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Article

Tourism, Information Communication and Technology, Renewable Energy Consumption, Economic Growth and CO_2 Emissions in Indonesia

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ABSTRACT

This study uses annual data from 1995 to 2020 to investigate the Impact of Tourism, Information Communication and Technology, Renewable Energy Consumption, and Economic Growth on CO_2 Emissions in Indonesia. The relationship between the variables was investigated using an autoregressive distributed lag (ARDL) approach, which considered both the long and short runs. The unit root tests were used to determine the data's stationarity and the F-statistics bound test validated cointegration between variables. This study found short-run and long-term correlations between CO_2 emissions from Indonesia's tourism sector, information communication and technology, usage of renewable energy consumption, and economic growth. In the long run, Indonesia's CO_2 emissions rise by 0.034% and 0.079%, and in the short run, by 0.040% and 0.092%, with a 1% increase in ICT and economic growth, respectively. Furthermore, decreases in CO_2 emissions of 0.050% and 0.287 over the long run and 0.058% and 0.344% over the short run, respectively, may result from a 1% increase in tourism and renewable energy consumption. The study's findings show that although Indonesia's CO_2 emissions are growing due to ICT and economic growth, they are falling due to tourism and the use of renewable energy. Further research could be possible with more economic data and modern econometric techniques. According to these findings, in addition to eco-friendly tourist laws, the ICT sector, and renewable energy sources, authorities in Indonesia should prioritize greater environmentally friendly economic growth to protect the country's natural environment.

Keywords: Tourism; Information communication and technology (ICT); Renewable Energy Consumption (REC); Economic growth; CO_2 emissions

JEL Classification: Z30, L86, Q20, Q56, F64.

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INTRODUCTION

The aim of this article is to investigate the impact of tourism, ICT, the use of renewable energy consumption, economic growth, and CO_2 emissions in Indonesia, one of the world's most popular travel destinations. The links between economic growth, energy consumption, CO_2 emissions, and tourism have become a major study issue to promote economic growth and reduce CO_2 emissions. Over the last several decades, the tourism sector has been essential to the development of many nations, but it has also brought with it many environmental problems, such as rising temperatures, climate change, and gas emissions. Particularly, the climate affects traveler activities, location preferences, and vacation contentment in general (Hoogendoorn & Fitchett, 2018). Additionally, it is well-recognized that the tourism industry is significantly impacted by the effects of climate change and global warming, particularly sea level rise in coastal areas (Atzori et al., 2018). In the end, this pattern exacerbates the state of the surrounding ecosystem's deterioration and raises the amount of energy used at the tourist attraction (Raihan & Tuspekova, 2022).

Tourism is one of the primary contributors to carbon emissions. Previous study's results show that the link between CO_2 emissions and tourism is mixed. For instance, (Azam et al., 2018) looked at the connection between Singapore, Malaysia, and Thailand's tourism and CO_2 emissions. They demonstrated that whereas tourism lowers CO_2 emissions in Singapore and Thailand, it increases CO_2 emissions in Malaysia. But tourism also boosts the economy of the country in a number of other ways. Some studies findings show that because tourism boosts hotel profits, upgrades infrastructure, creates employment, and fosters the expansion of the manufacturing, agricultural, and service sectors, it helps the economy as a whole (Koçak et al., 2020). Although tourism boosts the economy in many ways, there are drawbacks as well, such as the pollution issue. Consequently, tourism is a significant component that might have a direct or indirect impact on both the local ecosystem and the global environment (Raihan, 2023). According to the (UNWTO, 2020)., the share of transportation-related emissions from tourism in total human-caused CO_2 emissions is expected to increase from 5% in 2016 to 5.3% in 2030.

The positive correlation between economic growth and CO_2 emissions indicates that economic expansion has a favorable impact on CO_2 emissions (Khan et al., 2022) More research is needed to understand the relationship between economic growth and the environment in order to ensure sustainable economic growth and development (Ullah et al., 2022). Over the last decades, tourism has demonstrated a strong positive impact on global economic growth, and it has become a key driver of economic development in both developed and developing nations (Cetin et al., 2018; Chai et al., 2019; Kirikkaleli et al., 2022). While In EU countries' CO_2 emissions was increased by 0.072% for every 1% increase in GDP (Onofrei et al., 2022). On the other hand,(De Siano & Canale, 2022) consider (Rehman et al., 2023)tourism as a component in economic growth.

