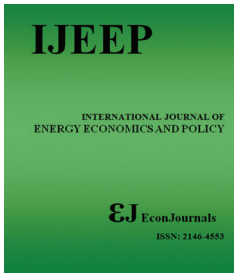

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2026, 16(1), 251-261.

Analysis of Green Investment, Access to Clean Fuels, Green Jobs, Green Energy, and CO_2 Emissions on Economic Growth and Welfare: An Empirical Study in Developing Countries

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Received: 11 June 2025 **Accepted:** 12 October 2025 **DOI:** https://doi.org/10.32479/ijeep.21375

ABSTRACT

The adoption of a sustainable economic model aims to enhance community well-being and promote social equity while minimising the potential for ecological harm. Economic development focused on a green economy is realised by minimising CO_2 emissions through the reduction of fossil fuel consumption and the transition to renewable energy sources. This study aims to examine the effects of implementing a green economy, focussing on aspects such as renewable energy investment, renewable energy consumption, green jobs, and access to clean energy, on economic growth and overall welfare. The investigation took place across 10 developing nations, spanning the years 2015-2023. The analytical method employed was Generalised Least Squares (GLS). The findings indicate that environmentally sustainable investments contribute positively to economic growth in all developing nations. In the meantime, the consumption of renewable energy, access to clean energy, and the creation of green sector jobs have failed to stimulate economic growth and improve welfare in developing countries; rather, they persist in placing a strain on the economy and overall well-being. The negative effects of CO_2 emissions on economic growth and long-term welfare are significant.

Keywords: Green Economy, Renewable Energy Investment, Renewable Energy Consumption, Green Jobs, Clean Energy Access, Economic Growth
JEL Classifications: I31, Q2, Q5

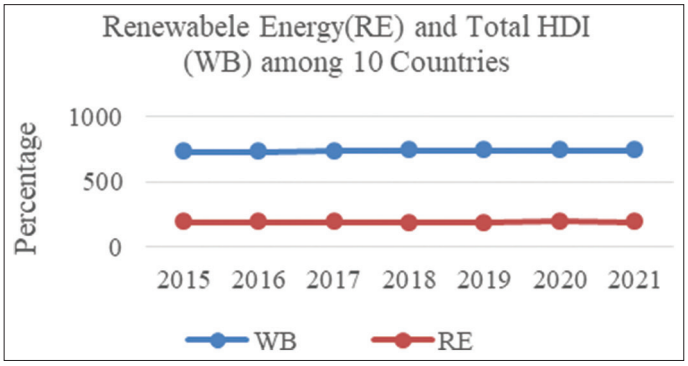
1. INTRODUCTION

The United Nations Environment Programme (UNEP) characterizes a green economy as an economic framework that enhances human welfare and social equity while mitigating the risks associated with environmental and ecological deficits (Haddad and Solomon, 2023). This economic paradigm aims to improve individual well-being and promote social equity, concurrently minimizing environmental harm. It also entails the management of natural resources with a focus on sustainability and efficiency (Kazitskaya et al., 2021). The fundamental tenets of an eco-friendly economy encompass sustainable economic practices, societal inclusivity, and environmental conservation (UNEP, 2012). A green economy is predicated on three principal pillars: economic, social, and environmental sectors, each playing a crucial role in fostering economic growth (Lumbanraja and Lumbanraja, 2023). This economic model is integral to the Sustainable Development Goals (SDGs), particularly Goal 8, which advocates for inclusive and sustainable economic growth, alongside full and productive employment and decent work for everyone (Stukalo and Simakhova, 2019). Developing countries have acknowledged the need to tackle the negative and potentially disastrous effects of climate change on both current and future generations, as well as its impact on economic development, by embracing a green economy as outlined in the Paris Agreement (Lyeonov et al., 2019). To meet economic growth targets, it is vital to move away from reliance on a carbon-based economy and begin developing a circular economy, a green economy, and a blue

economy (Kasztelan, 2017). The transition to a sustainable green economy requires a careful balance among economic, social, and environmental aspects, in line with the Sustainable Development Goals (SDGs) and the Paris Agreement (Mikryukov et al., 2021). The essence of sustainable development lies in the ability of scientific and technological advancements to drive economic progress while maintaining ecological balance.

The ongoing implementation of a sustainable economy in developing nations is expected to improve economic stability, lower CO_2 emissions, and create job opportunities, while also helping to avoid the middle-income trap (Pan et al., 2019). There are two main opportunities for advancing the development of a sustainable economy. Firstly, shifting economic activities towards the renewable energy sector is crucial for reducing carbon emissions and addressing greenhouse gas emissions. Secondly, fostering new centers of economic growth by developing innovative circular sectors and activities, which include sustainable natural resource-based industries, the bioeconomy, the blue economy, and industries focused on waste utilization. Embracing a green economy stands as the most effective approach to fostering both economic growth and social advancement (Lyeonov et al., 2019; Thormann et al., 2023) Research by Ali et al. in developing nations, with a focus on Ghana, highlighted several factors that influence the shift towards a green economy: the country's strategic geographic position, forward-thinking environmental policies, potential for a diverse green energy mix, a vibrant young population, and ongoing efforts to alleviate poverty and reduce illiteracy rates (Ali et al., 2021). In the interim, the findings from Firmansyah's investigation in Indonesia indicate that a significant weakness exists in institutions that lack the robustness necessary to foster a green economy, compounded by elevated levels of corruption (Firmansyah, 2022). The empirical data regarding the implementation of renewable energy and its correlation with the Human Development Index in the developing countries included in this study is illustrated in the following figure:

