in 2019 (Malau, et al, 2023). Indonesia's low carbon development must address social justice and equity issues to effectively mitigate climate change and transition to a green, low carbon economy (Elliott & Setyowati, 2020). Another several sectors such as electricity, heat, manufacturing, construction, and green investment attractiveness are also crucial for Indonesia's transition to a green economy and to achieve both GGEI improvements and SDG 8 targets. Some of the progress that has been made by Indonesia in attracting green investments is the green bonds issuance reaching $5.5 billion in 2021 (New Zealand Ministry of Foreign Affairs and Trade, 2024), as green bonds can potentially fund renewable energy sectors, improving climate change mitigation and sustainable economic development in Indonesia (Santoso, 2020). Besides that, research conducted by Lou et al, (2024) also found that green investment in Indonesia could create up to 15.3 million jobs by 2030 in sectors such as renewable energy, sustainable agriculture, and eco-tourism.

As part of manufacturing and construction sectors, renewable energy in Indonesia also plays important roles, as studied conducted by Sugiawan & Managi, (2019) has found that a 1% increase in renewable energy consumption in Indonesia led to a 0.29% decrease in CO2 emissions, indicated that the policy recommendation should emphasizing the importance of clean energy transition. On the other hand, Indonesia also has big potential in their resources, one of which is its oceans, in which The World Bank estimates that Indonesia's blue economy has the potential to contribute up to $1.3 trillion to the country's GDP by 2030 if managed sustainably (World Bank, 2021). The result of causal relationships highlighted the interconnectedness of environmental sustainability and economic growth in Indonesia.

Policymakers should focus on creating an integrated approach that addresses these GGEI indicators while pursuing SDG 8 targets. This could involve cross-sectoral policies that promote green investments, sustainable resource management, and inclusive economic growth which detailed in the Table 4 as follows,

Table 4: Policy Recommendation to Achieve SDG 8 In Indonesia

GGEI Indicators	Policy Recommendation
Electricity & Heat and Manufacturing & Construction	Accelerate the transition to renewable energy in both electricity generation and industrial processes. This could involve: • Incentives for renewable energy adoption in manufacturing • Stricter energy efficiency standards for buildings and industrial processes • Support for research and development in clean energy technologies
Biodiversity, Oceans, and Water Stress	• Strengthen conservation efforts while promoting sustainable economic activities • Develop blue economy initiatives to sustainably utilize ocean resources • Implement water management strategies to reduce stress on water resources
Income Equality	Focus on creating more equitable economic opportunities, particularly in green sectors. This could involve targeted skills training programs and support for small and medium enterprises in sustainable industries.
Green Investment Attractiveness	• Strengthening the regulatory framework for green investments • Developing more green financial products • Enhancing transparency and reporting standards for environmental, social, and governance (ESG) factors

Source: Authors, 2024

Research Delimitation

Due to an inadequate quantity of available data, the indicators about forestry and agriculture were not incorporated into this research. This lack of data limits the analysis's breadth and might jeopardize the reliability of its conclusions. Future studies must focus on acquiring a more comprehensive dataset that includes the factors connected to forestry and agriculture to attain a more nuanced understanding of the role the green economy plays in sustainable development.

Conclusion

It shows that the GGEI indicators are related to *Income Equality, Electricity and Heat, Manufacturing and Construction, Green Invesment Attractiveness, Biodiversity, Oceans, Water Stress*, and fulfillment of SDG 8 in Indonesia. The results represent the need for integrated management among the three economic, social and environmental pillars. Examples include how green investment attractiveness is required for job creation in the renewable energy industry and biodiversity conservation for the economic sustainability of natural resources. However, Indonesia still faces challenges related to high dependence on fossil energy, income inequality, and less-than-optimal use of marine potential for the blue economy.

Others include speeding up the transition to renewable energy, strengthening incentive policies for green investment, and modernizing the manufacturing sector through adopting the circular economy. Equally important, smarter water management includes water-saving irrigation technologies and recycling industrial waste, which are part of the priority list to reduce water stress. Blue economy development through sustainable aquaculture and ecotourism has huge potential to raise productivity while maintaining ecosystem balance. This policy approach will enable Indonesia to strengthen its standing in GGEI further and achieve SDG 8 rapidly for economic growth that is inclusive sustainable, and resilient to climate change.

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