Gusau Journal of Economics and Development Studies (GUJEDS), Vol 5 (1), May, 2024
ISSN: 3027-1126 (Online); 2786-9695 (Online)
©Authors

GUSAU JOURNAL OF ECONOMICS AND DEVELOPMENT STUDIES (GUJEDS)

A Bi-annual Publication of the Department of Economics, Federal University Gusau, Zamfara State - Nigeria

Vol. 5 (1) May 2024

©Gusau Journal of Economics and Development Studies (GUJEDS), 2024

Copy rights:
This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are credited. Authors retail copyright.

To view a copy of this license, visit https://creativecommons.org/licenses/by/4.0/

ISSN: 2786-9695

Published by:
Department of Economics,
Federal University Gusau,
Zamfara State – Nigeria

Printed by:
Ahmadu Bello University Press Limited, Zaria,
Kaduna State, Nigeria. Tel.: 08065949711
E-mail: abupress2020@yhoo.com
abupress2013@gmail.com
Website: www.abupress.com.ng

Note:
The articles published in this journal do not in any way reflect the views or position of the GUJEDS. Author are individually responsible for all issues relating to their articles. GUJEDS is an open access journal. This means that authors retain all copyrights.

EDITORIAL BOARD

Editor-in-Chief
Prof. Badeyi M. Sani
HOD, Department of Economics,
Bayero University, Kano

Associate Editor-in-Chief
Prof. Yahya Zakari Abdullahi
V.C. Zamfara State University,
Zamfara State

Assistant Editor-in-Chief I
Prof. Aliyu Sunusi Rafindadi
HOD, Economics Department,
ABU, Zaria Kaduna State.

Assistant Editor-in-Chief II
Prof. M. C. Duru
Department of Economics,
ABU, Zaria Kaduna State.

Managing Editor
Dr. Mutiu Abdulganiyu
Department of Economics,
Federal University, Gusau
Zamfara State

EDITORIAL ADVISER
Dr. Suleiman Dahiru
Department of Economics,
ABU, Zaria Kaduna State.

Dr. Mustapha Muhammad Abdullahi
HOD, Department of Economics,
Federal University, Gusau
Zamfara State

REVIEWER BOARD
Prof. M. C. Duru
Department of Economics,
ABU, Zaria Kaduna State.

Dr. Suleiman Dahiru
Department of Economics,
ABU, Zaria Kaduna State.

Dr. Shehu Usman Adamu
Department of Economics,
University of Maiduguri, Borno State

Dr. Kabiru Ibrahim Maji
Department of Economics,
Army University Biu, Borno State

Dr. Bashir Umar Faruk
Dean, Faculty of Management and Social Science,
Federal University, Gusau
Zamfara State

Dr. Abdullahi Badaru
Economics Department,
Federal University, Dust-ma
Kastina State

Dr. Mutiu Abdulganiyu
Department of Economics,
Federal University, Gusau
Zamfara State

Dr. Mustapha Muhammad Abdullahi
HOD, Department of Economics,
Federal University, Gusau
Zamfara State

Dr. Hussaini Dambo
Department of Economics,
Federal University, Gusau
Zamfara State.

©Authors

Dr. Taofik M. Ibrahim
Department of Economics,
ABU, Zaria Kaduna State.

Dr. Jamaldeen Abubakar
Research Department,
Central Bank of Nigeria
Abuja

Dr. Adam Usman Abubakar
Department of Economics,
ABU, Zaria Kaduna State.

CALL FOR PAPERS

The editorial board of Gusau Journal of Economics and Development Studies (GUJEDS) is hereby inviting authors to submit their unpublished manuscript for publication. The journal is published in two issues of May and November annually. GUJEDS is a double-blind peer reviewed journal published by the Department of Economics, Faculty of Management and Social Sciences, Federal University Gusau, Zamfara State Nigeria The Journal accepts contribution from scholars, academics, Researchers on wild range of issues related to monetary/fiscal policy, Economic growth and Development, Energy and Environmental and other related Economics Issues.

GUIDELINES FOR SUBMISSION AND MANUSCRIPT FORMAT

The submission language is English and must be a well-researched original manuscript that has not previously been submitted elsewhere for publication. The paper should not exceed more than 15 pages on A4 type paper in MS-word format, 1.5-line spacing, 12 Font size in Times new roman. Manuscript should be tested -for plagiarism before submission, as the maximum similarity index acceptable by GUJEDS is 25 percent. Furthermore, the length of a complete article should not exceed 5000 words including an abstract of not more than 250 words with a minimum of four key words-immediately after the abstract. All references including in text citation and reference list, tables and figures should be in line with APA 7th Edition publication manual. Finally, manuscript should be send to our email address gjedsfugus@gmail.com

PUBLICATION PROCEDURE

After receiving a manuscript that is within the similarity index threshold, a confirmation email will be send together with a request to pay a review proceeding fee. At this point, the editorial board will take a decision on accepting, rejecting or making a resubmission of the manuscript based on the outcome of the double-blind peer review. Those authors whose manuscript were accepted for publication will be asked to pay a publication fee, after effecting all suggested corrections and changes made on the manuscript. All corrected papers returned within the specified time frame will be published in that issue.