Figure 1: Total HDI and Renewable Energy from 10 countries during 2015-2021



Source: World Bank (2025) and UNDP (2025)

Figure 1 presents a comparative analysis of the HDI and RE across ten developing nations: Brazil, Vietnam, Chile, India, Kazakhstan, South Africa, Egypt, Mexico, Indonesia, and Morocco, spanning the period from 2015 to 2021. The data indicate a consistent increase in HDI, reflecting advancements in education, health, and income. Conversely, the growth of renewable energy remains sluggish, suggesting significant challenges in transitioning to sustainable energy sources. These challenges encompass limited financial resources, reliance on fossil fuels, slow investment in clean energy, and technological deficiencies.

Many developing countries prioritize short-term economic growth and affordable energy, thereby relegating green energy to a lower priority. Consequently, despite heightened awareness of sustainable energy, its adoption remains gradual. Figure 1 underscores a critical issue: while human development is on an upward trajectory, the adoption of renewable energy lags, illustrating the difficulty faced by developing countries in balancing economic growth with environmental objectives.

In emerging economies, policies intended for fostering a green economy frequently encounter a conflict between advancing economic growth and protecting the sustainability of the environment (Ali et al., 2021; Tomashuk, 2022). The majority countries that are developing continue to depend on industries centred around natural resources, resulting in significant pollution levels (Manea and Cozea, 2022). Consequently, moving towards a green economy is essential, not just a choice, to guarantee sustainable growth over the long term (Kabeyi and Olanrewaju, 2022). The transition encompasses modifications in policies, industrial practices, and individual consumption behaviours that necessitate solid assisting from governments and all pertinent stakeholders (Imppola, 2020).

A significant challenge in the realm of economic development within developing nations lies in balancing economic growth with the imperative of environmental protection (Ali et al., 2021; Sasana et al., 2022; Tomashuk, 2022). Many developing nations continue to depend on industries centred around natural resources, resulting in significant pollution levels (Manea and Cozea, 2022; Sasana et al., 2022, 2023). Conversely, inadequate institutions and insufficient funding present significant barriers to the realisation of a green economy, potentially leading to a decline in welfare levels over the long term (Ali et al., 2021; Firmansyah, 2022). This study investigates the integration of environmental and social factors in sustainable economic development strategies, offering pertinent empirical evidence regarding the significance of access to clean energy and a green workforce in the shift towards a low-carbon economy.

2. LITERATURE REVIEW

Relying on fossil fuels for economic growth often boosts GDP figures but adversely affects human development outcomes. Economic growth that overlooks environmental considerations only worsens long-term disparities in development. The Environmental Kuznets Curve (EKC) theory posits a non-linear, inverted-U relationship between per capita income and environmental pressures (Ali et al., 2021; Firmansyah, 2022). In the initial stages of economic growth, there is typically a connection between rising incomes and increased environmental degradation, driven by the expansion of industrial activities, urban growth, and reliance on fossil fuel energy sources. During this phase, nations prioritize economic growth, often ignoring

ecological consequences, leading to inevitable outcomes such as air pollution, deforestation, and the overexploitation of natural resources. As income levels increase and economic structures transition from the primary sector to the service and technology sectors, there is a corresponding rise in social awareness regarding the significance of environmental sustainability. There is a growing public demand for more stringent environmental policies and the integration of sustainable technologies in both production and consumption practices. In this context, economic growth transcends its traditional role, emerging not as a threat to the environment but rather as a driving force for green innovation and enhanced resource efficiency. Consequently, there is a noticeable reduction in environmental pressures, even as income levels continue to rise.

Figure 2 presents the green economy has transformed into a more inclusive model, characterised by not just low-carbon, efficient, and clean production, but also by inclusive consumption, output, sharing, circularity, collaboration, solidarity, resilience, opportunity, and interdependence. A sustainable economy should focus on generating job opportunities and minimising income disparity while ensuring the protection of our environment for future generations (UNEP, 2012). Here are several key principles of the green economy: (a) an economy that prioritises sustainability, (b) inclusivity within society, (c) the preservation of the environment.

a. Sustainable economy: A green economy highlights the significance of economic growth that is sustainable, considering both environmental and social factors. This encompasses the prudent utilisation of natural resources and the advancement of sustainable technologies.
b. Social inclusiveness refers to an effective green economy plan should encourage economic opportunities across all levels of society, with the goal of minimizing economic disparities and enhancing access to jobs and educational resources.
c. Environmental conservation, protection, and restoration are essential for nurturing a sustainable economy. This involves responsible management of natural resources, cutting down carbon emissions, and safeguarding biodiversity.

