The Impact of Renewable Energy Output and Consumption Policies and Environmental Taxes on the Environmental Sustainability

Abdelwehab Alwehab

Center of Urban and Regional Planning for Post Graduate Studies, University of Baghdad, Jadyria, Baghdad, Iraq. Email: alwehab@iurp.uobaghdad.edu.iq

Abstract

Due to extensive environmental degradation, environmental sustainability has recently become an important issue, and this aspect requires the regulators' and researchers' attention. Consequently, this article examines the effect of renewable energy (RE) policies on RE output, RE consumption, and environmental taxes on environmental sustainability in four major industrial nations, including China, India, the United States, and Australia. The research also utilized the control variable, which included industrialization and population growth. From 2001 to 2020, this article extracted secondary data from World Development Indicators (WDI). The researchers used the Methods of Moments-Quantile-Regression (MMQR) technique to examine the relationship between constructs. In China, India, the United States, and Australia, the RE output, RE consumption, environmental taxes, industrialization, and population growth have a positive relationship with environmental sustainability and a negative relationship with carbon dioxide (CO2) emissions. The study assists policymakers in formulating environmentally sustainable policies utilizing effective RE policies.

Keywords: Renewable energy policies, renewable energy output, environmental taxes, environmental sustainability

Introduction

The economic significance of a sustainable environment created by various social and for-profit groups is remarkable. A sustainable environment is clean, rich in high-quality natural resources, teeming with healthy living organisms in the air, on land, and below the water's surface, and has an optimal climate for human habitation (Oláh et al., 2020). A sustainable environment can preserve the quality of living and nonliving natural resources. It supplies raw materials and other resources to present and future industries. Additionally, it can preserve human health and supply valuable human resources for sustained economic use (Kour et al., 2020). A sustainable environment promotes the growth of healthy, energetic administrators, employees,

consumers, and members of the general public. It is more likely that a country will prosper and proliferate when its population is in good health, as these individuals will manage businesses and carry out activities. Businesses can also rely on natural resources for energy and raw materials in a sustainable environment. Moreover, businesses rely on natural resources for production materials and energy, which is achievable in a sustainable environment (Jimoh & Lin, 2019).

Nevertheless, the relationship between an economy and the environment is mutual. The geographical distribution of a country, its natural resources, and climate influence businesses' performance and operations. The objective of integrating environmental sustainability into the economic system is to reduce the negative impacts of business activities on the environment, as well as on people and natural resources. CO2 emissions, one of the primary pollutants released by industrial activity, destabilize the delicate equilibrium of the ecosystem. Renewable energy and environmental taxation are the strategies that promote green economic reformation to construct a sustainable environment. Both the generation and consumption of renewable energy (RE) alleviate the need for fossil fuels to power mechanical and technological processes, reducing waste and other harmful pollutants.

Consequently, Co2 emissions are lowered, and the capacity to attain environmental sustainability grows (Umar et al., 2020). In addition, the creation of RE absorbs current CO2 emissions. So, the environment is sustainable. Environmental taxes are fees imposed by the government on individuals and organizations for engaging in activities that pollute the environment. This results in CO2 emissions and sustainability for the environment.

The current study assesses CO2 emissions in China, Australia, India, and the United States for measuring environmental sustainability. The United States has an ascending economy with a growing middle-high income. The United States produced 291.64 million tons of CO2 emissions in 2021, representing its annual emissions, although its cumulative CO2 emissions are 216.90 billion tons of annual CO2 emissions. This implies that the United States is responsible for 13.49% of yearly global CO2 emissions and that the area is responsible for 24.29% of total global CO2 emissions. Oil is the largest source of CO2 emissions among coal, oil, gas, and cement,

the three primary sources of CO2 emissions (Sarkodie & Strezov, 2018). Australia's economy is reviving, and it has an upper-middle income. Australia was able to reduce its annual CO2 emissions by -8.73 million tons in 2020, while its cumulative CO2 emissions amounted to 18.58 billion tons of CO2 emissions. Australia's percentage of yearly global CO2 emissions is 1.05 percent, whereas its part of total global CO2 emissions is 0.9 percent. Coal and oil are the two primary sources of carbon dioxide emissions (Kuswardinah et al., 2021; Wei, Wei, & Western, 2017).

India is a developing nation with a more significant middle-to-upper income. In 2021, the United States produced 264.67 million tons of CO2 emissions annually, with a total of 54.40 billion tons of annual CO2 emissions. India is responsible for 3.29 percent of total global CO2 emissions, accounting for 7.30 percent of yearly global CO2 emissions. Coal, oil, gas are the three primary sources of CO2 emissions, with coal being the most significant contributor (Gupta & Gupta, 2020). China is an economy on the rise with a middle-to-high income. China produced 235.57 billion tons of CO2 in 2020, compared to annual emissions of 10.66 billion tons. This reveals that China is responsible for 30.65 % of the world's yearly CO2 production and 13.89 % of the world's total CO2 emissions (Zhang et al., 2019). If CO2 emissions into the atmosphere continue to increase steadily, the economic development of these four states will be gravely jeopardized. Specific measures must be taken to reduce CO2 emissions, improve the quality of natural resources, and develop a productive workforce for nations to achieve sustainable growth.