PAYMENT DETAILS

Bank: Zenith Bank
Account Number: 1214203858
Account Name: Gusau Journal of Economics and Development Studies

FOR INQUIRY
The Managing Editor
Department of Economics
Federal University Gusau, Zamfara State.
gjedsfugus@gmail.com
+2348134539669

Gusau Journal of Economics and Development Studies (GUJEDS), Vol 5 (1), May, 2024
ISSN: 3027-1126 (Online); 2786-9695 (Online)
©Authors
DOI: https://doi.org/10.57233/gujeds.v5i1.21

THE INFLUENCE OF INSTITUTIONAL QUALITY ON ENVIRONMENTAL SUSTAINABILITY IN SUB-SAHARA AFRICA: USING ECONOMIC GROWTH, FDI AND RENEWABLE ENERGY AS MODERATORS

DR. DAHIRU ALHAJI BALA BIRNINTSABA
BANKING AND FINANCE DEPARTMENT FEDERAL POLYTECHNIC KAURA NAMODA
dahirubala5002@gmail.com

ABSTRACT

Using data from the World Development Index, this study examines the relationship between institutions and environmental sustainability in Sub-Saharan African nations, with a particular emphasis on the dynamic interacting effect of institutional quality. All six of the elements that make up institutional quality are employed as independent variables, while CO2 is used as a stand-in for environmental sustainability. In addition to independent variables, the study takes into account the moderating variables of economic growth, use of renewable energy, and foreign direct investment. This study demonstrates the existence of an influence relationship between institutional quality and environmental sustainability via the six indexes employed for the analysis by utilising Hansen tests and higher-order serial correlation as the optimal methodologies for the GMM model. In a similar vein, all of the moderator factors showed their effect on the environment, with the exception of FDI, which in SSA showed no environmental neutrality. We recommend that in order to mitigate climate change, combat corruption, uphold the rule of law, enhance government efficiency, and accelerate economic growth, legislators should fortify the institutional, legal, and policy framework. Aspects of environmental sustainability must also be taken into account.

1.0 Introduction

Sub-Saharan African's (SSA) developing economies have the significant problem of finding a stable route between economic growth and environmental sustainability (Riti et al., 2022), which has led to a significant rise in energy demand in the area. Natural resources, such as soil, water, and air, are being depleted, which harms ecosystems, obliterates plant and animal habitats, and causes pollution. In order to reduce the environmental costs of economic activity, these circumstances call for institutions (such as the United Nations (UN), International Energy Agency (IEA), and Organization for Economic Cooperation and Development

(OECD) to take the initiative in establishing, regulating, and putting into practice laws and regulations in developing economies. Strong institutions aid in the resolution of commercial disputes, the reduction of crime and corruption, the facilitation of the growth of financial markets, and the effective enforcement of competition laws, according to several related theories (Tan et al., 2023). On the other hand, low institutional quality in developing nations is a reflection of regional hazards or covert indirect production costs that have a detrimental impact on FDI location choices (Zhang & Kim, 2022). At same time, a major barrier to a nation's capacity that encourages expropriation activities and jurisdictional manipulation as well as stifles the development of productive elements and innovative technologies (Mohsin et al., 2021; Rahman & Sultana, 2022; Salman et al., 2019a), have become as major challenges in those countries to date, since changes in green policy have a detrimental effect on carbon emissions and renewable energy output (Xu et al., 2023)

Since there are nonrenewable energy options and energy use is not the only element determining environmental pollution, researchers have recently started to focus on the role of institutions in society as well as the level of institutional quality (Karim et al., 2022). The policies put in place by domestic institutions to establish the legal and cultural frameworks within which socioeconomic activities are conducted and associated with the quality of such institutions. Thus, demonstrating the government's capacity to formulate and implement laws and policies that support the private sector, enhance contract execution quality, safeguard property rights, uphold the rule of law, and keep institutions impartial against political influence (Phuc Canh et al., 2019; Salman et al., 2019a). The degree of economic development in each country varies according to the quality of its institutions, and vice versa. A country's capacity has been found to be significantly hampered by a deficient institutional framework, which not only encourages expropriation operations and manipulation of jurisdiction but also impedes the development of creative and productive elements and technologies (Mohsin et al., 2021; Salman et al., 2019a). The impact of institutional variables on environmental policies and programs to reduce carbon emissions is believed to be significant. These variables include political