Figure 2: Inclusive green economy

Source: Zoboli et al. (2014)

Narayan and Narayan's extensive research suggests that as income levels rise in developing countries, there may be a corresponding decrease in emissions, thereby lending support to the Environmental Kuznets Curve (EKC) hypothesis. Initially, the increase in emissions poses significant challenges, as it is not mitigated by the adoption of sustainable technologies (Wang and Komonpipat, 2020). Furthermore, Shahbaz et al.'s study reveals a long-term correlation between economic growth and CO_2 emissions in Pakistan, characterized by a non-linear relationship consistent with the EKC model (Ahmad et al., 2022). This underscores the intricate nature of the emissions-economic growth nexus in developing nations. In the early phases of economic development, emissions often obstruct productivity owing to factors such as inadequate infrastructure, outdated technology, and adverse health effects.

The Environmental Kuznets Curve (EKC) provides a critical theoretical framework for analyzing the shift from growth driven by resource exploitation to sustainable development. However, the applicability of the EKC is significantly shaped by the unique institutional frameworks, regulatory capacities, and policies concerning energy transition and environmental justice in each nation. In the context of developing countries implementing the Paris Agreement, it is crucial to evaluate how factors like green investment, green labour, and access to clean energy can expedite the realization of the environmental degradation reduction phase as proposed in the EKC concept. The execution of a sustainable economy is intrinsically linked to the application of its associated concepts, including green jobs, green tourism, green growth, green financing, and green investment.

3. RESEARCH METHODOLOGY

This study aims to examine how the implementation of a sustainable economy—encompassing aspects including green investments, renewable energy sources, forest conservation, access to clean energy, and green employment—affects economic growth and overall well-being in developing nations, alongside

Table 1: Variables and data source

Variables	Symbol	Data	Unit	Sources
Economic Growth	GDP	Economic Growth	% percent	World bank
Well Being	WB	HDI	% percent	UNDP (2025)
Renewable Energy Invest.	IRE	Investation Renewable Energy	USD	IRENA STAT (2025)
Renewable Energy	RE	Renewable Energy	% percent	World Bank (2025c)
CO_2 Emission	CO_2	CO_2 Emission	million ton	Global Carbon Budget
Forest area	FA	Forest Area	% percent	FAO (2025)
Access to Clean Fuels	ACF	Access Clean Fuel	% percent	IEA (2023)
Green Job	GJ	Employment in Agriculture	% percent	ILO (2025)

the role of CO_2 emissions. This study focusses on developing nations that have adopted net-zero emissions commitments as defined by the 2015 Paris Agreement. The investigation took place across 10 developing nations: Brazil, Vietnam, Chile, India, Kazakhstan, South Africa, Egypt, Mexico, Indonesia, and Morocco. The timeframe of this analysis spans from 2015 to 2023, encompassing eight years of green economy initiatives following the signing of the Paris Agreement in 2015. Nevertheless, these emerging nations persist in their significant dependence on fossil fuels to propel economic advancement.

The data utilised in this study were obtained from the World Bank, the International Renewable Energy Agency, the International Labour Organisation (ILO), and Our World in Data. To tackle the research questions, a quantitative approach employing Generalised Least Squares (GLS) was utilised. The modelling of the impact of green economy implementation on achieving SDGs outputs is presented as follows:

$$Y_{it} = \beta_O + \beta_n X_{nit} + e_{it} \quad (1)$$

The empirical model demonstrating the impact of green economic variables on the attainment of SDGs (economic growth rate and welfare) can be expressed in the subsequent equation:

Empirical equation model 1:

$$GDP = \beta_0 + \beta_1 IRE_{it} + \beta_2 RE_{it} - \beta_3 CO2_{it} + \beta_4 FA_{it} + \beta_5 ACF_{it} + \beta_6 GJ_{it} + e_{it} \quad (2)$$

Empirical equation model 2:

$$WB = \beta_0 + \beta_1 IRE_{it} + \beta_2 RE_{it} - \beta_3 CO2_{it} + \beta_4 FA_{it} + \beta_5 ACF_{it} + \beta_6 GJ_{it} + e_{it} \quad (3)$$

Table 2: Descriptive statistics

Variables	Obs	Mean	Standard deviation	Min	Max
GDP growth	80	3.165	4.408	−8.65	12.40
Well Being	80	0.735	0.061	0.619	0.86
Green Investment	80	3.659	2.502	−4.505	6.701
Green Consumption	80	1.910	2.313	0.24	9.8
CO_2 Emission	80	5.797	0.986	4.068	7.948
Forest Area	80	24.659	19.547	0.05	60.29
Access to Clean Fuels	80	89.046	12.275	47.4	100
Green Job	80	22.756	11.922	6.328	44.68
Number of id	10	10	10	10	10

Source: STATA 14, processed

GDP: Economic growth; WB: Welfare being (Human Development Index); IRE: Renewable energy investment; RE: Renewable energy; CO_2: Carbon dioxide emission; FA: Forest area; ACF: Access to clean Fuels; GJ: Green job; t: time; i: sample country; e: error term; β_0: constant dan β_1, β_2, β_3, β_4, β_5, β_6: regression coefficients. Information on variables, data, and research data sources can be seen in Table 1.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Table 2 shows descriptive statistical data on the primary variables of ten developing countries that have implemented a green economy in accordance with the Paris agreement of 2015. These countries have adopted a green economy. In the following arrangement, the data from the observations are presented in a balanced panel formation.