This study will investigate the effects of RE output, RE consumption, and environmental taxes on environmental sustainability, with industrialization and population increase serving as control variables. Due to its contributions, this work holds a unique place in the field of study. 1) In previously published studies, the GHG emission proxy is employed to quantify environmental quality changes. This work contributes to the body of knowledge since CO2 emission is used as a proxy for gauging environmental sustainability. 2) The effects of RE production, RE consumption, and environmental taxes on environmental sustainability have been evaluated most of the time separately. This study simultaneously assesses the effects of RE output, RE consumption, and environmental taxes on maintaining a sustainable

ecosystem. 3) This study contributes to the environmental sustainability literature for China, Australia, India, and the United States.

The study consists of five sections, the second of which analyzes the link between components using reasoning from prior research. In the third section, the research methods are addressed briefly. The following section evaluates data to determine the link between the factors. The results are discussed in light of past research in the fifth section. The discussion of the study is followed by its implication, conclusion, and limitations.

Literature Review

If the environment is affected by pollution or contamination, the availability of natural resources may be harmed or diminished. Consistent CO2 emissions from using technologies, energy, and other resources are the leading cause of environmental damage. Emissions of carbon dioxide trap the earth and lead to climate change. Nevertheless, renewable energy output, renewable energy consumption, and environmental taxation are three elements that may effectively reduce CO2 emissions (Henry, Laitala, & Klepp, 2019). This study investigates the role of RE output, RE consumption, environmental taxation, industrialization, and population increase in the reduction of CO2 emissions. The relationship between RE output, RE consumption, environment taxes, industrialization, and population expansion about CO2 emissions and environmental sustainability is prominent in the literature. The following paragraphs review previous research to establish the effects of RE production, RE consumption, environmental taxation, industrialization, and population expansion on CO2 emissions and environmental sustainability.

There are numerous strategies and approaches for acquiring energy from natural resources and making energy production recyclable. These technologies and approaches minimize the levels of CO2 and other air and soil contaminants. If a country raises its RE output based on replenishing natural resources, it can reduce CO2 emissions and preserve the ecosystem and natural cycle (Murshed, 2020). Chen, Wang, and Zhong (2019) examine the relationship between renewable and non-renewable energy output, economic growth, trade openness, and CO2 emissions, the

environmental sustainability index. From 1980 to 2014, the Chinese economy was the focus of the researchers' attention as they compiled data on various topics. For relationship confirmation, the ARDL bounds testing method and the VECM Granger causality method were employed to evaluate the data. In this study, the authors compare RE and NRE manufacturing methods regarding CO2 emissions. The authors conclude that all NRE production operations, including plant construction, mining, and processing of fossil fuels, result in CO2 emissions and environmental damage.

Conversely, RE production activities, such as installing solar panels, reforestation, and trash disposal, absorb CO2 emissions and contribute to a sustainable environment. Magazzino, Mele, and Schneider (2021) investigate the link between wind, solar, and bioenergy production and CO2 emission. The study focuses on China, India, and the United States to explore wind energy, solar power, bioenergy, CO2 emissions, GDP, and coal usage. For analysis, sophisticated Machine Learning techniques and The Causal Direction from the Dependency (D2C) methodology were utilized. According to the research, the RE out results in a significant drop in CO2 emissions in these three nations. Therefore, RE output is the most effective method for achieving environmental sustainability.

There are a variety of non-human causes of CO2 emissions, but energy consumption is by far the largest. Since the beginning of life on earth, humans have relied on fossil fuels, chemicals, and processes to obtain energy and satisfy many domestic and commercial demands. Using these resources and methods for energy production produces hazardous byproducts and gases. Instead of them, the use of RE resources satisfies the requirements without harmful wastes and gases. Environmental sustainability can be accomplished by regulating CO2 emissions (Destek & Aslan, 2020). Kirikkaleli and Adebayo (2021) investigate the relationship between RE use, CO2 emissions from consumption, and environmental sustainability. In India, quantitative data were collected between 2014 and 2018. The factors and their relationship were analyzed using the FMOLS and DOLS long-run estimators.