stability, corruption, government regulation, the rule of law, and government efficacy. Environmental programs aimed at lowering carbon emissions, which could be in danger if institutions lack effectiveness and efficiency. Understanding institutions' effects on carbon emissions is more crucial, even though they serve as indicators and a precursor to many development outcomes (Karim et al., 2022). Thus, the function of institutions is essential to maintaining good environmental standards and promoting economic development, in other word, Gao & Fan, (2023) By boosting technology advancements and institutional efficacy, the problem of environmental sustainability can be handled. Specifically, effective organizations can lower the environmental costs associated with growing economic activity by developing, enforcing, and implementing guidelines and policies on the contextual framework (Rahman & Sultana, 2022). In related studies, that examined the connections between institutional quality and FDI in developing economies (particularly in Arabs and Asians countries) shows that, there are complicating influences between institutions and FDI see the work of Aziz, (2018) and Zhang & Kim, (2022). Similarly in SSA countries many scholars examines the influence of institutions, environment, renewable energy and economic growth, see (Acheampong et al., 2021, 2021; Bournakis et al., 2023; Chomen, 2022; Karim et al., 2022; R. Alaganthiran & Anaba, 2022; Riti et al., 2022)

In the impoverished world, using biomass instead of firewood for cooking is a long-standing practice for renewable energy. About 67% of the world's primary energy consumption and roughly 63% of global CO2 emissions are attributed to these emerging nations (U. S. Ahmad et al., 2022; Jahanger et al., 2022; Qader et al., 2022). As part of their development goals and sustainable development agendas, the developing world has begun incorporating renewable energy technology (from conventional energy sources to clean energy sources) (Jahanger et al., 2022; Qader et al., 2022). As a result, there is an urgent need for thorough and in-depth research on the institutions, sustainable environment of SSA, with an emphasis on finding workable solutions that will promote quality of institutions and the healthier environment in harmony while promoting economic growth.

In light of this knowledge gap and to make this work as unique, this study uses economic growth, FDI and renewable energy as moderators to investigate the influence of good governance on environmental sustainability in 47 Sub-Saharan African countries between 2002 and 2021. In order to accomplish its purpose, the study attempts by introducing institutional quality as a measure to good governance and to address two crucial questions: (i) do institutional quality in sub-Saharan Africa affect environmental sustainability? And (ii) does the moderators variables contribute in the relationship between institutional quality and environmental sustainability?

The rest of the paper is organized as follows: The literature is discussed in Section 2; data and estimation methodology are presented in Section 3; results and discussion are described in Section 4; a conclusion and recommendation are given in Section 5.

2.0 Literature Review

2.1 Institutional Quality and Environmental Sustainability Review

Lately, the role of institutions in influencing the environment has drawn the attention of policymakers. Theoretically, institutions can affect environmental quality through growth, policy, and technical consequences. The policy impact channel holds that institutions determine policies; therefore, while effective institutions may lessen environmental problems, insufficient institutions may exacerbate them. Similarly on this relationship, there are differing opinions in the literature. Institutional quality has a big influence on environmental sustainability (Sarkodie & Adams, 2018). Research by Salman et al., (2019b) and Wang et al., (2018) demonstrated that institutional quality can lower CO2 emissions. The caliber of the nation's institutions is one of the key drivers of economic development. This ensures that funding is distributed to the most effective and environmentally responsible projects. Reputable establishments offer an environment where everyone can effectively fulfill their environmental protection responsibilities. While some empirical studies (Hassan et al., 2020; Yamineva & Liu, 2019) have confirmed that institutional quality degrades the ecosystem, other studies (Rizk & Slimane, 2018; Ulucak et al., 2020) have shown that certain indicators of institutional quality, such as bureaucratic

quality, quality of regulation, and control of corruption, improve environmental quality. It follows that institutions set limits on environmental policy (Karim et al., 2022). Inferentially, poor institutions—like high levels of corruption—can inhibit foreign direct investment and trade policy, which raises carbon emissions, and vice versa. In summary, nations with strong institutional frameworks are better equipped than those with weak ones to enact and uphold stringent environmental policies. The quality of institutional increases the environment quality (Gao & Fan, 2023) for example, the application of the law becomes essential in addressing environmental issues. Therefore, strict adherence to the law is necessary to implement carbon dioxide (CO2) management (Salman et al., 2019b). Renyong & Sedik, (2023) assert that governments that have robust institutions and policies pertaining to environmental sustainability have a higher probability of implementing these measures, hence enhancing the environmental quality of their countries.

An environmental challenges that includes water pollution, air pollution, loss of natural resource, poor sanitation and forest reserve are recently becomes global concern (Renyong & Sedik, 2023) These concerns have led to a global movement to address climate change through the Kyoto Protocol and the Paris Agreement. Reducing the damaging impacts of carbon emissions on the environment is the main objective of these international movements. One of the international treaties that are currently binding on the nations that are committed to reducing global emissions is the Kyoto Protocol, which was adopted in 1997 and went into effect in 2005. As part of the Kyoto Protocol, rich nations have committed to lowering their national emission levels, but they also have an obligation to work together with poorer nations to minimize the effects of climate change that are spread through trade (Buanawaty & Faisal Hastiadi, 2017). This drives the essential of inflow investment within the context of SSA. Based on the benefits of foreign direct investment, it may be concluded that African nations are at the margins of development. The neoclassical theory of capital flows validated this interpretation, demonstrating that foreign assets complement domestic capital and promote economic growth (Abdouli & Hammami, 2017). Through the transfer of

technology, the creation of new jobs, and the sharing of managerial and skill-related knowledge, Duodu et al., (2021) have demonstrated in their work that foreign direct investment flows contribute to economic revitalization. While foreign direct investment (FDI) might be beneficial to certain economies, as those in east Africa, it can also have negative effects on the environment due to its interactions with it.