The average annual economic growth across the examined countries was modest at 3.17%, exhibiting significant variability. The well-being score was commendably high, averaging 0.735. Patterns of green investment and consumption exhibited disparities, with certain countries facing decline or stagnation. CO_2 emissions in developing countries were notably elevated, averaging 5.80%, thereby requiring sustained initiatives to mitigate emissions for the green transition. Forest cover exhibited significant variability, ranging from nearly absent to over 50% of the land area being forested. Average access to clean fuels attained 89%, yet considerable access deficiencies persisted in certain nations. Employment in the green sector constituted roughly 22.76% of total labour force participation, indicating the disproportionate allocation of green economy opportunities. These descriptive findings underscore the diverse capabilities and degrees of advancement among developing nations in fulfilling their collective obligations to the green transition. These descriptive findings underscore the diverse capabilities and degrees of advancement among developing nations in fulfilling their collective obligations to the green transition.

The model specification test presented in Table 3 demonstrates that the optimal method for the initial model is random effects. This is predicated on test results that lack enough rationale for the use of fixed effects. Subsequent testing suggests that random effects are more suitable than pooled OLS. Consequently, the first model is more suitable for analysis employing random effects, as it accounts for variation among units without presuming permanent disparities among individuals.

Table 3: Model specification test table

	Y=GDP				Y=WB			
Test	Statistic	Prob.	Description	Conclusion	Statistic	Prob	Description	Conclusion
Chow	1.71	0.106	Prob<0.05; H0=FEM Prob>0.05; H1=CEM	CEM	136.32	0.0000	Prob<0.05; H0=FEM Prob>0.05; H1=CEM	FEM
Hausman t	4.11	0.66	Prob<0.05; H0=FEM Prob>0.05; H1=REM	REM	11.29	0.0797	Prob<0.05; H0=FEM Prob>0.05; H1=REM	REM
LM	0.415	0.0000	Prob<0.05; H0=REM Prob>0.05; H1=CEM	REM	188.32	0.0000	Prob<0.05; H0=REM Prob>0.05; H1=CEM	REM

Source: STATA 14, processed

The model specification test presented in Table 3 demonstrates that the optimal method for the initial model is random effects. This is predicated on test results that lack enough rationale for the use of fixed effects. Subsequent testing suggests that random effects are more suitable than pooled OLS. Consequently, the first model is more suitable for analysis employing random effects, as it accounts for variation among units without presuming permanent disparities among individuals.

Concurrently, the second model suggests that random effects represent the most suitable methodology. Despite suggestions that fixed effects may be viable, the test findings predominantly support the utilisation of random effects. Consequently, for both the initial and subsequent models, the random effects methodology is the statistically stronger option.

Table 4 shows the multicollinearity test results, utilising the Variance Inflation Factor (VIF), indicate that all independent variables exhibit modest VIF values, spanning from 1.10 to 3.73, with a mean VIF of 2.01. The regression model employed is free from multicollinearity issues. This indicates that each independent variable possesses distinct information and does not substantially overlap in elucidating the variance of the dependent variable. This requirement ensures the validity of the estimation findings, allowing for an unbiased interpretation of the regression coefficients despite substantial correlations among explanatory variables.

Table 4: Multicollinearity test

Test	Y=GDP	Y=WB
	VIF	VIF
ACF	3.73	3.73
Log CO_2 Emission	3.18	3.18
GJ	1.62	1.62
Log_IRE	1.30	1.30
RE	1.11	1.11
FA	1.10	1.10
Mean VIF	2.10	2.01

Source: STATA 14, processed

Table 5: Diagnostic test

Test	Y=GDP (REM)		Y=WB (REM)	
	Statistic	Prob.	Statistic	Prob.
Heteroscedasticity	607.84	0.000	210.26	0.000
Autocorrelation	1.635	0.233*	21.760	0.0012
Cross-sectional Dependence	11.358	0.602*	3.838	0.389

*Significant
Source: STATA 14, processed

Table 6: Result on economic performance and well being

	Model 1 (Y=GDP)			Model 2 (Y=WB)		
Variables	GDP	Z	P>|z|	WB	Z	P>|z|
log_IRE	0.361*	1.75	0.081	−0.0013	−0.97	0.333
RE	−0.395*	−1.91	0.057	−0.0042***	−3.26	0.001
log_ CO_2 Em.	−0.873	−1.06	0.288	−0.0171***	−3.33	0.001
FA	−0.030	−1.22	0.222	0.0001	0.24	0.814
ACF	−0.060	−0.83	0.405	−0.0010**	−2.19	0.028
GJ	0.073	1.51	0.131	−0.0046***	−15.12	0.000
Constant	12.030	1.11	0.266	1.0385***	15.37	0.000

Standard errors in parentheses; ***P<0.01; **P<0.05; *P<0.1
Source: STATA 14, processed

