

How does Green Finance affect the environment in the ASEAN emerging countries?

Isnaini Nuzula Agustin*, Rizky Adi Mahendra, Hesniati Hesniati

Faculty of Business and Management, Universitas Internasional Batam, Batam, Indonesia

*Corresponding author: isnaini.nuzula@uib.ac.id

Article Info

Article history:

Received 10 June 2024

Accepted 26 March 2025

Published 28 April 2025

JEL Classification Code:

G10; F62

Author's email:

2141134.rizky@uib.edu

hesniati@uib.ac.id

DOI:

[10.20885/ejem.vol17.iss1.art6](https://doi.org/10.20885/ejem.vol17.iss1.art6)

Abstract

Purpose — This study examines how economic growth, green finance, and renewable energy affect environmental quality (CO₂ emissions) under the Environment Kuznets Curve (EKC) hypothesis framework.

Methods — This study uses data from ASEAN-6 developing countries —Indonesia, Malaysia, Thailand, Vietnam, the Philippines, and Cambodia —from 2000 to 2020. It employs the Panel Autoregressive Distributed Lag (ARDL), which is widely used in time series analysis because it captures short- and long-run effects among variables.

Findings — The result shows the presence of the EKC Hypothesis in ASEAN developing countries. Green Finance and Renewable Energy reduce CO₂ emissions only in the long run. In contrast, in the short run, Green Finance shows no effect in lowering CO₂ Emissions due to initial costs, infrastructure challenges, market dynamics, and delayed policy implementation; the effect seems to increase in the long run as economies evolve, technologies mature, and awareness of environmental issues rises within emerging economies.

Implication — This study suggests that ASEAN developing countries should enhance their green finance efforts and expedite the transition to renewable energy by attracting additional investments in green finance and renewable energy transition. Governments in Southeast Asia must improve their policies and laws.

Originality — Revisiting the EKC hypothesis by including Green Finance within the ASEAN-6 emerging countries, an area that has been scarcely examined in recent literature, this study contributes to the region's policymakers on green finance allocation and its relationship to environmental quality.

Keywords — EKC Hypothesis, environmental quality, CO₂ emissions, green finance, renewable energy

Background

During the last decade, Economic growth in the Southeast Asia (ASEAN) region has shown a remarkable average growth rate of 4% to 5%. Strengthened by the economic growth in 2022, which reached 5.7%, the ASEAN region has become the 5th largest economy and the 4th largest exporter globally. In addition, the ASEAN region was also used as a destination for investment, with the second-highest investment in the world (Limanseto, 2023). Progress in various sectors, such as commerce, investment, household consumption, and the industrial sector, undeniably bolsters

economic growth. Industrialization significantly contributes to the economic prosperity of developing countries in the ASEAN region.

However, the rapid growth of industrialization, especially in the manufacturing sector, can also have adverse environmental consequences. Most manufacturing industries rely on fossil fuels such as natural gas, coal, and oil, especially in emerging countries where technological innovation has not been well developed. Thus, the use of resources in the form of fossil fuels will also increase, leading to adverse environmental consequences, such as CO₂ emissions. The increase in CO₂ emissions is due to population growth, the greenhouse effect, and the use of fossil fuels such as natural gas, coal, and oil for industrial activities, motor vehicle use, and electricity generation (Bhutta et al., 2022; Ridwan et al., 2024). Industry is the main contributor to the increase in CO₂ emissions in ASEAN developing countries due to aggressive industrialization to improve their national economies.

Based on the data, 5 of the 6 ASEAN developing countries are among the top 5 in CO₂ emissions in Southeast Asia, driven of their aggressive efforts to improve their national economies. Indonesia is ranked first with a CO₂ emissions figure of 619.28 million tons, arguably high compared to the second position occupied by Vietnam, with a CO₂ emissions figure of 326.01 million tons. Responding to high levels of CO₂ emissions, ASEAN members are striving to achieve zero carbon emissions through decarbonization. For emerging ASEAN countries, the primary demand is to use energy sources that are more environmentally friendly, and assessing the pace of renewable energy implementation has become a significant concern (Hidranto, 2023). Furthermore, the poorer nations of ASEAN also ratified the Paris Agreement in 2015, which mandates that all United Nations (UN) member states reduce their greenhouse gas emissions and fulfil the agreement's objectives of achieving carbon neutrality by 2050. Net zero emissions refers to a state in which the quantity of carbon dioxide (CO₂) released into the atmosphere is lower than the amount of CO₂ absorbed by the Earth (Novia & Candy, 2023).

According to Johnson et al. (1997), environmental quality is a pair of characteristics and properties of an environment that will impact humans and organisms. It involves the natural environment, including water and air cleanliness, pollution, and noise disturbance that potentially cause physical and mental health problems (Nguyen et al., 2020). Several proxies, such as CO₂ and greenhouse gas emissions, can measure environmental quality. CO₂ emissions are generated from fossil fuel combustion and the cement production process, which includes using fuels in liquid, solid, and gas form (World Bank, 2023).