2.2 Empirical Review

Many academics from around the globe have placed a focus on the empirical research on the connection between institutional quality and environmental sustainability. Using a combination of industrialized and developing nations with the rule of law as an institutional indicator, Lau et al., (2018) investigated the relationship between institutional quality and environmental sustainability. Their findings showed that institutional quality lowers CO2 emissions. In a similar vein, Zakaria & Bibi, (2019) investigated five South Asian nations that used corruption control and demonstrated that doing so can lower CO2 emissions. According to Ali et al., (2019) study, CO2 emissions can be decreased with an increase in institutional quality. The study included data from 47 developing nations and examined corruption control, law, and bureaucratic quality. The study conducted by Kamah et al., (2021) in Sub-Saharan nations demonstrated that regulatory quality and government effectiveness are effective in lowering carbon dioxide emissions. Conversely, Hassan et al., (2020) found that using 12 institutional quality indicators in their study of the Pakistani economy, the indicators have the potential to increase CO2 emissions. Hosseini & Kaneko, (2013) also found that the indicators have the potential to increase CO2 emissions when they looked at the impact of political and civil liberties as indicators of institutional quality in 12 different countries.

The study conducted by Gao & Fan, (2023) investigates the impact of technological advancements in environmentally friendly fields and top-notch educational institutions on the carbon dioxide emissions levels of nations involved in the Belt and Road initiative from 2002 to 2019. Various models, including OLS, fixed effect, two-step system GMM, and two-step difference GMM, were utilized. The findings suggest that technological innovation and, consequently,

environmental quality are positively correlated with institutional excellence. This result is consistent with the findings of Khattak et al, (2020), who discovered a positive relationship between carbon dioxide emissions and technological innovation. and studies' contradictory findings Suki et al., (2022). Salahuddin et al., (2018) used Kuwait to assess the dynamic effects of power consumption, foreign direct investment (FDI), economic growth, and financial development on carbon dioxide (CO2) emissions using the autoregressive distributed lag (ARDL) bounds testing econometric technique. The years of study are 1980–2013. The main study shows that electricity consumption, foreign direct investment, and economic growth all significantly and favorably affect carbon dioxide emissions over the short and long terms. FDI, economic expansion, and electricity consumption on the other hand highly Granger-cause carbon dioxide emissions in Kuwait, according to the VECM Granger causality conclusion.

3.0 Methods and Data

The study adapts A. Ahmad et al., (2024) estimation methods to investigate the dynamic interactive effect of institutional quality on environmental sustainability using economic growth, renewable energy consumption and foreign direct investment as moderators variables, in 47 Sub-Sahara African countries

Simple Model Panel Regression

The study commonly used the below Eq1 for the regressions and estimation to produce different results.

$$CO2_{it} = \vartheta_0 + \beta_1 CC_{it} + \beta_2 GE_{it} + + \beta_3 PV_{it} + \beta_4 RQ_{it} + \beta_5 RL_{it} + \beta_6 VA_{it} + \beta_7 \lambda_{it} + \delta_i + \xi_{it}$$

Where the previously described institutional quality index, represented by; CC, GE, PV, RQ, RL, and VA respectively while FDI and RE are among the vector of control variables that make up the additional λ (see Table 2) i and t stand for the nations and the time, respectively, and ϑ_0 displays a constant term. The error terms and the unobserved time-invariant factors are δ_i andξ_{it}.

Table Two: Data Sources and Variables description

Variables	Acronym	Definitions	Sources
Control of Corruption	CC	Percentile Rank [CC.PER.RNK]	WDI (World Bank Data)
Government Effectiveness:	GE	Percentile Rank [GE.PER.RNK]	WDI (World Bank Data)
Political Stability & Absence of Violence/Terrorism	PV	Percentile Rank [PV.PER.RNK]	WDI (World Bank Data)
Regulatory Quality	RQ	Percentile Rank [RQ.PER.RNK]	WDI (World Bank Data)
Rule of Law	RL	Percentile Rank [RL.PER.RNK]	WDI (World Bank Data)
Voice and Accountability	VA	Percentile Rank [VA.PER.RNK]	WDI (World Bank Data)
Gross Domestic Product	GDP	GDP per capita growth (annual %) [NY.GDP.PCAP.KD.ZG]	WDI (World Bank Data)
CO2 emissions	CO2	metric tons per capita) [EN.ATM.CO2E.PC]	WDI (World Bank Data)
Foreign direct investment	FDI	Net inflows (% of GDP) [BX.KLT.DINV.WD.GD.ZS]	WDI (World Bank Data)
Renewable energy consumption	RE	(% of total final energy consumption) [EG.FEC.RNEW.ZS]	WDI (World Bank Data)

