

CO2 Emission, Renewable Energy Consumption, and Green Growth in Developing Countries

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ABSTRACT

Green growth is an economic development model that encourages growth by ensuring natural assets provide the resources and environmental services indispensable for welfare. It emphasizes low-carbon, resource-efficient, and socially inclusive approaches, aiming to boost GDP, reduce poverty, and prevent environmental degradation. Renewable energy is a foundation stone of green growth, transforming economic development by balancing industrial progress with environmental sustainability. For this, we have examined the effect of CO2 emission, renewable energy consumption, financial development index, trade openness, and inflation on green growth by using data from 1996 to 2023 from eight developing countries. Random effect results show the negative relationship between CO2 emissions and green growth. The results also show that renewable energy consumption and trade openness increase green growth in these countries. Finally, it is found that financial development and inflation tend to decrease green growth. The existing research recommends clean energy usage and reducing CO2 emissions. Focus should be made on promoting domestic production, exports, and trade openness. There is a need to emphasize economic growth by making investments in new technologies, creating high-quality jobs, and lowering energy costs while reducing pollution. Finally, it is necessary to use renewable energy sources for reduced pollution and for high green growth.

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INTRODUCTION

In recent years, attention on the green economy and green growth has increased internationally. The growing occurrence of environmental issues requires a move away from conventional economic models and the appearance of a green economy as an alternative economic model (Šneiderienė & Ruginė, 2019). Conventional growth models cause resource shortage, ecological injury, and negative effects on human health, which assist uphold the significance of the green growth notion. In addition, the change to a green growth model is very important for adapting to climate change and plummeting emissions (Naimoğlu, 2025). The idea of green growth stands for a lively change from a brown economy to a green economy. Green growth is a sustainable development model that develops during eco-technological competence, combats poverty, ensures human comfort, and has a positive effect on social inclusion (Sarkodie et al., 2023). The lack of a conventional meaning of the idea on global stages has led to the emergence of dissimilar definitions.

The objective of green growth is to use natural capital and sustain growth by considering the carrying capacity of natural resources. In line with the World Bank's definition, green growth is a growth model that makes use of natural resources professionally and takes into account ecological pollution and degradation. The Global Green Growth Institute, in contrast, considers green growth as an innovative economic model and cites the rising significance of ecological sustainability (Allen & Clouth, 2012). The most significant objective of the green growth model is to improve natural resource management, increase production, and concentrate on jointly strengthening the features of financial and ecological strategy. One more objective is to find a gainful answer to make sure that ecological capability does not go beyond at the restricted, local, or worldwide level and to make sure the change to a green economy model. Green growth has the capacity to add to productivity, use natural resources at their highest worth, create novel employment opportunities, plan new environmental strategies, and set up fair macroeconomic circumstances. Though there is no single green growth instruction that fits all economies. Countries will experience dissimilar chances and issues dependent on their development level (Kanianska, 2017).

Additionally, two ecological performance indicators very near to economic affluence are greenhouse gases and air quality. The release of greenhouse gases causes climate change, whose influences on the economy can be tremendous as they ground infrastructure destruction, disrupt supply chains, and destroy biodiversity required by different industries. Insufficient air quality can pretend long-term public health problems that lower the efficiency of workers and increase healthcare expenditure. Strong ecological regulations and cleaner air are connected with improved public health and more robust nations. The cause is that the environmental features must be accounted for whenever an economy is making financial choices. The utilization of renewable sources of energy is furthermore a dissimilar central thought that has both an environmental effect and an economic effect. In view of the significance of CO₂ emission, renewable energy consumption, trade openness, financial development, and inflation, our work aims to analyze such factors affecting green growth in developing countries.

This section explains a lot of factors influencing green growth in underdeveloped and rich nations of the world. Economic growth is significant for the economies. Considering this, Alam and Kabir (2013) found that increased growth sustained the environment by plummeting carbon emissions. Lukas (2015) used data from 60 countries. The author has found that the global green economy index tends to decrease economic growth; however, increased per capita income and reduces poverty. Free trade also affected growth. Shahbaz et al. (2019) analyzed that trade openness improved the environment. However, increased foreign direct investment determined a greener environment. The study suggested more investment in technological innovation and capital stock. Likewise, Rahman et al. (2020) checked the influence of unsafe emissions on economic growth. It was found that hazardous emissions, together with the population, promoted economic growth.