The study concludes that renewable energy consumption has a considerably smaller impact on the environment and the resources it supports than coal, oil, natural gas, and other energy sources, such as nuclear power. By utilizing RE, companies

lower their CO2 emissions and display their environmental consciousness. Shahzad et al. (2022) investigate the effects of various types of RE consumption on economic growth and CO2 emissions, the surrogate for environmental sustainability. G7 countries were selected for data gathering, and data for the years 1991 to 2014 were collected. The paper examined the association using the Lagrange Multiplier (LM) bootstrap panel cointegration technique. The analysis suggests that if businesses employ various types of RE, they can largely offset the CO2 emissions caused by their use of fossil fuels. The transition toward RE by businesses contributes to environmental sustainability.

Environmental taxation is the green notion of integrating government fiscal policy and a tool to prevent the spread of environmental contamination. According to Bashir et al. (2021), environmental taxes, commonly known as "green taxes," are a broad spectrum of legal penalties imposed on individuals and businesses for reducing pollution-causing behaviors such as CO2 emissions that are harmful to the environment. The prevention of CO2 emissions supports climate equilibrium and environmental viability. Ulucak and Kassouri (2020) investigated the relationship between environmental taxes and CO2 emissions while discussing the environmental sustainability corridor. The relationship between environmental taxes and CO2 emissions was examined using a panel smooth transition regression model using data about the world's economies from 1995 to 2015. According to the study, many components, including chemicals, fossil fuels, cement manufacture, various machines, and processes, are implicated in CO2 emissions if they are not effectively controlled. When the government deems these behaviors illegal and applies taxes to prohibit them, CO2 emissions decrease, and the country is more likely to have a sustainable environment. As a metric of environmental sustainability, Wolde-Rufael and Mulat-Weldemeskel (2021) examined the relationship between environmental taxes and CO2 emissions. The seven emerging economies form the sample for the study, and data on the determinants were collected between 1994 and 2015. Apply the slope heterogeneity tests using the Augmented Mean Group (AMG). The study demonstrates that enterprises that utilize fossil fuels, nuclear energy, chemicals, and technologies accelerate their processes and achieve greater profits. However, these

resources and commercial methods result in CO2 emissions and environmental destruction. Environmental enforcement regulates the CO2-emitting behavior of businesses and promotes a clean, productive, and sustainable environment. Consequently, environmental taxes have a negative association with CO2 emissions and a positive association with environmental sustainability.

Increasing industrialization drives economic expansion and contributes to the country's sustained development. In this circumstance, environmental governance and renewable energy output and consumption expand within the nation. As a result, environmental quality is sustainable (Bulut, 2021). Raihan et al. (2022) study industrialization, technical innovation, urbanization, economic expansion, renewable energy sources, and forestation in the context of achieving environmental sustainability. Bangladesh collected statistics for industrialization, technological innovation, urbanization, GDP, renewable energy use, forestation, and CO2 emissions from 1990 to 2019. The ARDL and DOLS, in conjunction with the Granger causality test, were utilized to examine the relationship between the variables. The results demonstrated that even though industrialization generates an increase in CO2 emissions when it fosters innovation, controlling CO2 emissions and achieving sustainable development is advantageous. Wang, Rehman, and Fahad (2022) examine the connection between industrialization, renewable energy, trade openness, CO2 emissions, and a sustainable environment. The findings demonstrated a clear correlation between industrialization and environmental sustainability, as industrialization promotes the usage of renewable energy sources, which fosters technical innovation.

Population increase influences CO2 emissions and environmental sustainability in addition to renewable energy and environmental taxes. The pace of population increase affects the availability of human capital and the development of a nation. A nation with increased human capital and a higher development rate can build the capacity to address environmental problems such as CO2 emissions if population growth is strong. There is still space for sustainable growth (Saint Akadiri, Bekun, & Sarkodie, 2019). Khan, Hou, and Le (2021) investigate the relationship between population growth, CO2 emissions, and environmental sustainability. Data

from the United States between 1971 and 2016 were utilized for this study. If population growth is appropriately managed and investments are made in people, it would be possible to combat CO2 emissions and achieve environmental sustainability, according to the findings of a study. Mohsin et al. (2019) examine the connection between population growth, economic development, energy consumption, and CO2 emissions. The data was collected from the Pakistani economy's transport industry. Population growth, according to the study, can be effective in reducing CO2 emissions and maintaining a sustainable environment.