Eq. (1), which presupposes that the regressors are uncorrelated with the composite error term ($\delta_i + \xi_{it}$), is estimated using OLS. This is only true if it is assumed that every variable that influences the regressors and the regressand is included in the model, which empirical research shows is not realistic (Leszczensky & Wolbring, 2022). When OLS assumptions are not met, heterogeneity bias in the results leads to the endogeneity problem (Wooldridge, 2012).

In order to estimate Eq. (1), this study uses both fixed and random effects estimators. The two estimators are different from one another because of the assumption that the unobserved time-invariant components (δ_i) correlate with the regressors. Random effects estimators do not make this assumption, whereas fixed effects estimators do. Unlike fixed effect and random effect estimators, δ_i captures all the time-invariant unobserved heterogeneity by correlating with the regressors, and the fixed effects estimators are free of bias resulting from that.

Dynamic Model Panel Regression

The dynamic panel model is specified as follows:

$$CO2_{it} = CO2_{it-1} + \beta_1 CC_{it} + \beta_2 GE_{it} + + \quad 2$$
$$\beta_3 PV_{it} + \beta_4 RQ_{it} + \beta_5 RL_{it} + \beta_6 VA_{it} + \beta_7$$
$$\lambda_{it} + \delta_i + \xi_{it}$$

Where i = 1, 2,…, N, where N denotes the number of countries, t, is time indicator and t-1 signifies the present of lag dependent variable, that specified the different between Eq1 and Eq2. Similarly, Eq. (2) contains the term that expresses the interaction between

the diffusion of the dependent and independent actors.

$$CO2_{it} = CO2_{it-1} + \beta_1 CC_{it} + \beta_2 GE_{it} + + \quad 3$$
$$\beta_3 PV_{it} + \beta_4 RQ_{it} + \beta_5 RL_{it} + \beta_6 VA_{it}$$
$$+CO2_{i,t-2} + \beta_7 \lambda_{it} + \delta_i + \xi_{it}$$

The previous equation (1-3) is estimated using the GMM technique. The difference in GMM lies in the estimate approach we use. The CD method was used before selecting method of preliminary tests, to perform a robustness check and compare the two estimated models' performances. As the number of regressors and periods rises, the number of instruments in the framework of the GMM rises considerably (Roodman, 2009). The two specification tests available for GMM models are Hansen tests and higher-order serial correlation. A second-order serial correlations test is performed on first-differenced error terms; the report of the second-order serial correlation is given when the error term exhibits serial correlation with the dependent variable.

The null hypothesis is rejected if the endogenous lagged variables cause the internal instruments to be invalid, but since the endogenous lagged variables in our instance are valid, the null hypothesis cannot be rejected. The Hansen test, also known as the over-identification test, is used with the second-order serial correlation test to evaluate the validity of the instrument. The Kleibergen-Paap LM test and the Kleibergen-Paap F-test are two diagnostic tests that can be used to diagnose weak instruments.

4.0 Results and Conclusion

4.1 Statistical Summary

Table 3 presents the summary statistics for the variables. The mean values of the six institutional quality indexes are as follows: growth, FDI, and RE are 1.059, 31.099, 26.049, 33.685, 28.261, 29.189, 32.320, 1.610, 4.443, and 64.124, respectively. GDPI and FDI display average values. The data from all other variables showed that they were the most highly valued and widely distributed variables. The correlation matrix given in Table 4 shows strong positive and negative correlations between the dependent and independent variables

Table Three: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	940	1.059	1.877	0.000	9.986
CC	940	31.099	22.291	0.474	91.904
GE	940	26.049	20.045	0.948	84.615
PV	940	33.685	22.510	0.476	93.750
RQ	940	28.261	18.868	0.474	86.058
RL	940	29.189	20.052	0.469	82.587
VA	940	32.320	19.912	0.000	79.126
GDP	940	1.610	8.061	-58.848	150.432
FDI	940	4.443	8.060	-17.292	103.337
RE	940	64.124	27.433	0. 700	98.300

Note: Standard deviation is denoted by stand. dev. Minimum is indicated by min., and maximum by max.