Apergis et al. (2023) are research that has focused on the link between renewable energy and CO_2 emissions recently. Since renewable energy contributes to a reduction in greenhouse gas emissions and climate change, the researchers

identified a negative correlation between carbon dioxide emissions and renewable energy. However, the estimates show that 1%-point increase in renewable energy consumption decreased leads to 1.25% in CO_2 emissions top natural resources rents depending on countries(Szetela et al., 2022). However, much research (Anwar et al., 2021; Fan et al., 2023; Ikram et al., 2020; Z. Z. Li et al., 2021) indicate a positive relationship between energy and emissions.

Based on earlier studies conducted by many scholars, the link between ICT and CO_2 is not clear (Amri, 2018; Danish et al., 2018; Faisal et al., 2020). A drop or rise in CO_2 emissions has been linked in certain studies to the spread of financial development and ICT in both good and negative ways (Islam & Rahaman, 2023) The study by (Asongu et al., 2018) demonstrates that there is little correlation between CO_2 emissions and ICT. Furthermore, whereas (Sun et al., 2023) shown that ICT significantly lowers CO_2 emissions in high-income nations, (Tzeremes et al., 2023) revealed that ICT may alleviate ecological concerns.

A member of the G-20, Indonesia is a developing country in Southeast Asia. Over 280 million population in Indonesia, which is the fourth most populous country in the world and has a Muslim population. Covering an area of 735,358 square miles, or 1,904,569 square kilometers. More than 17,000 islands make up the country. The rationale for our sample selection of Indonesia was that according to the (BPS-Statistics Indonesia, 2023), there was a 52.76% increase in international visitors in 2023 compared to 2022, with 1.07 million foreign visitors arriving in Indonesia. This study's goal is to determine whether or not Indonesia's tourist industry has an impact on the environment in addition to other variables.

To the best of our knowledge, i) this is the unique first study to examine the impact of Tourism, information communication and technology, renewable energy consumption, economic growth, and CO_2 emissions in Indonesia. ii) We employ the ARDL model to examine the long-run and short-run relations between the variables. iii) We add different variables to examine the effect (ICT, Renewable energy, and Economic growth). iv) This paper adds significantly to the body of the current literature on environmental and tourism relations with other variables. v) The analysis's results may help policymakers that support ecologically responsible tourism strategies and more environmentally friendly economic growth.

METHODOLOGY

Data and Model

The aim of this study is to investigate the short-run and long-run relationships between tourism, information communication, renewable energy consumption and economic growth factors on CO_2 emissions in Indonesia. The entire set of variable annual data, which spans the years 1995 to 2020, was gathered through the World Development Indicators (WDI). The variables used in this study investigation to achieve the goal are; CO_2 emissions (metric tons per capita), tourism (number of International visitors), information communication and technology (mobile cellular subscriptions per 100 people), renewable energy consumption (percentage of total final energy consumption), and gross domestic product (measured in GDP constant 2015 USD). In this present study, tourism and ICT are the primary independent variables, renewable energy consumption, and economic growth are the control variables, and CO_2 emissions in metric tons per capita are the dependent variables. The data definitions, sources, and references are displayed in Table 1.

To show the relationship between the variables, this study defined the following model at time t.

$$CO_{2t} = \tau_0 + \tau_1 TOR_t + \tau_2 ICT_t + \tau_3 REC_t + \tau_4 EG_t + \varepsilon_t \quad (1)$$

Here CO_2 emissions, tourism (Tor), information communication and technology (ICT), renewable energy consumption (REC) and economic growth (EG), respectively.

In addition, $\tau_o, \tau_1, \tau_2, \tau_3, and\ \tau_4$ are the coefficients, whereas ε is the error term. The variables were employed by following the logarithmic to clarify smooth data. data.

$$ln\ CO_{2t} = \tau_0 + \tau_1 ln\ TOR_t + \tau_2 ln\ ICT_t + \tau_3 ln\ REC_t + \tau_4 ln\ EG_t + \varepsilon_t \quad (2)$$

Table 1.

Definition, sources and references of the data

Variables	Definition of variables	Sources	References
CO2 emissions	Metric tons per capita	WDI	J. Li et al., 2023
Tourism	Number of international tourist arrivals	WDI	Ghaderi et al., 2023
Information communication and technology	Mobile cellular subscriptions per 100 people	WDI	Sun et al., 2023
Renewable energy consumption	% of total final energy consumption	WDI	Zhang et al., 2023
Economic growth	measured in GDP constant 2015 USD	WDI	Raihan, 2023a

Stationary Test

This study initially examines the relationships between the response variable and its explanatory components to establish if the dataset is unified at I (0) or I (1). The presence of a unit root or non-stationarity in a series causes explosiveness in the estimate, which prevents valid inference (Nelson & Plosser, 1982).