Taşkın et al. (2020) examine the relationship between renewable energy consumption and green growth using panel cointegration tests for OECD economies by using data from 1990 to 2015. It was found that renewable energy reduced carbon emissions and positively affected the green growth. Fernandes et al. (2021) examined the impact of green growth on economic growth in 32 economies. They used OECD data from 1990 to 2013. The results showed that green growth increased economic growth. By using data from 2000 to 2017, Tawiah et al. (2021) highlighted the factors affecting green growth in 123 developed and developing economies. The results revealed that renewable energy consumption enhanced green growth, while energy consumption hindered green growth. Hussain et al. (2022) checked how green growth, energy consumption, and green technologies affected environmental sustainability in high-income economies by using data from 2000 and 2020. The results found that green growth reduced carbon emissions. Environmental sustainability supported communal comfort, and green growth increased human development. Energy consumption, which favored green strategies at times, positively affected human development.

Liu et al. (2023) investigated the relationship between green growth and human development in China. ARDL result concluded that human development increased green growth. Improved education level of society enhanced ecological awareness. Kadioğlu (2024) examined the relationship between carbon emissions and green growth in Türkiye by using data from 1990 to 2020. It was found that financial development and total energy production increased carbon emissions. This effect has a positive impact on green growth due to the increase in carbon emissions. Hassan (2025) highlighted the factors affecting green growth in developing economies, taking into consideration the moderating effects of institutional quality. By using panel data of ninety-six developing countries from 2004 to 2023. It was found that foreign direct investment, financial development, urbanization, and human capital decreased green growth. Though population growth increased, green growth. Financial institutions had a direct effect on green growth. IQ did not moderate the impact of foreign investment, population growth, and human capital, representing institutional constraints in channeling structural drivers towards green growth.

By using data from 1990 to 2021, Akın and Akçayır (2025) examined the influence of human development and renewable energy consumption on green production in Mexico, Indonesia, South Korea, and Türkiye. The results showed that renewable energy improved human development. However, carbon emissions decreased human development. Bahtiyar and Mukiyen Avcı (2025) emphasized the determinants of green growth in 35 OECD economies by using data from 1996 to 2022. GMM results showed that per capita income tended to enhance production-based carbon emissions, which negatively affected ecological pollution and green growth. Ngo et al. (2026) investigated the determinants of green growth in ASEAN-6 countries by using data from 2000 to 2021. The results showed that trade openness and institutional quality increased green growth. However, foreign direct investment, financial development, industrialization, natural resources, and technological innovation decreased green growth. Institutional quality exhibits significant but varied moderating effects. Terzi and Harunoğulları (2026) used data from 2010 to 2023 in EU countries. Fixed effects results showed that human development increased green growth. Tabak and Kaya (2026) used data from 33 OECD countries from 2000 to 2019. They used the green growth index as the dependent variable. The results showed that renewable energy, green technology, political stability, and environmental taxes increased green growth, whereas non-renewable energy decreased green growth.

Objective of the study

1. To examine the impact of CO2 emissions on green growth.
2. To find out the effect of renewable energy consumption on green growth.
3. To show how trade openness affects green growth.
4. To explain the effect of financial development on green growth.
5. To estimate the impact of inflation on green growth.

Research Questions

1. How does CO2 emission affect green growth?
2. How does renewable energy affect green growth?
3. What is the impact of trade openness on green growth?
4. How does financial development affect green growth?
5. What is the effect of inflation on green growth?

Significance of the Study

Studies seem to highlight the effect of industrialization, gross fixed capital formation, CO2 emission, and ecological footprint consumption. Though our study makes an effort to check the effect of CO2 emission, renewable energy consumption, trade openness, financial development, and inflation on green growth in developing countries.

Research Hypotheses

- H1: CO2 emissions reduce green growth.
- H2: The higher the renewable energy consumption and lower the green growth.
- H3: The higher the trade openness, the higher the green growth.
- H4: Financial development and green growth are negatively associated.
- H5: A negative link is found between inflation and green growth.

Data and Methodology

By using data from 1996 to 2023, we found the role of CO2 emission, renewable energy consumption, trade openness, financial development, and inflation in affecting green growth in developing countries. Green growth was used as the dependent variable. Data were drawn from eight developing countries, including Bangladesh, India, Indonesia, Iran, Jordan, Malaysia, Pakistan, Thailand, and the Philippines are selected for the analysis. These countries are chosen based on data availability. Data is taken from WDI.

We have used the random effect technique here.