Table Four: CD and Unit Root Test

	CD Test	**Second Generation**			
	CD	**CIPS**		**CADF (P.Value)**	
Vars		**I(0)**	**I(1)**	**I(0)**	**I(1)**
CO2	36.628***	-1.298	-3.955***	-1.383	-2769***
CC	0.046	-2.096	-4.180***	-1.643	-3.229***
GE	3.993***	-2.638***	-	-2.109	-3.502***
PV	-0.234	-2.553***	-	-2.516	-5.333***
RQ	7.522***	-2.501***	-	-1.851	-8.630***
RL	1.076	-2.163**	-	-1.339	-2.024**
VA	3.126***	-2.203***	-	-1.992	-2.202***
GDP	23.426***	-3.608***	-	-1.837	-5.410***
FDI	7.302***	-2.826***	-	-1.777	-4.267***
RE	44.176**	-1.981	-3.834***	-1.663	-2.194**

Note: The Pesaran unit root test is called CIPS, cross-sectional dependency is called CD, and the enhanced Dickey-Fuller test is called CADF when cross-sectional dependence is present. The figures * and ** denote 1% and 5%, respectively.**

The results of the CD test are listed in Table 4. With the exception of CC, PV, and RL, the test findings show that cross-sectional dependence exists in all variables. We used CIPS and CADF unit root tests to determine whether the variables were stationary or not. The scaled form of the average of the CADF statistics is then used to produce the panel unit root test statistic, or CIPS. To guarantee the presence of second-order moments, individual CADF statistics are further shortened. These moments are demonstrated to be significant when T is quite small (Kyung et al., 2023). With the exception of CO2, CC, and RE, which display I(1) and suggest that those variables are stationary at level I (0) for CIPS, the unit root null hypothesis is not rejected in any of the cases.

The outcomes of the classical models—poised-OLS, and fixed effects, estimators—represented by Eq. (1) are shown in Table 5 & 6. To determine which estimators are the most reliable and effective among them, we do the Hausman tests, the Wooldridge test for autocorrelation, and the Modified Wald test for group-wise heteroscedasticity. The findings show a substantial p-value, indicating the validity and non-zero variances of the fixed individual effects (Baltagi, 2005). Inferentially, pooled OLS estimation of Eq. (1) yields biased estimates for the study. The study compares fixed effects and random effects, estimators, using a robust Hausman test in an effort to identify an effective and trustworthy estimator. The null hypothesis of random effects is rejected by the test's significant p-value. As a result, Table 7 recommends a fixed-effects estimator as a reliable and effective estimator.

Table Five: Pooled Linear regression

Dep. Var (CO2)	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
CC	-0.023	0.004	-6.020	0.000	-0.031	-0.016	***
GE	0.020	0.006	3.250	0.001	0.008	0.032	***
PV	0.000	0.003	0.060	0.950	-0.006	0.006	
RQ	0.006	0.005	1.050	0.296	-0.005	0.016	
RL	00000	0.006	0.070	0.945	-0.012	0.013	
VA	-0.019	0.003	-5.750	0.000	-0.026	-0.013	***
GDP	0.010	0.005	2.090	0.037	0.001	0.020	**
FDI	0.001	0.005	0.260	0.795	-0.008	0.011	
RE	-0.055	0.002	-30.140	0.000	-0.059	-0.052	***
Constant	5.229	0.178	29.320	0.000	4.879	5.579	***

Mean dependent var	1.060	SD dependent var	1.877
R-squared	0.598	Number of obs	940
F-test	153.646	Prob > F	0.000
Akaike crit. (AIC)	3013.900	Bayesian crit. (BIC)	3062.359

*** *p<.01, ** p<.05, * p<.1*

Table 6 displays the results of the estimation of fixed effects, which indicate that all variables have positive significant effects on environmental sustainability, with the exception of foreign direct investment and renewable energy, which have negative significant effects. The major independent variables, political stability (PV) and

regulatory quality (RQ), influence environmental friendliness in Sub-Saharan African countries positively, with significance levels of 5% and 10%, respectively. Other indexes, such as control of corruption (CC), government effectiveness (GE), rule of law (RL), voice and accountability (VA), and government effectiveness (GE), do not promote environmental prosperity in Sub-Saharan Africa, while ICT diffusion encourages inclusive economic growth in Sub-Saharan Africa. However, a consistent fixed effects estimator requires tight exogeneity of the regressors. The exogeneity of these regressors in Eq. 1 is verified by this research using the Wooldridge test. As indicated in Table 7, the test findings demonstrate a significant p-value (0.00) and reject the null hypothesis that there is no first-order serial correlation. This disproves the fixed effects model's premise that the regressors are absolutely exogenous and verifies a relationship between the error term and the regressors' future values. As a result, the fixed effects model's parameter estimations are inconsistent and biased.