Research Methods

The article investigates the impact of RE output, RE consumption, environmental taxes, industrialization, and population growth on environmental sustainability in China, India, the USA, and Australia. The article extracted secondary data from WDI from 2001 to 2020. The study developed the equation with variables used in the study given below:

$$CO2E_t = \alpha_0 + \beta_1 REO_t + \beta_2 REC_t + \beta_3 ENT_{it} + \beta_4 IND_t + \beta_5 PG_t + e_t \quad \textbf{(1)}$$

Where;

CO2E = Carbon Dioxide Emissions

t = Time Period

i = Countries

REO = Renewable Energy Output

REC = Renewable Energy Consumption

ENT = Environmental Taxes

IND = Industrialization

PG = Population Growth

Environmental sustainability was used as the dependent variable, with the sustainable development index serving as a proxy. In addition, the study utilized RE policies as the independent variable to measure RE output (percentage of total output), RE consumption (percentage of total consumption), and the ratio of environmental taxes to total taxes. In addition, the study employed control variables,

such as industrialization's industry value added (% of GDP) as a proxy and population growth's annual population growth percentage as a proxy. Table 1 displays the measured variables.

Table 1: Variables with Measurements

S#	Variables	Measurement	Sources
01	Environmental Sustainability	CO2 emissions	WDI
02	Renewable Energy Output	RE output (% of total output)	WDI
03	Renewable Energy Consumption	RE consumption (% of total consumption)	WDI
04	Environmental Taxes	The ratio of environmental taxes to total taxes	WDI
05	Industrialization	Industry value added (% of GDP)	WDI
06	Population Growth	Population growth annual percentage	WDI

Using descriptive statistics, the study gives detailed information on the constructs. In addition, the study provides the association using a correlation matrix. In addition, the study examines multicollinearity with the variance inflation factor (VIF). The estimation formulae for VIF are listed below:

$$R^2_Y \longrightarrow Y_{it} = \alpha_0 + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + e_{it} \quad \textbf{(2)}$$

$$j = R^2_Y, R^2_{X1}, R^2_{X2,} R^2_{X3,} R^2_{X4,} R^2_{X5} \quad \textbf{(3)}$$

$$Tolrance = 1 - R^2_j \qquad VIF = \frac{1}{Tolerance} \quad \textbf{(4)}$$

The researchers have used the MMQR approach to check the connection among constructs. Machado and Silva (2019) develop this approach. This approach is considered the best because it deals effectively with outliers (Adebayo et al., 2022). This approach also examines asymmetric associations by controlling endogeneity and heterogeneity (Adebayo et al., 2022). So, conditional quantile $Q\tau(\tau/X)$ related to the "locational-scale alternate model" is developed as under:

$$Y_{it} = \alpha_i + X_{it}\beta + (\delta_i + Z_{it}\lambda)U_{it} \quad \textbf{(5)}$$

In equation (5), the probability is presented by $P\{\delta_i + Z_{it}\lambda > 0\} = 1$, while parameters that are being assessed are represented by $\alpha, \beta, \lambda, and\ \delta$, and the components are transformed with component l mentioned below:

$$Zl = Zl\ (X), l = 1, \ldots \ldots, k \quad \textbf{(6)}$$

In equation (6), orthogonal to X_{it} is represented by U_{it}. Thus, the conditional quantile of Y is established as under:

$$Q\tau(\tau/X_{it}) = (\alpha_i + \delta_i q(\tau)) + X_{it}\beta + Z_{it}\,\lambda\, q(\tau) \quad \textbf{(7)}$$

In equation (7), X_{it} shows predictors, for example, REO, REC, ENT, IND, and PG, and Y_{it} represents the dependent variable, like CO2E. So, $Q(\tau)$ is formulated as under:

$$Min_q = \sum_t \sum_i p\tau\ (R_{it} - (\delta_i + Z_{it}\,\lambda\,)q) \quad \textbf{(8)}$$

Research Findings

Using descriptive statistics, the study gives detailed information on the constructs. The results indicated that the average CO2E value was 10.377 percent, the average REO value was 14.427 percent, and the average REC value was 17.395 percent. In addition, the results demonstrated that the mean value for ENT was 4.720 percent, while the mean value for IND was 29.204 percent, and the mean value for PG was 1.041 percent. These results are listed in Table 1.

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2E	80	10.377	7.096	0.887	20.172
REO	80	14.427	4.357	6.784	23.927
REC	80	17.395	12.957	4.680	47.110
ENT	80	4.720	6.108	0.001	22.382
IND	80	29.204	9.289	18.042	47.557
PG	80	1.041	0.435	0.238	2.061

In addition, the study provides the association using a correlation matrix. In China, India, the United States, and Australia, the RE output, RE consumption, environmental taxes, industrialization, and population growth have a positive relationship with environmental sustainability and a negative relationship with CO2 emissions. These results are listed in Table 2.

Matrix of correlations

Variables	CO2E	REO	REC	ENT	IND	PG
CO2E	1.000					
REO	-0.706	1.000				
REC	-0.873	0.378	1.000			
ENT	-0.009	0.551	-0.358	1.000		
IND	-0.581	0.631	0.190	0.381	1.000	
PG	-0.058	-0.434	0.305	-0.764	-0.399	1.000

In addition, the study examines multicollinearity using VIF. The results demonstrated that the reciprocal VIF values are more significant than 0.20 and that VIF values are less than five. These results did not show multicollinearity. These results are listed in Table 4.