Table 5 with GDP as the dependent variable, the Modified Wald Test indicates heteroscedasticity, while autocorrelation and cross-unit dependence were not detected. This indicates that the residual variance is not constant across cross-sectional units, thus using OLS or conventional FE methods could potentially produce inefficient estimates. Meanwhile, Table 5 with WB as the dependent variable, the diagnostic test results indicate that the model suffers from heteroscedasticity and autocorrelation, while the cross-sectional dependence test is insignificant. These findings indicate that panel data models face issues with variance structure and correlation in the error terms, making the use of OLS or fixed/random effects models inefficient. Generalized Least Squares (GLS) was chosen as the estimation technique due to its ability to generate consistent and efficient estimators by addressing heteroscedasticity and autocorrelation in panel data. To empirically investigate the influence of green economy initiatives on sustainable development outcomes in developing countries, a panel data regression model utilizing GLS was implemented. The search for the most suitable model began with the application of the Chow test, the Hausman test, and the Breusch-Pagan Lagrange Multiplier test. Despite these efforts, heteroscedasticity among time units and autocorrelation were discovered, rendering the Ordinary Least Squares (OLS) model inadequate for producing valid estimates. Consequently, GLS was considered more pertinent due to its generation of unbiased standard errors (Houssam et al., 2023). The GLS model is appropriate for addressing these limitations, particularly when employing panel data with a data unit structure that exceeds the time period, as demonstrated in this study. Table 6 presents the results of the assessment of green economy implementation on economic growth and welfare.

4.2. Impact of Green Investment on Economic Growth and Welfare

Estimation results indicate that green investment enhances economic growth (GDP), yet it has not succeeded in improving welfare. Investment in the green energy sector might boost economic activity, especially through the multiplier effects of green infrastructure development and technological innovation. This discovery aligns with research conducted by Salim and Rafiq, indicating that the driving force for renewable energy adoption in developing nations is predominantly influenced by the necessity for energy efficiency, energy security, and policy incentives (Deka et al., 2024). This study highlighted that governmental commitment is essential for enhancing the economic effects of green investment. In Sub-Saharan African nations, energy consumption, including renewable sources, positively influences economic growth, especially when utilised effectively in the industrial and service sectors (Ugur et al., 2023). These results verify the favourable findings regarding the correlation between green investment and GDP growth. The integration of green energy into a productive economic framework extends beyond its symbolic representation of environmental efforts, fostering genuine economic growth. The success of green investment is contingent not only on the scale of the investment but also on the presence of institutional support

and the efficiency of its implementation. Developing countries that lack sufficient infrastructure, or effective policies may struggle to fully harness the economic benefits of such investments. Research by Apergis and Payne has demonstrated a long-term causal link between renewable energy investments and economic growth in developed countries. Over time, green investment proves to be both advantageous and significant, acting as an early indicator of green growth trends if sustained commitment is maintained (Patsoulis and Demetriou, 2024; Houssam et al., 2023; Pan et al., 2019). The effectiveness of green investment is largely shaped by institutional factors, the readiness of the energy system, and the direction of national policy. Developed nations generally have better access to efficiency and infrastructure compared to their developing counterparts.

In developing nations, investments in renewable energy often face challenges such as inadequate infrastructure, high financial risks, and regulatory barriers. These issues can impede the effectiveness of these investments in improving human well-being. Green investment in these regions is further complicated by regulatory and bureaucratic hurdles, unequal access to technology and financing, and a disproportionate emphasis on large-scale projects that do not directly benefit vulnerable communities. In contrast to the green transition efforts in India and Sub-Saharan Africa, many solar and wind energy investment projects have either stalled or underperformed due to mismatches between broad plans and localized implementation (Azam, 2019; Bello, 2015; Charles Rajesh Kumar and Majid, 2020). When investments lack inclusive and participatory implementation, their economic impact is not broadly experienced, particularly in the short term. According to the research conducted by Azam et al., the impact of renewable energy consumption on Human Development Index (HDI) is significantly influenced by the efficacy of the investment execution (Azam, 2019; Azam et al., 2015). In India, substantial solar power initiatives did not enhance HDI in rural regions due to inadequate transmission and distribution infrastructure (Charles Rajesh Kumar and Majid, 2023). The disparity between investment magnitude and regional requirements led to conflicting outcomes. Conversely, the effects of investment are typically realised only in the long term, particularly regarding infrastructure development. Welfare indicators, such as the HDI represent present conditions rather than future projections. A negative coefficient may occur due to direct costs, such as operational expenses, while the community has not experienced significant benefits (Azam et al., 2015).

4.3. Impact of Consumption of Renewable Energy on Economic Growth and Welfare

Another finding indicates that the rising consumption of renewable energy adversely affects economic growth and welfare. This finding might come as unexpected initially, given that renewable energy is generally believed to contribute to sustained economic growth over time. Upon closer examination, these findings can be logically understood in relation to the energy transition occurring in developing nations, where the energy and economic frameworks are still not sufficiently capable to effectively accommodating significant transformations. Throughout the decade of this analysis, the shift in energy consumption appears to be a continuous process and has yet to yield the most efficient economic results. This may result from the application of outdated technology, elevated implementation expenses, and the diminishing impact of the currently prevailing traditional energy sector. In developed countries, there exists a positive and significant correlation between renewable energy consumption and economic growth (Manea and Cozea, 2022; Sasana et al., 2023). The results bolster the idea that developing nations might not be reaping the full advantages of green energy use, attributed to inadequate technology implementation, the inability to realise economies of scale, or insufficient policy structures (Sasana et al., 2018).