ARDL Model

The lag order of the variables must be ascertained to estimate long-term and short-term coefficients using the ARDL model. We employed the AIC criterion to ascertain the optimal lag order of variables, considering the sample size. With a maximum lag order of one, the long-term and short-term coefficients of the model were computed using the E-views 12 program. We examine both short- and long-term relationships between variables in this study. Numerous statistical approaches are frequently used in the examination of data stationarity. One popular test is the Augmented Dickey-Fuller (ADF) test, which was initially proposed by (Dickey & Fuller, 1981) The cointegration among the variables was ascertained by this study using the ARDL limits testing technique proposed by (Pesaran et al., 2001) This approach offers several benefits over prior cointegration methods. This methodology has significant advantages over previous cointegration approaches (Raihan et al., 2022).It may, for example, be applied to any investigative series integration scenario. When the variables are integrated with order I(1) or are stationary at I(0), the ARDL model outperforms conventional econometric approaches. Finally, even with a small number of observations, the ARDL model remains valid (Pesaran et al., 2001). The ARDL-bound testing strategy may be created using the econometric model provided in Equation (3).

$$\Delta\, lnCO_{2t} = \alpha_0 + \sum_{k=1}^{n} \alpha_1 \Delta\, lnTOR_{t-k} + \sum_{k=1}^{n} \alpha_2 \Delta\, lnICT_{t-k} + \sum_{k=1}^{n} \alpha_3 \Delta\, ln\, REC_{t-k} + \sum_{k=1}^{n} \alpha_4 \Delta\, ln\, EG_{t-k} + \lambda_1 lnTOR_{t-1} + \lambda_2 lnICT_{t-1} + \lambda_3 lnREC_{t-1} + \lambda_4 lNEG_{t-1} + \varepsilon_t \quad (3)$$

where α_0 represents drift component while Δ shows the first difference, ε_t shows the white noise. The Akaike information criterion (AIC) is employed in the study to determine the lag duration. The study used the error correction model (ECM) to determine the short-run dynamics after determining the long-run connection between variables. Equation (4) below represents Equation (3)'s ECM general form:

$$\Delta\, ln\, CO_{2t} = \alpha_0 + \sum_{k=1}^{n} \alpha_1 \Delta\, lnTOR_{t-k} + \sum_{k=1}^{n} \alpha_2 \Delta\, ln\, ICT_{t-k} + \sum_{k=1}^{n} \alpha_3 \Delta\, ln\, REC_{t-k} + \sum_{k=1}^{n} \alpha_4 \Delta\, Ln\, EG_{t-k} + \emptyset ECM_{t-k} + \varepsilon_t \quad (4)$$

where, for short-run dynamics, Ø stands for the ECM coefficients and Δ for the initial difference. ECM displays the rate of long-run equilibrium adjustment following a short-term shock.

RESULT AND DISCUSSION

Summary of Variables

The basic summary statistics offer a summary of all variables used in this study. The findings are shown in Table 2. Ln CO_2 had a mean of 0.47 and a standard deviation of 0.19. The average TOR was 15.71, with a standard deviation of 0.42. On the other hand, the ICT average was 2.86 with a standard deviation of 2.31. Renewable energy sources consumed an average of 3.58 kWh, with a standard deviation of 0.28. EG's mean value is 27.10, with a standard deviation of 0.36. Skewness scores around zero, kurtosis values below three, and Jarque-Bera test statistics below their respective requirements all imply that the data has a normal distribution.

Unit Root Test

The stability of each variable must be guaranteed while doing empirical research using econometric models (Harvey et al., 2001). To utilize the ARDL-bound test, we must confirm the unit root of each variable. Each variable must be stable at I(0), I(1), or both for the F-statistic test to be performed. The same augmented Dickey-Fuller (ADF) unit root test as the prior research is used in the analysis to verify the integration order of each variable.

F-Statistics Bound Test

At the level and first difference levels, every variable is stationary. The ARDL-bound test results are displayed in Table 4. At the 5% significance level, the F-statistic of 6.50 is greater than the upper and lower critical limits. the empirical data presented evidence that long-term cointegration did exist among the variables.