Regarding climate change and environmental issues, Kuznets (1955) investigated the relationship between economic growth and income inequality. Their study revealed a correlation between economic growth and income disparity that follows an inverted U-shaped curve. Specifically, as economic growth rises, income inequality likewise grows. However, as economic growth progresses, there will be specific turning points when income inequality diminishes. The inverted U-shaped Environment Kuznets Curve (EKC) studied by Grossman and Krueger (1995) is utilized to assess the relationship between the deterioration of the environment and economic growth. According to the EKC hypothesis, there is a positive correlation between environmental degradation and income growth in the initial phases of economic development, illustrated by an upward-sloping curve. There is a positive correlation between economic growth and environmental degradation. Once the economy reaches a turning point, the correlation between economic growth and environmental degradation will turn negative, implying increasing income levels associated with simultaneous reductions in CO₂ emissions.

Research examining EKC in G7 countries conducted by Raza and Shah (2018) shows that economic growth (GDP) has a significant positive impact, while GDP² has a negative and significant effect on CO₂ emissions, which supports the U-shaped EKC hypothesis. Likewise, subsequent studies proved the existence of the EKC hypothesis as implied by the negative effect of GDP² on environmental quality, specifically in OECD countries (Zafar et al., 2019), Pakistan (Wang et al., 2022), South Asian countries (Tahir et al., 2021), and Africa (2022). Research by Ibrahiem (2020) shows that economic growth has a significant positive effect on CO₂ emissions. If economic growth increases by 1%, CO₂ emissions increase by about 1.1%, which is consistent

with the case in Egypt, as one of the developing countries struggling to achieve high levels of economic growth. In line with what has been done by [Raza and Shah \(2018\)](#) and [Tahir et al. \(2021\)](#), research conducted by [Usman et al. \(2022\)](#) shows that income level is statistically significantly positively related to CO₂ emissions across all quantiles. [Khan et al. \(2022\)](#) revealed that the overall GDP in a region has a significant positive effect on CO₂ emissions, where an increasing GDP will worsen environmental quality.

Producers of greenhouse gas emissions include energy use from fossil fuels, agriculture, industrial processes, deforestation, and waste. The largest source of Greenhouse Gas (GHG) emissions is the use of fossil fuel energy ([Filonchuk et al., 2024](#); [Putri, 2023](#); [Wang & Azam, 2024](#)). ASEAN countries must face up to achieving a balance point between economic growth and environmental quality ([Claire & Widyawati, 2023](#)). This balance requires that transitioning from traditional to renewable energy is essential since it reduces CO₂ emissions, mitigates climate change, enhances environmental sustainability, and fosters long-term socioeconomic benefits, including consistent economic growth ([Altaf et al., 2025](#)).

Numerous studies have proved that renewable energy significantly negatively affects environmental quality. [Khan and Hou \(2021\)](#) found that renewable energy has a negative effect on environmental quality in the United States, where every 1% increase in renewable energy will help reduce CO₂ emissions by 0.062% using the ROBUSTLS measurement tool and 0.057% using the GLM measurement tool. This shows that environmental quality in the United States can improve with renewable energy in the long term. [Triki et al. \(2023\)](#) stated that renewable energy significantly negatively affects the ecological footprint, which measures environmental quality both in the long and short term. These results imply that every level of improvement in environmental quality in Saudi Arabia is concrete, with 18.4% of renewable energy use. [Usman et al. \(2022\)](#) concluded that renewable energy significantly negatively affects CO₂ emissions in all quantiles. [Wei et al. \(2023\)](#) noted that renewable energy has a significant negative effect on CO₂ emissions, where an increase in the use of renewable energy by 1% will decrease CO₂ emissions by 0.09% in the short term and by 0.66% in the long term in the top 10 green future countries.

Despite studies indicating that this energy type can mitigate CO₂ emissions and facilitate climate adaptation, the share remains minimal in many countries, with a significant portion of energy still derived from fossil fuels, resulting in environmental challenges such as rising CO₂ levels and adverse effects on the global climate ([Kassi & Li, 2025](#)). Consequently, transitioning from traditional to renewable energy is essential as it reduces CO₂ emissions, mitigates climate change, enhances environmental sustainability, and fosters enduring socioeconomic benefits, including consistent economic growth ([Ahmed et al., 2025](#)). The shift from fossil fuel-based energy to renewable energy is a top priority for developing countries in the ASEAN region. Renewable energy will likely reduce CO₂ emissions within the ASEAN region. Delays in energy transition will exacerbate the detrimental impacts of climate change, rendering future mitigation endeavours more challenging and expensive.

On the other hand, the energy transition requires financial support to finance renewable energy manufacturing. In this case, green finance plays a significant role ([Sadiq et al., 2024](#); [Candy et al., 2022](#)). Green finance is financial services and products that support sustainable and environmentally friendly infrastructure. By increasing the amount of financial resources allocated to renewable energy projects, green finance plays a critical role in influencing ecosystems, production methods, and consumption patterns, serving as a significant catalyst for achieving a more sustainable and resilient economy ([Yadav et al., 2024](#)). Studies by [Wang and Ma \(2022\)](#), [Guo et al. \(2022\)](#), [Hu et al. \(2023\)](#), and [Zhang et al. \(2023\)](#) found that green finance has a significant negative impact on carbon emissions, implying that green finance can reduce CO₂ emissions in China. Likewise, [Zhan et al. \(2023\)](#) illustrate that a 1% increase in green finance will reduce CO₂ emissions by 0.492% and greenhouse gas emissions by 0.456% in China. These results show that green finance effectively reduces carbon emissions intensity and carbon emissions per capita in China, both in the short and long term. These findings imply that green finance investment in China is effective in the process of mitigating CO₂ emissions in China. In another region, [Altaf et al. \(2025\)](#) and [Ahmed et al. \(2025\)](#) recently demonstrated that the implementation of green finance

had a substantial marginal impact on environmental quality in the OECD, Azerbaijan, and BRICS countries, respectively. On the contrary, Chan et al. (2024) pointed out that Green Finance and transitions to green technologies are inadequate. Attempts to achieve carbon neutrality require greater collaboration among emerging Asian nations, such as China, to safeguard the environment. Likewise, Kassi and Li (2025) revealed that Green Finance is only efficient in less polluted regions in China.