Table Six: Fixed Effect Regression results

co2	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
CC	0.000	0.002	-0.010	0.991	-0.003	0.003	
GE	0.000	0.002	-0.020	0.988	-0.005	0.004	
PV	0.003	0.001	2.130	0.033	0.000	0.005	**
RQ	0.004	0.002	1.710	0.088	-0.001	0.008	*
RL	0.001	0.003	0.270	0.785	-0.004	0.006	
VA	0.000	0.002	-0.070	0.941	-0.005	0.004	
GDP	0.003	0.001	2.590	0.010	0.001	0.006	**
FDI	-0.001	0.002	-0.970	0.331	-0.004	0.002	
RE	-0.016	0.002	-7.220	0.000	-0.021	-0.012	***
Constant	1.912	0.166	11.490	0.000	1.585	2.239	***

Mean dependent var	1.060	SD dependent var	1.877
R-squared	0.075	Number of obs	940
F-test	7.985	Prob > F	0.000
Akaike crit. (AIC)	380.611	Bayesian crit. (BIC)	429.070

*** *p<.01, ** p<.05, * p<.1*

Table Seven: Model Specification Exploration (Group-wise heteroscedasticity, Wooldridge and Hausman tests)

Tests	**Chi2/Prob.**	**Present**
Group-wise Heteroskedasticity	6200.00(0.000)	Yes, Cannot reject Ho
Wooldridge test (Autocorrelation)	248.22 (0.000)	Yes, Cannot reject Ho
Hausman Test	30.00 (0.003)	Yes Difference in coefficients not systematic **Cannot reject Ho**

Previous research indicates that in situations when the dependent variable has a temporal lag, GMM prevents biased estimates and takes into account unobserved heterogeneity (Beggs & Nerlove, 1988). This work complies with the suggestions made by Kiviet, (2020) and A. Ahmad et al., (2024) to explore model specifications in order to obtain an effective and reliable GMM estimator. According to economic theory, the model definition process aims to categorize all pertinent regressors as strictly exogenous, endogenous, or preset. A variable is considered strictly exogenous if there is no association between regressors and error terms (time-variant); endogenous variables exhibit the opposite correlation. Pre-determined variables are ones that might have a correlation with historical values of time-variant error terms, but not with their current or future values. Refers to Table 8

Table Eight: Wooldridge test for autocorrelation in panel data Using OLS regression

CO2	Coef.	S.E.	t-v	p-v	[95% C	Interval]	Sig
CC	-0.023	0.004	-6.020	0.000	-0.031	-0.016	***
GE	0.020	0.006	3.250	0.001	0.008	0.032	***
PV	0.000	0.003	0.060	0.950	-0.006	0.006	
RQ	0.006	0.005	1.050	0.296	-0.005	0.016	
RL	0.000	0.006	0.070	0.945	-0.012	0.013	
VA	-0.019	0.003	-5.750	0.000	-0.026	-0.013	***
GDP	0.010	0.005	2.090	0.037	0.001	0.020	**
FDI	0.001	0.005	0.260	0.795	-0.008	0.011	
RE	-0.055	0.002	-30.140	0.000	-0.059	-0.052	***
Constant	5.229	0.178	29.320	0.000	4.879	5.579	***

Mean dependent var	1.060	SD dependent var	1.877
R-squared	0.598	Number of obs	940
F-test	153.646	Prob > F	0.000
Akaike crit. (AIC)	3013.900	Bayesian crit. (BIC)	3062.359

**** p<.01, ** p<.05, * p<.1*

Table Nine: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) e	1.000										
(2) co2	0.634*	1.000									
	(0.000)										
(3) cc	0.000	0.193*	1.000								
	(1.000)	(0.000)									
(4) ge	0.000	0.317*	0.852*	1.000							
	(1.000)	(0.000)	(0.000)								
(5) pv	0.000	0.315*	0.718*	0.690*	1.000						
	(1.000)	(0.000)	(0.000)	(0.000)							
(6) rq	0.000	0.222*	0.792*	0.906*	0.637*	1.000					
	(1.000)	(0.000)	(0.000)	(0.000)	(0.000)						
(7) rl	0.000	0.227*	0.872*	0.912*	0.757*	0.886*	1.000				
	(1.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
(8) va	0.000	0.139*	0.726*	0.732*	0.653*	0.741*	0.792*	1.000			
	(1.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
(9) gdp	0.000	0.055	0.051	0.066*	0.021	0.052	0.059	0.048	1.000		
	(1.000)	(0.092)	(0.121)	(0.044)	(0.522)	(0.110)	(0.069)	(0.141)			
(10) fdi	0.000	-0.002	0.064*	0.008	0.088*	-0.016	0.011	0.085*	0.029	1.000	
	(1.000)	(0.954)	(0.049)	(0.805)	(0.007)	(0.629)	(0.727)	(0.009)	(0.373)		
(11) re	0.000	-0.736*	-0.471*	-0.528*	-0.562*	-0.411*	-0.463*	-0.416*	-0.022	-0.031	1.000
	(1.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.503)	(0.342)	

**** p<0.01, ** p<0.05, * p<0.1*

The Pearson correlation parameters are presented in Table 9 and show the strength and direction of the linear link between the series that are being studied in the panel. Following a thorough model search, this study uses both one-step and two-step difference GMM estimators. The model matches the data fairly well and passes all post-estimation tests.