Countries including India, Indonesia, and South Africa are engaging with green energy; however, they have not yet seen a direct impact on GDP due to limitations in scale and efficiency, or because they are still in the initial phases of development. This aligns with earlier investigations, indicating that in developing nations, renewable energy contributes positively to GDP only when paired with supportive policies and sufficient infrastructure (Ito et al., 2021; Stuchtey et al., 2023). Sadorsky's findings indicate that the consumption of renewable energy in G7 countries positively influences GDP, albeit with a time lag; the economic advantages are realised only in the medium to long term (Sadorsky, 2022). Conversely, Alper and Oguz highlight that the consumption of renewable energy has the potential to bolster economic growth, provided it is paired with advancements in technology and enhanced operational efficiency (Han et al., 2023).

In developing nations, there is a notable transition within traditional sectors, particularly as the predominant fossil energy-based industries, including coal in Indonesia and petroleum in Mexico, admit a downturn in activity without a corresponding productive replacement. Furthermore, the constraints of institutional capacity and existing policies play a significant role, as not every country has regulations that effectively promote renewable energy, including mechanisms like feed-in-tariff policies or resilient fiscal incentives. Menegaki's research conducted in Europe indicates that there is often a neutral relationship between renewable energy and economic growth, which varies based on the structural conditions and development level of a country (Menegaki and Tiwari, 2023). This offers further clarification on why green investment often lacks statistical significance in most regression models, reinforcing the perspective that in developing nations, the economic effects of renewable energy remain inconsistent and heavily reliant on systemic preparedness.

The results of this study suggest that the use of renewable energy will enhance welfare in developing nations. The consumption of renewable energy has the potential to positively influence human development; however, the extent of its impact is contingent upon the efficacy of policy implementation and support mechanisms. Sarkodie and Strezov noted that while there is a rise in renewable energy usage in developing nations, biomass, coal, and oil energy continue to hold a dominant position in certain countries. The share of renewable energy is on the rise, yet it remains insufficient to bring about a substantial transformation in the energy framework. The continued use of solid fuels adversely affects health, which is one of the indicators of the Human Development Index (Sarkodie and Strezov, 2019). The implementation of green energy initiatives

may lead to tensions between renewable energy developments and the surrounding social landscape. Certain renewable energy initiatives, like large-scale hydropower, lead to the displacement of local communities and agrarian disputes, often lacking adequate compensation or social integration. Consequently, they may negatively impact welfare, despite the technical advancements in renewable energy (Asumadu-Sarkodie and Owusu, 2016). Another assumption pertains to the constrained capabilities of the local workforce. In numerous instances involving renewable energy initiatives undertaken by foreign investors, the local workforce often lacks access to training or capacity-building opportunities. Consequently, renewable energy initiatives fail to generate sustainable economic prospects for the community.

4.4. Impact of CO_2 Emission on Economic Growth and Welfare

CO_2 emissions adversely affect economic growth and diminish welfare in the long term. This negative relationship is consistent with the findings of multiple studies, which suggest that elevated levels of pollution and emissions can diminish labour productivity (due to health issues), escalate economic expenses (including health and mitigation costs), harm the environmental resources that underpin the economy (such as water, air, and agricultural production), and lower quality of life and long-term economic viability (Zhai et al., 2024). Carbon dioxide emissions lead to global warming, resulting in disruptions to local climates, decreased agricultural productivity, and the loss of biodiversity. The reliance of numerous developing nations on fossil fuels, including coal and oil-based sectors, contributes to environmental pollution and obstructs advancements in energy innovation and economic efficiency. The intricate relationship between economic growth and forest area in Malaysia reveals how CO_2 emissions are deeply intertwined with the economy. Should emissions rise without being offset by forest growth or the adoption of clean technologies, this could adversely affect GDP, consistent with the negative trend indicated by the GLS model in this analysis (Abbas et al., 2025). This is in-line with study by Dong et al., who found that rising CO_2 emissions are connected to reduce human health and increasing inequality in economy (Dong et al., 2020).

The deterioration of the environment profoundly affects the quality of life and the overall well-being of communities. Carbon dioxide emissions have significant implications for both long-term climate change and local air quality. They contribute to a rise in respiratory and cardiovascular diseases, while also hindering economic productivity. Mohmmed et al. showed that in nations with the highest CO_2 emissions, the primary elements of the HDI decline (Mohmmed et al., 2019). The reliance on fossil fuels for economic growth may boost GDP figures, yet it tends to have adverse effects on human development. According to Ranis et al., economic growth that lacks human development results in misleading growth (Ranis et al., 2000). Economic growth that overlooks the health and education aspects only intensifies long-term development disparities and may even diminish the overall Human Development Index. The increase in GDP could occur; however, if we fail to address environmental degradation and health issues, the very foundations of economic development—human and natural capital—risk becoming unstable. This situation exemplifies a scenario where growth occurs without genuine development, leading to inequality and degradation rather than true prosperity. As environmental damage intensifies, the costs associated with recovery escalate, further straining the fiscal resources of the nation.