Table 4: Variance inflation factor

	VIF	1/VIF
ENT	4.234	0.236
REO	3.864	0.259
REP	2.546	0.393
PG	2.533	0.395
IND	1.738	0.575
Mean VIF	2.983	.

The researchers used the MMQR method to examine the relationship between constructs. In China, India, the United States, and Australia, the RE output, RE consumption, environmental taxation, industrialization, and population growth have a positive relationship with environmental sustainability and a negative relationship with CO2 emissions. These results are listed in Table 5.

Table 5: Panel Quartile Estimation (MMQR)

Variables	Method of Moments Quantile Regression (MMQR)										
	Location	Scale	Grid of Quartiles								
			0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
REO	0.344***	0.674*	-0.783**	-0.893**	-0.783*	-0.774*	-0.773*	-0.674	-0.444*	-0.243	-0.552*
REC	0.983**	0.783*	-0.192**	-0.893*	-0.894*	-0.827**	-0.183	-0.632**	-0.263**	-0.323	-0.163*
ENT	0.739***	0.281**	-0.736**	-0.202**	-0.182*	-0.278*	-0.647*	-0.282**	-0.765*	-0.128**	-0.131
IND	0.531*	0.473**	-0.367*	-0.784*	-0.991**	-0.363	-0.621	-0.291**	-0.744*	-0.674*	-0.111
PG	0.900*	0.478**	-0.748*	-0.292**	-0.674**	-0.364*	-0.373*	-0.883*	-0.433	-0.843*	-0.746*

***, **, and * shows level of significance at 1%, 5%, and 10%.

Discussions

In addition, the data demonstrated that RE output positively affects environmental sustainability. These findings are consistent with Alola et al. (2019) examination of the importance of RE in preserving environmental quality. This study claims that producing renewable energy (RE) comprises methods that are beneficial to environmental quality because they can minimize emissions of hazardous substances like carbon dioxide. Either CO2 emissions constitute the primary component of RE production, such as bioenergy, or they mitigate the effects of CO2, such as solar energy. These findings are consistent with Ahmed, Cary, Shahbaz, and Vo's (2021) assertion that business organizations release less CO2 if they employ a system of RE production and primarily rely on RE outputs to complete their activities. Thus, environmental sustainability is possible.

In addition, the findings demonstrated that RE use positively affects environmental sustainability. These results concur with S. A. R. Khan, Yu, Belhadi, and Mardani's (2020) assertion that the consumption of RE instead of coal, oil, gas, and other fossil fuels have a comparatively more minor impact on the environment and its productivity. By reducing CO2 emissions using RE, companies demonstrate concern for environmental sustainability. These findings are consistent with Agyekum, Amjad, Mohsin, and Ansah's (2021) assertion that firms that adopt RE consumption in their energy consumption patterns are better at mitigating CO2 emissions and, consequently, have a higher proportion of environmental sustainability.

In addition, the findings demonstrated that environmental taxes significantly impact environmental sustainability. These findings are consistent with Kwilinski, Ruzhytskyi, Patlachuk, Patlachuk, and Kaminska's (2019) assertion that environmental pollution, such as CO2 emissions, is caused by the excessive use of chemicals, fossil fuels, and machines or procedures that do not function properly and may emit waste. When these activities are deemed illegal and environmental levies are applied to prevent them, the country's CO2 emissions decrease, and environmental sustainability is ensured. These findings are consistent with Hao, Umar, Khan, and Ali's (2021) assertion that when the government regulates public actions within a country and makes environmental taxes enforceable, CO2 emissions decrease, and environmental sustainability can be attained.

In addition, the findings demonstrated that industrialization positively affects environmental sustainability. These findings concur with Nasrollahi, Hashemi, Bameri, and Mohamad Taghvaee's (2020) conclusion that industrialization creates opportunities for promoting RE production because it fosters economic growth within the country and facilitates the organization of the necessary resources. With the promotion of RE production, RE consumption rises, offsetting CO2 emissions and contributing to environmental sustainability's viability. These findings align with those of Miao et al. (2022). This study asserts that technological advancements are also at their highest point in countries where industrialization is rising. Knowledge of technological advances improves business processes and decreases CO2 emissions, resulting in environmental sustainability.

In addition, the results demonstrated that population growth positively impacts environmental sustainability. These results concur with Nepal et al. (2021), who assert that human resources improve as the population grows. Quality human resources handle business matters more effectively and do not cause CO2 emissions. Therefore, they safeguard the environment and maintain its viability. These findings are consistent with Sandberg, Klockars, and Wilén's (2019) assertion that countries with rapid population growth have a large labor force. Their economy is predominately based on human labor as opposed to energy-intensive machinery. Reduced CO2 emissions ensure environmental sustainability.