Given the results, it is urgent to conduct studies to harness the potential of renewable energy and green finance to decouple economic activity from CO₂ emissions. Numerous studies indicate a substantial impact of Green Finance and Renewable Energy use on environmental quality (Hu et al., 2023; Zhan et al., 2023; Zhang et al., 2023; Wang & Ma., 2022; Guo et al., 2022; Altaf et al., 2025; Kassi & Li., 2024). However, most studies focus on China and developed countries, while research on emerging countries within the ASEAN region is scarcely available.

The environment and economic growth nexus in emerging countries might be distinctive from developed economies because of the financial and technological gaps (Ahmed et al., 2025). In the study of (Yang & Tang, 2024), in the ASEAN region, a linear model was used, excluding the EKC hypothesis, which is widely applied to assess the relationship between environmental factors and economic growth. As explained above, the situation might be more pertinent given that ASEAN nations have pursued rapid industrialization in recent decades, resulting in significant regional environmental degradation. This study aims to address the gap by scrutinizing the relationship between green finance and renewable energy on environmental quality in developing ASEAN countries within the framework of the EKC hypothesis. This study offers policymakers, investors, and other ASEAN-6 stakeholders insight into addressing environmental issues.

The rest of the paper is organised into two sections: Section 2, comprising methodologies, including information on data sources, recommended variables, and the econometric methodology; and Section 3, which delves into the findings and results. Lastly, the concluding section, comprising a summary and recommendations, is discussed in section 4.

Methods

Data

This study examined the effects of GDP, GDP², green finance, and renewable energy on environmental quality proxied by CO₂ emissions. Using data from 2000 to 2020, we focused on ASEAN developing countries, including Indonesia, Malaysia, Thailand, Vietnam, the Philippines, and Cambodia. The data were obtained from Our World in Data World Development Indicators. Table 1 provides detailed information on the data source.

Table 1. Measurement of Variables

Variable	Operational Definition	Units	Source
Environment Quality (CO ₂ Emissions)	Environment quality (CO ₂ emissions) refers to the level of environmental quality affected by CO ₂ emissions.	Tonnes	Our World in Data (https://ourworldindata.org/co2-emissions)
GDP per Capita	GDP is the measurement of a country's nominal GDP divided by population.	2015 US\$	WDI - World Bank (https://data.worldbank.org/indicator/NY.GDP.PC.AP.KD)
Green Finance	Green finance refers to financing environmentally friendly and sustainable projects to reduce CO ₂ emissions. It is measured by Adjusted Net Saving, including particulate Emission Damage	2020 US\$	Our World in Data (https://ourworldindata.org/grapher/international-finance-clean-energy)
Renewable energy	Renewable energy refers to the transition from using fossil fuels to renewable sources.	Percent (%)	WDI - World Bank (https://data.worldbank.org/indicator/EG.FEC.RN.EW.ZS)

According to the variables used, the following is the model specification of this study:

$$CO_{2t} = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 RE_t + \beta_4 GF_t + \varepsilon_t \quad (1)$$

Where CO_2 refers to CO_2 Emissions, β is a constant, GDP refers to Gross Domestic Product, GDP^2 refers to the square of Gross Domestic Product, GF refers to Green Finance, RE represents Renewable Energy, and ε represents the error term. The inclusion of GDP^2 in the model is intended to test the existence of the EKC hypothesis in the form of an inverse U-shaped curve. The positive influence of GDP, accompanied by the negative influence of GDP squared, indicates that the EKC hypothesis is proven (Kuznets, 1955; Grossman & Krueger, 1995). The variables used in this study refer to the studies of Ahmed et al. (2022), Baskaya et al. (2022), Han and Jun (2023), and Massagony and Budiono (2023).

Data analysis method

The method of data analysis employed in this study is a Panel Autoregressive Distributed Lag (ARDL) method with Pooled Mean Group Estimators by Pesaran et al. (1999). The reason for using this method is that it can be applied using a mixture of I(0) and I(1) variables (Bahmani-Oskooee et al., 2020; Sohail et al., 2022; Zhan et al., 2023). The ARDL method is more suitable for small sample sizes and offers different estimates at different lag sequences; thus, this approach provides reliable estimates that significantly eliminate the endogeneity problem in the model (Raghutla & Kolati, 2023). In addition, Pooled Mean Group estimation allows for heterogeneity in short-run coefficients across different panels while assuming that the long-run coefficients are the same across all panels.