A study conducted by Long et al. utilised the ecological footprint–HDI approach, revealing that there is a direct proportionality between increasing emissions and ecological pressure (Long et al., 2020). Areas characterised by elevated emissions struggle to achieve a sustainable development equilibrium, resulting in a deterioration of well-being quality. A study conducted in Brazil revealed that less affluent regions face a disproportionate challenge in reducing emissions, whereas the economic advantages derived from emission-producing activities, like industrial growth, are predominantly reaped by a limited elite segment (D'ambrosio et al., 2021). In similar findings indicate that fossil fuel-based electricity consumption prevails in developing nations. While there is a long-term trend of increasing access to electricity, this reliance on fossil fuels adversely affects health and the environment, ultimately hindering improvements in Human Development Index (HDI) (Costanza et al., 2014).

4.5. Impact of Forest Area on GDP Growth and Welfare

The findings indicate that the extent of forest area has no impact on GDP growth or overall welfare. The size of forested regions in developing nations has no impact on economic development. The observation that forest areas do not significantly influence economic outcomes aligns with the findings of Michinaka and Miyamoto. They noted that in numerous developing countries, short-term economic activity remains largely reliant on the exploitation of natural resources, indicating that forest conservation has not directly contributed to growth (Adekoya, 2023). Halkos and Skouloudis observed that the economic impact of alterations in forest area generally manifests over an extended time frame and is frequently not captured in yearly economic metrics (Gumede et al., 2024). Additionally, the findings of this study can be interpreted through a long-term lens, demonstrating that forest area plays a significant role in economic sustainability when linked with other elements like agriculture and energy (Manea and Cozea, 2022). In examining the 10 developing countries, it becomes evident that the influence of institutions, technological constraints, and pressures on the growth of the extractive sector account for the lack of statistically significant economic growth despite increases in forest area. Therefore, the significance of forest conservation cannot be overstated; however, its influence on economic growth necessitates time, cohesive policies, and a conducive institutional framework (Manea and Cozea, 2022; Sasana et al., 2018). The limited importance of the forest area variable in this model does not imply that forests are unimportant; instead, it reflects the timing and manner of their influence (Kanagawa and Nakata, 2008).

The impact of forest area on well-being is minimal. The evidence does not strongly support the notion that expanding forest area directly impacts human well-being in ten emerging economies. Forest benefits may manifest in more long-term or indirect ways concerning the HDI. Forests serve as crucial providers

of ecosystem services, including carbon storage, biodiversity protection, local climate regulation, and the supply of clean water. A study conducted on islands in China revealed that the ecological benefits of forests became apparent only in long-term, integrated development scenarios, rather than in annual or short-term dynamics (Adekoya, 2023). A study conducted in Japan indicated that access to environmental infrastructure and energy significantly influences well-being, whereas ecological benefits, like forests, tend to have an indirect effect that is challenging to quantify directly in the Human Development Index (Rahut et al., 2017). Indonesia and Brazil illustrate a pattern of agricultural growth encroaching on forest regions, leading to immediate financial gains while compromising ecosystem integrity and environmental well-being (Azam et al., 2015).

4.6. Impact of Access of Clean Energy on Economic Growth and Welfare

The presence of clean energy has been linked to adverse effects on economic growth and overall well-being. The evidence suggests that, although the transition to clean fuels is vital for sustainability and environmental health, it has not yet resulted in positive impacts on economic growth or well-being in the developing countries analyzed in the short term. This situation underscores the idea that, while clean fuels such as LPG, biogas, or modern electricity can enhance health and the environment, their adoption in developing nations is frequently impeded by insufficient infrastructure, high initial costs, and a systemic dependence on traditional, more labor and energy-intensive energy systems (Kasztelan, 2017; Lyeonov et al., 2019; Tomashuk, 2022). Moreover, research has indicated that, even with Research has demonstrated that, despite enhanced access to clean fuels, a significant number of households in developing countries continue to depend on a mix of energy sources, a practice known as energy stacking, which leads to less than ideal outcomes for economic productivity. The connection between clean energy access and economic development in these regions is complex, with the potential for long-term benefits requiring time, comprehensive policy-making, and integration across various sectors to be fully realized (Sadorsky, 2022).

The provision of clean fuels such as LPG, electricity, or biogas is contingent not only on the presence of infrastructure but also on the financial capacity of communities to afford them. In many developing nations, the reach of clean energy in urban areas is limited, resulting in a slowdown in the progress of the Human Development Index (HDI). Initiatives to enhance clean energy access often fail to address essential factors like affordability and sustainable distribution, creating a situation where clean energy is technically available but remains financially out of reach for many. Investigations into households in Nepal and Bangladesh that have access to LPG or electricity reveal significant disparities in HDI outcomes, influenced by factors such as education level, occupation, and housing quality (Pachauri and Spreng, 2011). The availability of clean energy is closely linked to a reduction in respiratory diseases caused by household smoke from biomass combustion, such as wood and charcoal. This issue particularly impacts women and children. Households transitioning to clean energy experience notable enhancements in health status, which subsequently contributes to better educational quality and increased productivity (Bonjour et al., 2013; World Health Organization, 2021). The availability of clean fuels enhances children's engagement in education by decreasing the time spent on cooking and gathering wood Choudhuri and Desai, 2021).