Implication

With its novel contributions, the current study serves as a guide for future research. This article examines the role of RE output, RE consumption, and environmental taxes with industrialization and population growth as control factors in environmental sustainability. This study examines the impacts of the abovementioned factors on environmental sustainability in countries such as China, India, the United States, and Australia using CO2 emissions as a metric.

There are numerous empirical implications for China, India, the United States of America, Australia, and other nations, as well as others, regarding how to achieve environmental sustainability. The study advises economic and environmental regulators to plan policies to promote RE output systems to combat CO2 emissions and guarantee environmental sustainability. The study suggests that policies must be designed to facilitate the transition to renewable energy consumption, which can contribute to environmental sustainability by reducing CO2 emissions. It is recommended that the government must be vigilant and decide to implement environmental taxes to reduce CO2 emissions and achieve environmental sustainability. The report assists policymakers in formulating environmentally sustainable policies utilizing effective RE initiatives. It also indicates that industrialization enabled the cultivation of crops for environmental sustainability by reducing CO2 emissions. It emphasizes that as the population grows, policymakers must use it to mitigate CO2 emissions and ensure environmental sustainability.

Conclusion

The purpose was to investigate the role of RE output, RE consumption, environmental taxes, industrialization, and population growth in environmental sustainability. To examine RE output, RE consumption, environment taxes, industrialization, population growth, and CO2 emissions, statistics from China, India, the United States, and Australia were collected. Results indicated a correlation between RE output, RE consumption, environment taxes, industrialization, population growth, and environmental sustainability. According to the results, the increase in RE output significantly reduces the demand for fossil fuels. Consequently,

the reduction in consumption of fossil fuels contributes to the reduction of CO2 emissions and the maintenance of environmental sustainability. In addition, the results demonstrated that the use of natural resources derived from RE reduces the total consumption of fossil fuels. Thus, CO2 emissions from burning fossil fuels and wastes are reduced, ensuring environmental sustainability. In addition, it was discovered that environmental taxes increase the financial burden of an organization's Co2 emissions. Therefore, they prioritize environmental sustainability. The results also showed that in areas where industrialization starts and grows, eco-friendly programs are more likely to be launched, and with reduced CO2, environmental sustainability is achieved. In addition, it was determined that when the population growth rate is notably high, the administrative structure within the country improves, which contributes to achieving a sustainable environment.

Limitations

This study has several limitations. It is recommended that authors consider these limited grounds for study implications and overcome them to present a superior paper. Several environmental sustainability determinants, including renewable energy output, renewable energy consumption, and environmental taxes, are discussed in this study. While many other factors, such as corporate social responsibility, green innovation, green finance also impact environmental sustainability. Future researchers must also consider these factors to conduct a comprehensive study on environmental sustainability. In addition, this study is based solely on data from four nations, including China, India, the United States, and Australia. For this reason, it lacks generalizability, and it is recommended that future authors conduct research in more countries for more general results.

References

Adebayo, T. S., Akadiri, S. S., Adedapo, A. T., & Usman, N. (2022). Does interaction between technological innovation and natural resource rent impact environmental degradation in newly industrialized countries? New evidence from method of moments quantile regression. *Environmental Science and Pollution Research, 29*(2), 3162-3169. https://doi.org/10.1007/s11356-021-17631-y

Adebayo, T. S., Rjoub, H., Akadiri, S. S., Oladipupo, S. D., Sharif, A., & Adeshola, I. (2022). The role of economic complexity in the environmental Kuznets curve of MINT economies: evidence from method of moments quantile regression. *Environmental Science and Pollution Research, 29*(16), 24248-24260. https://doi.org/10.1007/s11356-021-17524-0

Agyekum, E. B., Amjad, F., Mohsin, M., & Ansah, M. N. S. (2021). A bird's eye view of Ghana's renewable energy sector environment: A Multi-Criteria Decision-Making approach. *Utilities Policy, 70*, 101219. https://doi.org/10.1016/j.jup.2021.101219

Ahmed, Z., Cary, M., Shahbaz, M., & Vo, X. V. (2021). Asymmetric nexus between economic policy uncertainty, renewable energy technology budgets, and environmental sustainability: evidence from the United States. *Journal of Cleaner Production, 313*, 127723. https://doi.org/10.1016/j.jclepro.2021.127723

Alola, A. A., Yalçiner, K., Alola, U. V., & Saint Akadiri, S. (2019). The role of renewable energy, immigration and real income in environmental sustainability target. Evidence from Europe largest states. *Science of the total environment, 674*, 307-315. https://doi.org/10.1016/j.scitotenv.2019.04.163