Results and Discussion

Descriptive Statistics

Table 2. Descriptive Statistics

	CO ₂	GDP	GDP ²	GF	RE
Mean	1.97E+08	3689.842	2,053,6415	1.06E+08	32.597
Median	1.82E+08	2873.436	8257510.	10750000	30.095
Maximum	6.59E+08	11114.54	1.24E+08	1.09E+09	81.580
Minimum	1974896.	488.003	238,146.6	10,000.00	1.960
Std. Dev.	1.55E+08	2640.893	28275906	1.91E+08	20.552
Skewness	0.897	1.118	1.991	2.848	0.598
Kurtosis	3.509	3.423	6.302	12.401	2.933
Jarque-Bera	19.131	28.477	147.164	664.485	7.898
Probability	0.000	0.000	0.000	0.000	0.019
Sum	2.60E+10	487059.2	2.71E+09	1.40E+10	4302.750
Sum Sq. Dev.	3.14E+18	9.14E+08	1.05E+17	4.80E+18	55331.35
Observations	132	132	132	132	132

Table 2 summarises the statistics of the key variables analysed in this research. The findings show that CO_2 Emissions, GDP, its squared term, Green Finance, and Renewable Energy exhibit positive skewness, implying that most data points are clustered towards the lower end of the distribution. The standard deviations for most variables were much lower than the mean, indicating that the model variables were stable. The Jarque-Bera test indicates significant deviations from normality for renewable energy utilization and population, as evidenced by their low P-values.

Panel Unit Root Test

The results of the unit root test, as presented in Table 3, show that only the Green Finance variable is stationary at a 1% significance level, indicating that it is of I(0). The same tests for all other

variables, using first-differenced data, indicate that they are stationary at the 1%, 5%, and 10% significance levels, or are of I(1). The mixed results of the tests confirm the appropriateness of using ARDL to estimate the model.

Table 3. Results from the Panel Unit Root Test

Test	Variables	Level	First Difference
Levin, Lin, and Chu	CO ₂ Emissions	-0.285	-4.403***
	GDP	-0.404	-1.499*
	GDP ²	1.297	-1.669**
	Green Finance	-110.015***	-53.217***
	Renewable Energy	-0.013	-4.436***
Im, Pesaran and Shin W-Stat	CO ₂ Emissions	2.205	-3.899***
	GDP	2.286	-2.162**
	GDP ²	3.545	-1.857**
	Green Finance	-44.014***	-31.526***
	Renewable Energy	1.5822	-4.142***
ADF – Fisher Chi-square	CO ₂ Emissions	7.578	38.530***
	GDP	3.310	22.121**
	GDP ²	1.534	19.928*
	Green Finance	296.393***	347.678***
	Renewable Energy	4.443	39.473***
PP - Fisher Chi-square	CO ₂ Emissions	14.590	67.539***
	GDP	2.656	59.680***
	GDP ²	1.095	60.261***
	Green Finance	138.822***	621.914***
	Renewable Energy	3.883	65.718***

Notes: ***, **, and * indicated statistically significant at 1%, 5%, and 10%, respectively.

Cointegration Test

Table 4. Pedroni Residual Cointegration Test

Test Statistic	t-Statistic	Prob.
Panel PP-Statistic	-2.577***	(0.005)

Notes: Symbol ***, **, and * indicated statistically significant at 1%, 5%, and 10%, respectively.

Table 4 shows the results of the Pedroni residual cointegration test. Using the Panel PP-Statistic, the outcome indicates that the error correction parameter is negative and significant at the 1% level. This explains that the cointegration test rejects the null hypothesis, indicating long-term cointegration.

Long Run and Short Run Outcomes in ASEAN Developing Countries

Table 5 shows the findings of the panel ARDL model, where in the long run, GDP has a positive and significant effect on CO₂ emissions, while GDP² has a negative and significant effect on CO₂ emissions. The high economic growth most likely arises from a higher level of industrialization, which will, in turn, increase the level of CO₂ emissions, which will deteriorate the environmental quality in the region (Claire & Widyawati, 2023; Dong et al., 2019; Dong et al., 2021; Rehman et al., 2021). The quadratic effect of GDP on CO₂ emissions confirms an inverted U-shaped curve, indicating the presence of the Environmental Kuznets Curve (EKC) Hypothesis, which has been substantiated in developing ASEAN countries. This finding aligns with Kuznets's (1955) proposal, subsequently expanded by Grossman and Krueger (1995). The existence of the EKC hypothesis in developing ASEAN countries supports that of previous studies (Adeel-Farooq et al., 2020; Anwar et al., 2021; Claire & Widyawati, 2023; and Guzel & Okumus, 2020).

Table 5. Result of ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
LNGDP	1.405	0.031	40.643	0.000***
LNGDP2	-0.702	0.017	-40.643	0.000***
LNGF	-0.014	0.006	-2.523	0.014**
LNRE	-0.171	0.035	-4.811	0.000***
Short Run Equation				
COINTEQ01	-0.298	0.174	-1.711	0.091*
D(LNGDP)	0.705	0.280	2.522	0.014**
D(LNGDP(-1))	0.243	0.301	0.807	0.422
D(LNGDP ²)	-0.714	0.347	-2.056	0.042**
D(LNGDP ² (-1))	-0.236	0.256	-0.920	0.360
D(LNGF)	-0.001	0.001	-0.827	0.411
D(LNGF (-1))	-0.000	0.001	-0.302	0.764
D(LNRE)	-0.599	0.266	-2.254	0.027**
D(LNRE(-1))	-0.222	0.117	-1.899	0.061*
C	2.200	1.270	1.733	0.087*
Root MSE	0.032	Mean dependent var		0.053
S.D. dependent var	0.068	S.E. of regression		0.041
Akaike info criterion	-3.012	Sum squared resid		0.137
Schwarz criterion	-1.898	Log likelihood		249.784
Hannan-Quinn criterion.	-2.559			