4.7. Impact of Green Job on Economic Growth and Welfare

This investigation revealed that employees in the green sector did not influence economic growth (GDP) and had an adverse effect on welfare. The influence of green jobs on economic growth in developing nations remains weak and inconsistent at this stage. This finding aligns with Barbier's research on indicating that in numerous instances, green jobs remain fragmented and are not systematically incorporated into essential economic sectors, resulting in a limited impact on growth (Gumede et al., 2024). In a comparable way, Bowen et al. highlighted that realising the economic potential of green jobs necessitates time, innovation, and policy support to develop into a significant growth driver (Kwon et al., 2025). In developing nations, the limitation of technological capabilities, vocational training, and effective coordination across sectors poses significant challenges to the potential influence of green jobs on economic growth. According to the International Labor Organization (ILO), many green jobs in these countries are classified as informal and have low productivity, which means they have not yet to contribute to macroeconomic growth (Stuchtey et al., 2023). Rao and Pachauri identified that despite a growing awareness of the green economy, a significant gap persists between the creation of green jobs and the readiness of the local workforce to fill technical and strategic roles within this sector (Rao and Pachauri, 2017).

In nations such as India, South Africa, and Brazil, green jobs are predominantly concentrated in the renewable energy and waste management sectors. Despite their promising potential, these jobs have not yet achieved the economic impact seen in the manufacturing or extractive industries. The GLS regression results suggest that while green jobs can positively contribute to the economy, their current influence on GDP growth is limited. This limitation is largely due to their slow integration into the mainstream economic framework of developing countries.

The study also identified a negative correlation between employment in the green sector and well-being levels (HDI), highlighting a "green paradox." This paradox suggests that the initial expansion of the green sector has not significantly advanced human development and, in some cases, has shown an opposite trend. This could be attributed to the early stages of green jobs, their prevalence in the informal sector, the lack of widespread welfare generation, or their limited and uneven distribution.

In many developing countries, green employment opportunities are still emerging, with a significant portion of the low-wage informal sector including plastic waste collectors, composters, and organic farmers. A study by the International ILO indicated that green jobs in de veloping countries often fall short of decent work standards, social security, and adequate technical training, thus not fully enhancing the Human Development Index (ILO, 2021). The findings presented by Cai et al. have identified that green jobs frequently lack economic viability and inclusivity,

particularly in developing countries (Cai et al., 2011). A study conducted by Onyeaka and Akinsemolu further elucidated that disparities in access to green education and training in MENA countries are occupied by lower-skilled workers who earn reduced incomes, thereby failing to enhance the overall HDI (Onyeaka and Akinsemolu, 2025). Therefore, it is imperative to improve the quality of green work. This can be accomplished through initiatives such as the implementation of technical and vocational training programs specifically designed for the green sector, formal integration into national labor protection frameworks, and the provision of incentives for the private sector to generate high-quality green employment opportunities.

5. CONCLUSION

The transition to a green economy in developing countries presents a range of complex impacts on economic growth and well-being, as measured by the Human Development Index (HDI). These impacts are heavily influenced by the preparedness of ecosystems and the degree of policy support in each unique context.

This underscores the significance of promoting green investment as a catalyst for economic growth. The results support the idea that investing in environmentally sustainable sectors can enhance economic performance via multiplier effects, especially through the development of green infrastructure and advancements in technology. In the mean-time, the consumption of renewable energy appears to have a negative impact on economic growth. This suggests that developing nations continue to encounter obstacles in maximising their economic benefits, stemming from inadequate energy efficiency, elevated implementation expenses, and underdeveloped energy transition frameworks. Moreover, CO_2 emissions demonstrate an adverse effect on economic growth. This illustrates the intricate interactions involved in the transition to green energy within developing nations. The area of forest cover and the contributions of green jobs appear to have no impact on short-term economic growth. This indicates that the economic advantages of conserving forests and creating green jobs have not been completely acknowledged or are still disjointed. While green jobs hold promise for positive contributions, their impact on GDP growth remains constrained, as they have not yet gained momentum or integrated into the primary economic framework of developing nations.

The adoption of a green economy in developing nations has failed to enhance well-being as measured by the Human Development Index (HDI). The persistent and prevalent reliance on fossil fuels has continually resulted in CO_2 emissions and environmental degradation, thereby diminishing overall well-being (HDI). The rise in CO_2 emissions is linked to worsening human health outcomes and a growing disparity in development opportunities. The consumption of renewable energy, access to clean energy, and the workforce engaged in the green sector are also associated with adverse effects on well-being (HDI). This scenario highlights the challenges faced in the energy transition within developing nations, where the existing energy and economic frameworks are not adequately equipped to effectively accommodate significant transformations. Green jobs are mainly found in the informal sector, characterised by low wages, including roles like plastic waste collectors, composters, and organic farmers. They have not yet produced widespread welfare benefits and remain limited and unevenly distributed. Throughout the decade-long duration of this analysis, it appears that the transition to renewable energy has not produced the most favourable economic results.

6. ACKNOWLEDGEMENT

Thank you to Diponegoro University for providing funding support for this study through the 2025 research scheme.

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