Table 2.
Summary of Variables

Variable	Ln CO_2	LN TOR	LN REC	LN ICT	LN EG
Mean	0.47	15.71	3.577380	2.86	27.11
Median	0.47	15.50	3.689879	3.88	27.08
Maximum	0.81	16.59	3.925531	5.10	27.68
Minimum	0.12	15.22	2.984166	-2.24	26.65
Std. Dev.	0.19	0.42	0.279611	2.31	0.36
Skewness	-0.09	0.89	-0.65	-0.82	0.21
Kurtosis	1.99	2.55	2.20	2.29	1.61
Jarque-Bera	1.14	3.61	2.53	3.48	2.30

Probability	0.56	0.16	0.28	0.18	0.32
Sum	12.32	408.48	93.01	74.33	704.84
Sum Sq. Dev.	0.91	4.32	1.95	133.86	3.15
Observations	26	26	26	26	26

Table 3.
The results of unit root test

Log form of the variables	ADF at level	ADF at 1st difference
Ln CO2	-1.353 (0.589)	-5.276* (0.000)
LnTOR	-3.226* (0.033)	-0.052 (0.953)
Ln ICT	-0.040* (0.041)	-1.736 (0.401)
Ln REC	0.754 (0.991)	-3.715* (0.010)
Ln EG	-0.437 (0.980)	-3.344* (0.024)

Table 4.
F-Statistics Bound Test

F-BoundTest	Value	Sign.	I(0)	I(I)
F-Statistics	6.50	10%	1.9	3.01
		5%	2.26	3.48
		1%	3.07	4.44

ARDL Short Run and Long Run Test

The ARDL estimation's empirical results show that, both in the short and long periods, tourism has a negatively substantial weight on CO_2 emissions. In the short term, a 1% increase in visitor arrivals reduces CO_2 emissions by 0.058 12%, and over time, by 0.050%. ICT has a favorable and considerable impact on CO_2 emissions over the long and short terms, according to ARDL findings. More precisely, a 1% increase in ICT causes a 0.040% short-term increase in CO_2 emissions and a 0.034% long-term increase. Moreover, If a 1% rise in REC causes a short-term drop in CO_2 emissions of 0.344 and a long-term reduction of 0.287 in CO_2 emissions, then there is a negative statistical connection between REC and CO_2 emissions. Nonetheless, in the short and long terms, GDP has a favorable and noteworthy impact on CO_2 emissions. More precisely, a 1% increase in GDP causes a short-term increase in CO_2 emissions of 0.092% and a long-term increase of 0.079%. At the 1% level of significance, this study's assessment of ECM is negative. The magnitude and sign of the equilibrium correlation matrix (ECM) estimate can be used to determine how rapidly a system transitions from a state of short-run disequilibrium to one of long-run equilibrium. This finding shows that after 116.5% correction of short-run mistakes, the long-run equilibrium is attained.

Model Robustness Test

The Jarque-Bera test can be used to guarantee evenly distributed residuals. The serial correlation problem was investigated using the Lagrange multiplier (LM) method. The LM test result indicates that the serial correlation problem is model-free. The forecast model used the Breusch-Pagan-Godfrey analysis to look at the heteroscedasticity problem. The Breusch-Pagan-Godfrey analysis's findings indicate that the predictable model is not heteroscedastic. The Ramsey reset test was used to check whether the model was well-founded. The CUSUM and CUSUM SQUARED graphical representations are shown in Figures 8 and 9, respectively. It has been suggested that the model be considered stable and consistent if the plots stay under the crucial limit of 5%. We can observe from our model plots that, for the Indonesia data, the CUSUM and CUSUM SQUARED are both inside bounds and trends.

Table 5.
ARDL Short Run and Long Run Results

Var.	Coef.	t-stat	Prob.	Coef.	t-stat	Prob.
LnTOR	-0.058	-2.384	0.031	-0.050	-2.445	0.027
Ln ICT	0.040	4.327	0.000	0.034	8.445	0.000
Ln REC	-0.344	-4.447	0.000	-0.287	-9.483	0.000
Ln EG	0.092	4.203	0.000	0.079	5.841	0.000
ECT	-1.165	-6.415	0.000			