Table 5 reports the long-term negative and significant effects of green finance variables on CO₂ emissions. The relationship is significant at a 5% level. In terms of its strength, an increase in the use of Green Finance by 1% tends to reduce the CO₂ emission by 1.36%, indicating a positive role of Green Finance in improving environmental quality. This further entails that when an economy undertakes strategies in green finance aimed at enhancing environmental quality, it will achieve its intended purposes (Guo et al., 2022; Hu et al., 2023; Wang & Ma, 2022; Sadiq et al., 2024; Yadav et al., 2024; Zhan et al., 2023; Zhang et al., 2023; Yang & Tang, 2024). However, in the short run, Green Finance has an insignificant effect on CO₂ emissions, implying that immediate changes in financing may not lead to quick emissions reductions. This could be due to various factors, such as the uncertain time required to implement the projects or behavioral shifts among businesses and consumers. It emphasizes the importance of patience and sustained investment in green finance initiatives (Chan et al., 2024; Kasi and Li, 2025).

Additionally, Table 6 presents diagnostic tests for each specific group's empirical model. The results indicate the absence of heteroskedasticity, serial correlation, non-normally distributed residuals, and omitted variable bias. Therefore, the estimated results are valid for interpretation.

Table 6. Post Estimation Diagnostics Tests

Country	Heteroskedasticity (Breusch-Pagan-Godfrey)	Normality (Jarque Bera)	Serial Correlation (Breusch-Godfrey)	Specification (Ramsey Reset)
Indonesia	0.185 (0.950)	0.546	2.209 (0.142)	0.682 (0.188)
Malaysia	1.247 (0.322)	0.535	0.195 (0.825)	1.240 (0.082)
Thailand	1.922 (0.162)	0.448	1.006 (0.084)	1.188 (0.554)
Vietnam	0.008 0.999	1.699	3.511 0.054	0.503 (0.622)
Philippines	0.525 (0.671)	0.359	2.074 (0.158)	1.781 (0.093)
Cambodia	0.561 (0.647)	0.844	1.247 (0.501)	1.734 (0.083)

Further discussion, renewable energy hurts CO₂ emissions both in the long and short run. In the long run, this relationship is significant at a 1% significance level. In terms of its strength, it reflects that through renewable energy, there will be an eradication of the level of carbon emission by 17.04%, which reflects an appreciable role of Renewable Energy use towards environmental quality. In the short run, the effect of renewable energy is more marginally significant, at 5% and 10% levels. This suggests that while renewable energy can contribute to emissions reductions quickly, the extent of this impact may be limited initially. Several factors might be responsible, including existing reliance on fossil fuels, infrastructure constraints, or the time needed for the renewable sector to scale up. These results corroborate the studies by [Khan and Hou \(2021\)](#), [Raghutla and Kolati \(2023\)](#), [Triki et al. \(2023\)](#), [Usman et al. \(2022\)](#), [Wei et al. \(2023\)](#), and [Altaf et al. \(2025\)](#).

In summary, the results of this study underscore the critical relationship between green finance, renewable energy, and carbon emissions. The findings reveal that green finance and renewable energy are pivotal in reducing carbon emissions, highlighting the importance of integrating these elements into national and regional policies. The results indicate that renewable energy has a significantly higher impact on carbon emissions reduction than green finance, with a reduction of 17.04% versus 1.36% for green finance. This disparity suggests that while both factors are crucial for improving environmental quality, renewable energy is currently a more potent tool in the fight against carbon emissions. The significant long-run effect of green finance on carbon emissions indicates that sustained investment in environmentally friendly initiatives can lead to lasting changes in energy consumption and production patterns. In the rapidly industrializing context of ASEAN countries, where economic growth often comes at the expense of environmental degradation, green finance can provide the necessary capital to transition to cleaner technologies ([Yang & Tang, 2024](#)). For instance, Indonesia and Vietnam, which have been heavily reliant on fossil fuels, can benefit from green financial instruments that encourage investments in sustainable projects. By fostering a supportive regulatory environment and ensuring access to green finance, these countries can mitigate the carbon footprint associated with their industrial activities over time.

The dual impact of short- and long-run renewable energy highlights its role as a versatile solution for carbon emissions reductions. As countries like Thailand and the Philippines ramp up their solar and wind energy investments, immediate benefits include reduced dependence on coal and other fossil fuels. This transition is particularly vital in the face of rapid industrialization, which often leads to increased emissions. Malaysia's commitment to enhancing its renewable energy capacity can significantly reduce carbon emissions, foster a cleaner environment, and support sustainable economic growth. Most investments in renewable energy are going to Vietnam due to its advanced industrialization and rapid growth, making it an attractive destination for many investors. Significant financial resources and expenditures are required to expand renewable energy capacity, facilitate the transition to sustainable energy, and implement waste-reduction programs ([Sadiq et al., 2024](#)).