Bashir, M. F., Benjiang, M., Shahbaz, M., Shahzad, U., & Vo, X. V. (2021). Unveiling the heterogeneous impacts of environmental taxes on energy consumption and energy intensity: empirical evidence from OECD countries. *Energy, 226*, 120366. https://doi.org/10.1016/j.energy.2021.120366

Bulut, U. (2021). Environmental sustainability in Turkey: an environmental Kuznets curve estimation for ecological footprint. *International Journal of Sustainable Development & World Ecology, 28*(3), 227-237. https://doi.org/10.1080/13504509.2020.1793425

Chen, Y., Wang, Z., & Zhong, Z. (2019). CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renewable Energy, 131*, 208-216. https://doi.org/10.1016/j.renene.2018.07.047

Destek, M. A., & Aslan, A. (2020). Disaggregated renewable energy consumption and environmental pollution nexus in G-7 countries. *Renewable Energy, 151*, 1298-1306. https://doi.org/10.1016/j.renene.2019.11.138

Gupta, A. K., & Gupta, N. (2020). Effect of corporate environmental sustainability on dimensions of firm performance–Towards sustainable development: Evidence from India. *Journal of Cleaner Production, 253*, 119948. https://doi.org/10.1016/j.jclepro.2019.119948

Hao, L.-N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: how critical the network of environmental taxes, renewable energy and human capital is? *Science of the total environment, 752*, 141853. https://doi.org/10.1016/j.scitotenv.2020.141853

Henry, B., Laitala, K., & Klepp, I. G. (2019). Microfibres from apparel and home textiles: prospects for including microplastics in environmental sustainability assessment. *Science of the total environment, 652*, 483-494. https://doi.org/10.1016/j.scitotenv.2018.10.166

Jimoh, A. A., & Lin, J. (2019). Biosurfactant: A new frontier for greener technology and environmental sustainability. *Ecotoxicology and Environmental safety, 184*, 109607. https://doi.org/10.1016/j.ecoenv.2019.109607

Khan, I., Hou, F., & Le, H. P. (2021). The impact of natural resources, energy consumption, and population growth on environmental quality: Fresh evidence from the United States of America. *Science of the total environment, 754*, 142222. https://doi.org/10.1016/j.scitotenv.2020.142222

Khan, S. A. R., Yu, Z., Belhadi, A., & Mardani, A. (2020). Investigating the effects of renewable energy on international trade and environmental quality. *Journal of environmental management, 272*, 111089. https://doi.org/10.1016/j.jenvman.2020.111089

Kirikkaleli, D., & Adebayo, T. S. (2021). Do public-private partnerships in energy and renewable energy consumption matter for consumption-based carbon dioxide emissions in India? *Environmental Science and Pollution Research, 28*(23), 30139-30152. https://doi.org/10.1007/s11356-021-12692-5

Kour, D., Rana, K. L., Yadav, A. N., Yadav, N., Kumar, M., Kumar, V., Vyas, P., Dhaliwal, H. S., & Saxena, A. K. (2020). Microbial biofertilizers: Bioresources and eco-friendly technologies for agricultural and environmental sustainability. *Biocatalysis and Agricultural Biotechnology, 23*, 101487. https://doi.org/10.1016/j.bcab.2019.101487

Kuswardinah, A., Ansori, M., Rachmawati, R., & Fajri, M. P. (2021). Female Farmers' Knowledge as the Start-Up Capital for an Agribusiness Incubator: A Perspective of Banyubiru Village, Semarang Regency, Central Java, Indonesia. *Nurture, 15*(1), 43-49. https://doi.org/10.55951/nurture.v15i1.6

Kwilinski, A., Ruzhytskyi, I., Patlachuk, V., Patlachuk, O., & Kaminska, B. (2019). Environmental taxes as a condition of business responsibility in the conditions of sustainable development. *Journal of Legal, Ethical and Regulatory Issues, 22*, 1-6. http://izmail.maup.com.ua/assets/files/maup-2.4.-12.pdf

Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics, 213*(1), 145-173. https://doi.org/10.1016/j.jeconom.2019.04.009

Magazzino, C., Mele, M., & Schneider, N. (2021). A machine learning approach on the relationship among solar and wind energy production, coal consumption, GDP, and CO2 emissions. *Renewable Energy, 167*, 99-115. https://doi.org/10.1016/j.renene.2020.11.050

Miao, Y., Razzaq, A., Adebayo, T. S., & Awosusi, A. A. (2022). Do renewable energy consumption and financial globalisation contribute to ecological sustainability in newly industrialized countries? *Renewable Energy, 187*, 688-697. https://doi.org/10.1016/j.renene.2022.01.073