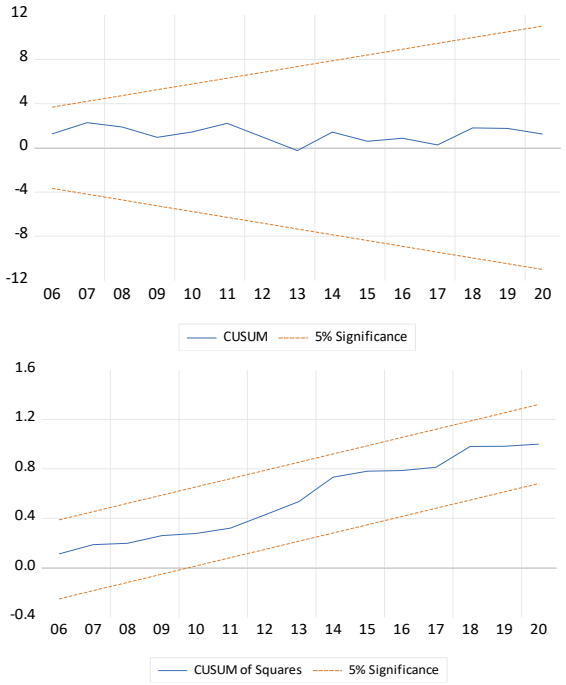
Table 6.
Model Robustness Test

Tests	Prob.	Decision
Breusch-Godfrey Serial Correlation LM Test	0.12	No serial correlation
ARCH Test (Heteroscedasticity Test)	0.54	No heteroscedasticity exists
Ramsey Reset test	0.23	The model is perfectly specified
Jarque-Bera (Normality Test)	0.43	The residues are normally distributed

Discussions

The wide range of tourists who come each year is a significant consideration. It is a significant challenge for LDCs to entertain a sizable number of visitors while offering them environmentally beneficial services (Ahmad et al., 2019). In Indonesia, tourism contributes to the reduction of pollution, demonstrating the environmentally sustainable practices of the tourism industry. The findings of our study are corroborated by the majority of earlier research (Balsalobre-Lorente et al., 2019; Ben Jebli et al., 2019; Dogru et al., 2020; Leitão & Lorente, 2020; Liu et al., 2022; Ozturk et al., 2023). Consequently, this study aims to ascertain if tourism contributes to reducing carbon dioxide emissions. The ARDL test findings show that an increase in tourists has a significant negative impact on Indonesia's CO2 emissions both over the long and short term. One of the major economic sectors in Indonesia is tourism (Saptutyningsih & Duanta, 2021).

Figure.1
Cusum and Cusum Squared



Thus, unless governments implement effective methods to manage it, it is likely that the influx of tourists will have a detrimental impact on the environment (Shakouri et al., 2017) . The "Every Step Movement" is an initiative launched by the Ministry of Tourism and Creative Economy of the Republic of Indonesia to support efforts to reduce the impacts of and adapt to sustainable tourism. Its goal is to raise public awareness about climate change, how it affects the travel industry, and the need to adopt environmentally responsible practices. Furthermore, there is a positive relationship between ICT and CO_2 emissions, implying that ICT causes CO_2 emissions. Nevertheless, our study's findings were supported by some earlier research (Batool et al., 2022; Khan et al., 2022; Yahyaoui, 2022). As per the World Bank, there was a 120–131 growth in mobile subscribers between 2019 and 2020. According to World Data, the Indonesian ICT industry was

estimated to be worth US$ 36.91 billion in 2022 and is projected to increase at a compound annual growth rate (CAGR) of 16.69% to US$ 79,87 billion by 2027. Between 2022 and 2027, Indonesian ICT providers might potentially generate $331.75 billion in revenue. Reducing CO_2 emissions through the use of renewable energy is something that our research finds to be supported by a large body of prior research (Haldar & Sethi, 2021; Kirikkaleli et al., 2022; B. Li & Haneklaus, 2021; Zafar et al., 2022). It is projected that Indonesia's energy consumption will rise by 80% and that, between 2015 and 2030, the country's electricity demand will quadruple. In terms of its vast potential for renewable energy, Indonesia is ranked among the top five nations in the Asia-Pacific region. Plants that produce geothermal and hydroelectric power account for five to eight percent of this total. (International Energy Agency (IEA), 2019). According to (BPS-Statistics Indonesia, 2023), GDP growth in Indonesia jumped from 3.70% to 5.31% between 2021 and 2022. As of right now, Indonesia is the most populous country in the world and has the tenth-largest GDP. Nevertheless, yearly CO_2 emissions rose by 615.92 mt to 728.88 mt in 2022 as compared to 2021 (*Our World in Data*, 2022). Our findings are corroborated by other research, which shows a positive correlation between economic growth and CO2(Hao & Cho, 2022; Raihan, Begum, Said, et al., 2022; Shi et al., 2022; Wang & Jia, 2022)