Conclusion

The present analysis quantifies the influence of GDP, green finance, and renewable energy on CO₂ emissions for the ASEAN-6 emerging. Several statistical tests, including the unit root test, Pedroni Residual Cointegration Test, descriptive statistics, Panel ARDL analysis, and post-estimation diagnostic testing, have been used to analyze the relationship among the variables in the network. The study's findings indicate that ASEAN enhances the UN's efforts to mitigate CO₂ emissions and address climate change. The study aims to offer relevant policy implications for ASEAN countries' ambitions to reduce CO₂ emissions, along with a crucial lesson for the future of the global community. The study's conclusions will assist policymakers in strategically allocating investments to achieve environmental sustainability. Our findings have significant policy implications. Firstly, prioritizing renewable energy utilization is essential for ASEAN nations to address the environmental challenges climate change poses. Establishing strong objectives for renewable energy and feasible laws is crucial to this process. Secondly, policymakers should

leverage the study's insights to develop green finance structures that optimize CO₂ reduction efficacy. Thirdly, comprehending the inverted U-shaped relationship enables policymakers to prioritize measures that speed up the attainment of the turning point, expediting the transition to the beneficial phase of renewable energy. The government's main objective is to ensure companies switch to renewable energy. Green Finance can facilitate the transition to green energy. Attractive financing interest rates, lower than the market rate, and simplified terms might incentivize corporations to engage in renewable energy or other sustainability sectors. All this would also be crucial in supporting economic growth while achieving environmental sustainability.

This study has determined that the EKC Hypothesis is valid in ASEAN developing countries when considering green finance and renewable energy variables. However, it only establishes a non-linear relationship between economic growth and environmental quality without identifying the possibility of a non-linear relationship between green finance and renewable energy on CO₂ emissions. This is imperative since the energy transitions in ASEAN countries are still in progress in recent and upcoming decades. Secondly, future studies might consider the turning point at which a country will achieve improved environmental quality, as the economic and industrial disparities among countries might lead to gaps between countries.

References

- Adeel-Farooq, R. M., Raji, J. O., & Adeleye, B. N. (2020). Economic Growth and Methane Emission: Testing The EKC Hypothesis in ASEAN Economies. *Management of Environmental Quality: An International Journal*, 32(2), 277–289. <https://doi.org/10.1108/MEQ-07-2020-0149>
- Ahmed, N., Areche, F., Sheikh, A., & Lahiani, A. (2022). Green Finance and Green Energy Nexus in ASEAN Countries: A Bootstrap Panel Causality Test. *Energies*, 15(14), 5068. <https://doi.org/10.3390/en15145068>
- Ahmed, S., Abdi, A. H., Sodal, M., Yusuf, O. A., & Mohamud, M. H. (2025). Assessing the Energy-Economy-Environment Nexus in Somalia: The Impact of Agricultural Value Added on CO₂ Emissions. *International Journal of Energy Economics and Policy*, 15(1), 221–232.
- Altaf, A., Anwar, M. A., Shahzad, U., & Bilan, Y. (2025). Exploring the Nexus among Green Finance, Renewable Energy, and Environmental Sustainability: Evidence from OECD Economies. *Renewable Energy*, 122589.
- Anwar, A., Siddique, M., Dogan, E., & Sharif, A. (2021). The Moderating Role of Renewable and Non-Renewable Energy in Environment-Income Nexus for ASEAN Countries: Evidence from Method of Moments Quantile Regression. *Renewable Energy*, 164, 956–967. <https://doi.org/10.1016/j.renene.2020.09.128>
- Bahmani-Oskooee, M., Akhtar, P., Ullah, S., & Majeed, M. T. (2020). Exchange Rate Risk and Uncertainty and Trade Flows: Asymmetric Evidence from Asia. *Journal of Risk and Financial Management*, 13(6), 128. <https://doi.org/10.3390/jrfm13060128>
- Baskaya, M. M., Samour, A., & Tursoy, T. (2022). The Financial Inclusion, Renewable Energy and CO₂ Emissions Nexus in The BRICS Nations: New Evidence Based on The Method of Moments Quantile Regression. *Applied Ecology and Environmental Research*, 20(3), 2577–2595. https://doi.org/10.15666/aecr/2003_25772595
- Bhutta, A. I., Ullah, M. R., Sultan, J., Riaz, A., & Sheikh, M. F. (2022). Impact of Green Energy Production, Green Innovation, Financial Development on Environment Quality: A Role of Country Governance in Pakistan. *International Journal of Energy Economics and Policy*, 12(1), 316–326. <https://doi.org/10.32479/ijcep.11986>
- Candy, C., Robin, R., Sativa, E., Septiana, S., Can, H., & Alice, A. (2022). Fintech in the time of COVID-19: Conceptual Overview. *Jurnal Akuntansi, Keuangan, Dan Manajemen*, 3(3), 253–262.