Model Specifications

$$GGI = \beta_0 + \beta_1 CO_2EM_{it} + \beta_2 LREN_{it} + \beta_3 FINDI_{it} + \beta_4 TOPN_{it} + \beta_5 CPI_{it} + u_{it} \tag{1}$$

GGI= Green growth index

CO2EM = Co2 emission kt per capita

LREN= Log of renewable energy consumption

FINDI= Financial development index (domestic credit to private sector & stock market capitalization % of GDP)

TOPN= Trade openness (Exports of goods and services % of GDP + Imports of goods and services % of GDP)

CPI= Consumer Price Index

ui= (error term)

it= it = (time trend)

RESULTS AND DISCUSSION

In Table 2, descriptive statistics are given. It is found that the green growth index is 00.3343 percent in developing countries. Its range varies from -0.392 to 1.077 percent. CO2EM is 502127.2 percent, and a low standard deviation shows the normality of the data. The mean value of renewable energy is 31.6559 percent in these economies. Though on average, the financial development index is -0.1237 percent. On average, TOPN is 74.4877 percent. Though the mean value of CPI is 7.1197 percent.

Table 3: Descriptive statistics

Variables	Observations	Mean	St. deviation	Minimum	Maximum
GGI	252	0.3343	0.3081	-0.392	1.077
CO2 EM	252	502127.2	379301.9	14187.62	2238377.0
LREN	252	31.6569	15.6623	4.06	58.25
FINDI	252	-0.1237	0.7435	-1.0246	3.1444
TOPN	252	74.4877	47.7630	21.4600	220.4068
CPI	252	7.1197	8.0735	-1.6107	58.4510

For choosing FEM or REM, focus has been made on the Hausman test.

Chi2 =2.73

Probability = 0.7418

Panel ARDL Results are given in Table 4. CO2 emissions affect green growth in developing countries. It is found that a one percent increase in CO2 emissions decreases green growth in these economies. The increase in CO2 emissions first and foremost is derived by rapid industrialization, increased international transportation, and the relocation of polluting industries with weaker ecological regulations.

Table 3: Random Effect Result

Variables	Coefficients	Standard Errors	t-values
LCO2	-0.0254	0.0431	-0.59
LREN	0.6123*	0.0546	11.22
FINDI	-0.0685 * * *	0.0368	-1.86
TOPN	0.0015*	0.0007	2.30
CPI	-0.0040* * *	0.0024	-1.67
C	-0.4960	0.2588	-1.92
Wald Chi2	138.47		
Probability	0.0000		
With R-squared	0.36		
Between R-Square	0.48		
Overall R-Square	0.36		

*** p<0.10, * p<0.1

The renewable energy consumption also has effects on green growth in developing countries. Finding shows that a one percent increased renewable energy consumption results in an increase in green growth by 0.6123 percent. It gives expansion to economic growth that is environmentally sustainable by driving investment into new technologies, creating high-quality jobs, and lowering energy costs while reducing pollution. The result is favored by Tabak and Kaya (2026).

Financial development negatively affects green growth. The result highlights that a one percent increase in financial development causes for decreased green growth by 0.0685 percent in developing countries. The reason may be that financial development can decrease green growth by prioritizing fast, conventional industrial expansion over environmental protection, often financing carbon-intensive projects through easy access to credit. The result is supported by Ngo et al. (2026).

Trade openness enhances growth in developing economies. Finding indicates that a one percent increased trade openness increases green growth by 0.0015 percent. The reason may be that trade openness increases green growth

first and foremost by accelerating the transfer of eco-friendly technologies, optimizing resource allocation, and stimulating innovation through competition. It makes easy access to renewable energy technology and promotes the adoption of environmental standards, leading to lower emissions and sustainable development. The result is supported by Shahbaz et al. (2019).

The role of inflation on green growth cannot be ignored. It is found that inflation has decreased green growth by 0.0040 percent. The reason may be that inflation hinders green growth by raising the costs of capital-intensive sustainable projects, plummeting household purchasing power for ecological products, and causing governments to deprioritize environmental initiatives for temporary financial firmness.

CONCLUSIONS

We have analysed the major macroeconomic variables affecting green growth in developing countries by using data from 1996 to 2023 for this analysis. We have used green growth as the dependent variable. However, CO₂ emissions, renewable energy consumption, financial development index, trade openness, and inflation affect green growth. We have used the random effect technique here by using data from 8 developing countries. The results indicated that CO₂ emissions tended to lessen green growth. The result also shows that renewable energy consumption and trade openness enhance green growth in these economies. Finally, it is found that financial development and inflation tend to decrease green growth. The study suggested clean energy usage and reducing CO₂ emissions. The government should focus on promoting domestic production, exports, and trade openness. The government must emphasize economic growth by making investments in new technologies, creating high-quality jobs, and lowering energy costs while reducing pollution. There is a need for the usage of renewable energy sources for reduced pollution and for high green growth.

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