CONCLUSION AND RECOMMENDATION

Conclusions

According to the World Bank, in addition to being the biggest economy in Southeast Asia, Indonesia also contributes to global CO_2 emissions. As per the 2023 report by EDGAR - Emissions Database for Global Atmospheric Research, Indonesia's CO_2 emissions in 2021 were ranked 10th globally, accounting for 1.59% of global CO_2 emissions. Furthermore, in 2022, Indonesia's CO_2 emissions escalated to rank 7th globally, contributing 1.80% of global CO2 emissions. However, according to the World Bank report, climate change in Indonesia is likely to have an impact on disaster risk management, water availability, nutrition and health, and urban growth, particularly in coastal zones, which will affect poverty and inequality. These emissions have a significant impact on a variety of social and environmental variables. This research aimed to investigate whether there is a dynamic link between CO_2 emissions, tourism, ICT, REC, and EG in Indonesia using a data set that spans from 1995 to 2020. By using unit root tests such as the ADF unit test and F-statists, it was possible to determine if the data exhibited stationarity. The findings also indicated that there was a cointegration between the variables.

Furthermore, the ARDL approach was applied to examine the components via both short- and long-term examination. The results show that for every 1% increase in ICT and economic development, there would be a corresponding rise in CO_2 emissions of 0.034% and 0.079% over the long run, and 0.040% and 0.092% over the short run. Policymakers may find it useful to use the assessment's conclusions to support more environmentally friendly economic growth, as well as to create environmentally friendly information, communication, and technology rules and policies. On the other hand, ARDL results indicate that a one percent increase in TOR and REC will lead to a long-term reduction in CO2 emissions of 0.050% and 0.287%, as well as a short-term reduction of 0.058% and 0.344%. This indicates that while TOR and REC aid in lowering CO2 emissions, rules of the tourist and renewable energy industries still require improvement.

Policy Implications

Over the last several decades, Indonesia's tourism industry has expanded. The country has had the largest increase in worldwide tourist rankings, rising from 44th to 32nd place. Even though Indonesia's tourism sector helps lower CO_2 emissions, more has to be done to improve laws, rules, and regulations. The Ministry of Tourist and Creative (2024)'s "Every Step Matters" campaign tackles climate change in the tourist sector and highlights the Ministry's commitment to helping reduce global emissions by 2030 under the Paris Agreement (2015). The campaign's objective is to attain zero emissions by 2045 with an emphasis on environmentally friendly travel to Indonesia. Policymakers and industry stakeholders should take into consideration putting policies in place to lower the carbon emissions of ICT operations to support sustainable ICT growth in the area. They also need to consider the larger social and other settings that ICT functions in, which include things like infrastructure, government regulations, and energy usage. The ICT and Tourism sector in Indonesia has to move quickly to implement renewable energy technology to ensure ongoing economic growth. More improvement is needed in these sectors; however, current research suggests that renewable energy can help lessen the consequences of CO_2 emissions. Nevertheless, to incentivize individuals and businesses to use renewable energy, lawmakers are encouraged to streamline the related administrative procedures. Public-private partnerships, or PPPs, may open up new investment opportunities for the private sector and promote more investment in renewable energy sources. Lawmakers create regulations and legislation that are easier for investors to understand. One of the most important indicators of a country's growth is its rate of economic development, and in recent years, Indonesia's GDP has expanded more quickly than CO_2 emissions. Policymakers should look at ways to encourage the transition to a more ecologically sensitive economy, invest in renewable energy sources, and introduce greener practices in business. Global collaboration on combating climate change and the development of comprehensive policies that combine economic goals with environmental sustainability are essential for a sustainable future. Policymakers must have a framework for evaluating the short-, medium-, and long-term outcomes of their actions; these procedures contribute to a country's decreased CO_2 emissions.

Study Limitations

This study has certain limitations. For instance, the data that is accessible only covers the years 1995 to 2020; earlier data is not available; also, the study only investigates one country. There is a great deal of room for growth in this research. Other variables like fossil fuels, forest rent, natural resources, trade, foreign direct investment, and energy consumption may be the subject of future studies utilizing more advanced econometric techniques. Future studies might focus on developed and emerging countries as well as other regions, such as ASEAN, the top 5 tourist economies, etc.

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