Mohsin, M., Abbas, Q., Zhang, J., Ikram, M., & Iqbal, N. (2019). Integrated effect of energy consumption, economic development, and population growth on CO2 based environmental degradation: a case of transport sector. *Environmental Science and Pollution Research, 26*(32), 32824-32835. https://doi.org/10.1007/s11356-019-06372-8

Murshed, M. (2020). An empirical analysis of the non-linear impacts of ICT-trade openness on renewable energy transition, energy efficiency, clean cooking fuel access and environmental sustainability in South Asia. *Environmental Science and Pollution Research, 27*(29), 36254-36281. https://doi.org/10.1007/s11356-020-09497-3

Nasrollahi, Z., Hashemi, M.-s., Bameri, S., & Mohamad Taghvaee, V. (2020). Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model. *Environment, Development and Sustainability, 22*(2), 1105-1122. https://doi.org/10.1007/s10668-018-0237-5

Nepal, R., Paija, N., Tyagi, B., & Harvie, C. (2021). Energy security, economic growth and environmental sustainability in India: Does FDI and trade openness play a role? *Journal of environmental management, 281*, 111886. https://doi.org/10.1016/j.jenvman.2020.111886

Oláh, J., Aburumman, N., Popp, J., Khan, M. A., Haddad, H., & Kitukutha, N. (2020). Impact of Industry 4.0 on environmental sustainability. *Sustainability, 12*(11), 4674. https://doi.org/10.3390/su12114674

Raihan, A., Muhtasim, D. A., Farhana, S., Pavel, M. I., Faruk, O., Rahman, M., & Mahmood, A. (2022). Nexus between carbon emissions, economic growth, renewable energy use, urbanization, industrialization, technological innovation, and forest area towards achieving environmental sustainability in Bangladesh. *Energy and Climate Change, 3*, 100080. https://doi.org/10.1016/j.egycc.2022.100080

Saint Akadiri, S., Bekun, F. V., & Sarkodie, S. A. (2019). Contemporaneous interaction between energy consumption, economic growth and environmental sustainability in South Africa: what drives what? *Science of the total environment, 686*, 468-475. https://doi.org/10.1016/j.scitotenv.2019.05.421

Sandberg, M., Klockars, K., & Wilén, K. (2019). Green growth or degrowth? Assessing the normative justifications for environmental sustainability and economic growth through critical social theory. *Journal of Cleaner Production, 206*, 133-141. https://doi.org/10.1016/j.jclepro.2018.09.175

Sarkodie, S. A., & Strezov, V. (2018). Empirical study of the environmental Kuznets curve and environmental sustainability curve hypothesis for Australia, China, Ghana and USA. *Journal of Cleaner Production, 201*, 98-110. https://doi.org/10.1016/j.jclepro.2018.08.039

Shahzad, M., Qu, Y., Rehman, S. U., & Zafar, A. U. (2022). Adoption of green innovation technology to accelerate sustainable development among manufacturing industry. *Journal of Innovation & Knowledge, 7*(4), 100231. https://doi.org/10.1016/j.jik.2022.100231

Ulucak, R., & Kassouri, Y. (2020). An assessment of the environmental sustainability corridor: Investigating the non-linear effects of environmental taxation on CO2 emissions. *Sustainable Development, 28*(4), 1010-1018. https://doi.org/10.1002/sd.2057

Umar, M., Ji, X., Kirikkaleli, D., & Xu, Q. (2020). COP21 Roadmap: Do innovation, financial development, and transportation infrastructure matter for environmental sustainability in China? *Journal of environmental management, 271*, 111026. https://doi.org/10.1016/j.jenvman.2020.111026

Wang, W., Rehman, M. A., & Fahad, S. (2022). The dynamic influence of renewable energy, trade openness, and industrialization on the sustainable environment in G-7 economies. *Renewable Energy, 198*, 484-491. https://doi.org/10.1016/j.renene.2022.08.067

Wei, J., Wei, Y., & Western, A. (2017). Evolution of the societal value of water resources for economic development versus environmental sustainability in Australia from 1843 to 2011. *Global Environmental Change, 42*, 82-92. https://doi.org/10.1016/j.gloenvcha.2016.12.005

Wolde-Rufael, Y., & Mulat-Weldemeskel, E. (2021). Do environmental taxes and environmental stringency policies reduce CO2 emissions? Evidence from 7 emerging economies. *Environmental Science and Pollution Research, 28*(18), 22392-22408. https://doi.org/10.1007/s11356-020-11475-8

Zhang, A., Venkatesh, V. G., Liu, Y., Wan, M., Qu, T., & Huisingh, D. (2019). Barriers to smart waste management for a circular economy in China. *Journal of Cleaner Production, 240*, 118198. https://doi.org/10.1016/j.jclepro.2019.118198