- Chan, T. H., Saqib, A., & Nuzula, A. I. (2024). Assessing the Carbon Footprints of Income Growth, Green Finance, Institutional Quality and Renewable Energy Consumption in Emerging Asian Economies. *Capital Markets Review*, 32(1), 1-27.
- Claire, B., & Widyawati, D. (2023). Impact of Industrialization and Renewable Energy on Carbon Dioxide Emissions in 9 ASEAN Countries. *Economic Journal of Emerging Markets*, 15(2), 183–198. <https://doi.org/10.20885/ejem.vol15.iss2.art6>
- Dong, F., Wang, Y., Su, B., Hua, Y., & Zhang, Y. (2019). The Process of Peak CO₂ Emissions in Developed Economies: A Perspective of Industrialization and Urbanization. *Resources, Conservation and Recycling*, 141, 61–75. <https://doi.org/10.1016/j.resconrec.2018.10.010>
- Dong, H., Xue, M., Xiao, Y., & Liu, Y. (2021). Do Carbon Emissions Impact The Health of Residents? Considering China's Industrialization and Urbanization. *Science of The Total Environment*, 758, 143688. <https://doi.org/10.1016/j.scitotenv.2020.143688>
- Filonchyk, M., Peterson, M. P., Zhang, L., Hurynovich, V., & He, Y. (2024). Greenhouse gas emissions and global climate change: Examining the influence of CO₂, CH₄, and N₂O. *Science of The Total Environment*, 935, 173359. <https://doi.org/10.1016/j.scitotenv.2024.173359>
- Grossman, G. M., & Krueger, A. B. (1995). Economic Growth and The Environment. *The Quarterly Journal of Economics*, 110(2), 353–377. <https://doi.org/10.2307/2118443>
- Guo, C.-Q., Wang, X., Cao, D.-D., & Hou, Y.-G. (2022). The Impact of Green Finance on Carbon Emission--Analysis Based on Mediation Effect and Spatial Effect. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.844988>
- Guzel, A. E., & Okumus, İ. (2020). Revisiting The Pollution Haven Hypothesis in ASEAN-5 Countries: New Insights from Panel Data Analysis. *Environmental Science and Pollution Research*, 27(15), 18157–18167. <https://doi.org/10.1007/s11356-020-08317-y>
- Han, S., & Jun, H. (2023). Growth, emissions, and climate finance nexus for sustainable development: Revisiting the environmental Kuznets curve. *Sustainable Development*, 31(1), 510–527. <https://doi.org/10.1002/sd.2406>
- Hidranto, F. (2023). *Dekarbonisasi Harga Mati*. INDONESIA.GO.ID.
- Hu, J., Chen, H., Dinis, F., & Xiang, G. (2023). Nexus Among Green Finance, Technological Innovation, Green Fiscal Policy, and CO₂ Emissions: A Conditional Process Analysis. *Ecological Indicators*, 154, 110706. <https://doi.org/10.1016/j.ecolind.2023.110706>
- Ibrahiem, D. M. (2020). Do Technological Innovations and Financial Development Improve Environmental Quality in Egypt? *Environmental Science and Pollution Research*, 27(10), 10869–10881. <https://doi.org/10.1007/s11356-019-07585-7>
- Johnson, D. L., Ambrose, S. H., Bassett, T. J., Bowen, M. L., Crummey, D. E., Isaacson, J. S., Johnson, D. N., Lamb, P., Saul, M., & Winter-Nelson, A. E. (1997). Meanings of Environmental Terms. *Journal of Environmental Quality*, 26(3), 581–589. <https://doi.org/10.2134/jeq1997.00472425002600030002x>
- Kassi, D. F., & Li, Y. (2025). Does green financing benefit the development of renewable energy capacities and environmental quality? Evidence from Chinese provinces. *Renewable Energy*, 122482.
- Khan, I., & Hou, F. (2021). Does Multilateral Environmental Diplomacy Improve Environmental Quality? The Case of The United States. *Environmental Science and Pollution Research*, 28(18), 23310–23322. <https://doi.org/10.1007/s11356-020-12005-2>
- Khan, S., Akbar, A., Nasim, I., Hedvičáková, M., & Bashir, F. (2022). Green Finance Development and Environmental Sustainability: A Panel Data Analysis. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.1039705>

- Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review*, 45(1), 1–28. <https://doi.org/10.2307/2118443>
- Limanseto, H. (2023). *Sebagai Salah Satu Titik Terang Pertumbuhan Ekonomi Global, ASEAN juga Tekankan Pentingnya Upaya Inklusif dan Kolaboratif dari Sektor Swasta*. Kementerian Koordinator Bidang Perekonomian Republik Indonesia.
- Massagony, A., & Budiono. (2023). Is the Environmental Kuznets Curve (EKC) hypothesis valid on CO2 emissions in Indonesia? *International Journal of Environmental Studies*, 80(1), 20–31. <https://doi.org/10.1080/00207233.2022.2029097>
- Nguyen, T. K. O., Le, Q. T., Kanabkaew, T., Chitaporpan, S., & Le, T. N. H. (2020). Introduction to Environmental Management and Services. In *TORUS 3 – Toward an Open Resource Using Services* (pp. 1–16). Wiley. <https://doi.org/10.1002/9781119720522.ch1>
- Novia, J., & Candy, C. (2023). Pengaruh Green Investment Dalam Financial Performance: Efek Moderasi dari Environmental Policy. *Widya Cipta: Jurnal Sekretari Dan Manajemen*, 7(2), 65–73. <https://doi.org/10.31294/widyacipta.v7i2.15567>
- Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94(446), 621–634.
- Putri, A. M. H. (2023, September). *Bursa Karbon, Ini Bukti Komitmen RI Pada Perubahan Iklim*. CNBC Indonesia.
- Raghuatla, C., & Kolati, Y. (2023). Does Renewable Energy Improve Environmental Quality? Evidence From RECAI Countries. *Environmental Science and Pollution Research*, 30(45), 100717–100730. <https://doi.org/10.1007/s11356-023-29402-y>
- Raza, S. A., & Shah, N. (2018). Testing Environmental Kuznets Curve Hypothesis in G7 Countries: The Role of Renewable Energy Consumption and Trade. *Environmental Science and Pollution Research*, 25(27), 26965–26977. <https://doi.org/10.1007/s11356-018-2673-z>
- Rehman, A., Ma, H., & Ozturk, I. (2021). Do Industrialization, Energy Importations, and Economic Progress Influence Carbon Emissions in Pakistan? *Environmental Science and Pollution Research*, 28(33), 45840–45852. <https://doi.org/10.1007/s11356-021-13916-4>
- Ridwan, M., Urbee, A. J., Voumik, L. C., Das, M. K., Rashid, M., & Esquivias, M. A. (2024). Investigating the environmental Kuznets curve hypothesis with urbanization, industrialization, and the service sector for six South Asian Countries: Fresh evidence from Driscoll-Kraay standard error. *Research in Globalization*, 8, 100223. <https://doi.org/10.1016/j.resglo.2024.100223>
- Sadiq, M., Chau, K. Y., Ha, N. T. T., Phan, T. T. H., Ngo, T. Q., & Huy, P. Q. (2024). The impact of green finance, eco-innovation, renewable energy, and carbon taxes on CO2 emissions in BRICS countries: Evidence from CS ARDL estimation. *Geoscience Frontiers*, 15(4), 101689. <https://doi.org/10.1016/j.gsf.2023.101689>
- Sohail, S., Ullah, S., & Javid, A. Y. (2022). Fiscal Decentralization, Institutional Quality, and Government Size: An Asymmetry Analysis for Asian Economies. *Transnational Corporations Review*, 14(3), 256–270. <https://doi.org/10.1080/19186444.2021.1956855>
- Tahir, T., Luni, T., Majeed, M. T., & Zafar, A. (2021). The Impact of Financial Development and Globalization on Environmental Quality: Evidence from South Asian Economies. *Environmental Science and Pollution Research*, 28(7), 8088–8101. <https://doi.org/10.1007/s11356-020-11198-w>
- Triki, R., Kahouli, B., Tissaoui, K., & Tlili, H. (2023). Assessing the Link between Environmental Quality, Green Finance, Health Expenditure, Renewable Energy, and Technology Innovation. *Sustainability*, 15(5), 4286. <https://doi.org/10.3390/su15054286>
- Usman, O., Iorember, P. T., Ozturk, I., & Bekun, F. V. (2022). Examining the Interaction Effect

- of Control of Corruption and Income Level on Environmental Quality in Africa. *Sustainability*, 14(18), 11391. <https://doi.org/10.3390/su141811391>
- Wang, H., Alfryyan, N., Al-Buriah, M. S., Khan, Y. A., Alhomrani, M., Alamri, A. S., Azhar, M., & Abbas, S. Z. (2022). Dynamic Linkages Between Developing Economy and Environmental Pollution: An Autoregressive Distributed Lag Statistical Approach. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.939349>
- Wang, J., & Azam, W. (2024). Natural resource scarcity, fossil fuel energy consumption, and total greenhouse gas emissions in the top-emitting countries. *Geoscience Frontiers*, 15(2), 101757. <https://doi.org/10.1016/j.gsf.2023.101757>
- Wang, J., & Ma, Y. (2022). How Does Green Finance Affect CO2 Emissions? Heterogeneous and Mediation Effects Analysis. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.931086>
- Wei, S., Jiandong, W., & Saleem, H. (2023). The Impact of Renewable Energy Transition, Green Growth, Green Trade and Green Innovation on Environmental Quality: Evidence from Top 10 Green Future Countries. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.1076859>
- World Bank. (2023). *Metadata Glossary*. The World Bank.
- Yadav, A., Gyamfi, B. A., Asongu, S. A., & Behera, D. K. (2024). The role of green finance and governance effectiveness in the impact of renewable energy investment on CO2 emissions in BRICS economies. *Journal of Environmental Management*, 358, 120906. <https://doi.org/10.1016/j.jenvman.2024.120906>
- Yang, M., & Tang, X. (2024). Investigating the asymmetric impact of tourism, green fiscal policy, and fintech on environmental emissions and coastal water quality: an empirical study using the method of moments quantile regression. *Frontiers in Environmental Science*, 12(January), 1–13. <https://doi.org/10.3389/fenvs.2024.1499558>
- Zafar, M. W., Saud, S., & Hou, F. (2019). The Impact of Globalization and Financial Development on Environmental Quality: Evidence from Selected Countries in The Organization for Economic Co-Operation and Development (OECD). *Environmental Science and Pollution Research*, 26(13), 13246–13262. <https://doi.org/10.1007/s11356-019-04761-7>
- Zhan, Y., Wang, Y., & Zhong, Y. (2023). Effects of Green Finance and Financial Innovation on Environmental Quality: New Empirical Evidence from China. *Economic Research-Ekonomska Istraživanja*, 36(3). <https://doi.org/10.1080/1331677X.2022.2164034>
- Zhang, Z., Linghu, Y., Meng, X., & Yi, H. (2023). Research on The Carbon Emission Reduction Effects of Green Finance in The Context of Environment Regulations. *Economic Research-Ekonomska Istraživanja*, 36(1). <https://doi.org/10.1080/1331677X.2023.2179513>