Table Ten: Dynamic panel-data estimation results

	Two-Steps System GMM		One-Step System GMM	
CO_2	**Coeff/ Prob. Values**	**S.E. Value**	**Coeff/ Prob. Values**	**S.E. Value**
L	0.640***	0.012	0.640***	0.065
CC	0.000	0.001	0.00	0.003
L	0.002***	0.001	0.002	0.002
L2	-0.002**	0.001	-0.003*	0.002
GE	-0.002***	0.001	-0.003	0.002
L	-0.001	0.001	-0.002	0.001
L2	-0.001	0.001	-0.002	0.002
PV	-0.001*	0.000	0.000	0.002

L	0.001**	0.000	0.001	0.001
L2	-0.001***	0.000	-0.002	0.002
RQ	-0.002**	0.001	-0.003	0.003
L	0.003***	0.001	0.004*	0.002
L2	0.004***	0.001	0.006*	0.003
RL	0.003***	0.001	0.005*	0.003
L	0.000	0.000	0.000	0.002
L2	0.007***	0.001	0.009**	0.004
VA	0.005***	0.001	0.007	0.005
L	-0.006***	0.001	-0.007*	0.004
L2	-0.001*	0.001	-0.001	0.002
GDP	0.013***	0.000	0.013***	0.002
L	0.009***	0.000	0.010**	0.004
L2	0.009***	0.000	0.009***	0.003
FDI	0.000	0.000	0.000	0.001
L	0.000	0.000	0.000	0.001
L2	0.000	0.000	0.000	0.001
RE	-0.015***	0.002	-0.018***	0.005
L	0.014***	0.001	0.017**	0.008
L2	0.004***	0.001	0.005	0.004
Observations		799	Observations	799
Group/Instrument		47/17	Group/Instrument	47/17
AR2		0.540	AR2	0.594
Hausen Statistics		1.000	Hausen Statistics	1.000

Note: SE = Standard Error, L, L2 = lag1 and lag2,

The outcomes of the several GMM models are shown in Table 10. With coeff values of 0.640 and prob at 1%, the results show that the first lag of the dependent variable at both techniques agreed to be self-significant, meaning that a 1% rise in carbon emissions in SSA will result in a 65% increase in the region's sustainability weakness of environment. Depending on the observed index, the output shows various influences related to institutional quality. The outcome demonstrates that all institutional quality (IQ) index proxies have a major impact on environmental sustainability, either positively or negatively. For example, the corruption control showed that a 1% rise in control at lag 1 has a favourable impact on environmental quality at 0.002%. However, at lag 2, a 5% decline in control results in a negative impact on sustainability assurance at -0.002%, indicating that corruption is fighting back. According to Sinha et al.,

(2019), this is corroborated. The findings of Akhbari & Nejati, (2019) in their analysis of 61 industrialized and developing nations were supported by this outcome. It can be inferred that as nations get cleaner, their levels of corruption control decrease and vice versa (Transparency International, 2019). With respect to government efficacy, the results indicate a negative impact on ES in SSA, with a 1% significance level and a negative coefficient of -0.002. This implies that any 1% decrease in the effectiveness of governance will lead to a 0.002 reduction in environmental sustainability; this corroborated the result of Bildirici, (2021). The region's regulatory quality, the outcome demonstrates that, after the succeeding period, L1 and L2 have a negative influence at 5% and -0.002 coefficients, whereas L1 and L2 are positively and statistically significant at 1% on environmental sustainability at 0.003 and 0.004 coefficients, respectively. This suggested that while there were initially lax environmental regulations impeding sustainability, laws were occasionally implemented and regulatory actions were necessary to affect a healthy environment at 1% in Sub-Saharan Africa. In a similar vein, the baseline model results of the study show that positive changes in environment occurred between 0.003 and 0.007 for every 1% increase in Rules of Law results. By extension, a region's rule of law enhances shared prosperity and supports the model's claim. Accountability and voice also have both favourable and unfavourable effects on the region's environmental sustainability.

When it comes to the moderator variable, the results indicate that while FDI has no statistically significant impact on environmental sustainability, economic growth and renewable energy are highly successful in promoting environmental sustainability. The outcome demonstrates that GDP has an increasing value at 1% and effects the environment between 0.009 and 0.013. This outcome is consistent with the research conducted by Yan et al., (2022) and ALAM & KABIR, (2013). The first stage of renewable energy (RE) has a negative effect on CO2 with a coefficient value of -0.015 and 1% statistical significance, and a coefficient value of 0.004 to 0.014 at the 1% level of significance. However, the consumption of RE has dual influences on environmental sustainability in SSA.

5.0 Conclusion

Because institutional quality is crucial to shared prosperity and sustainable development in Sub-Saharan Africa (SSA), this study looks into how it affects environmental sustainability in the region. However, the region's environmental sustainability has been moderated by variables such as economic growth, renewable energy, and foreign direct investment. As a result, understanding these processes is essential to developing wise policy. The institutional quality was measured in the analysis using an institutional index consisting of six factors, and the study makes use of annual data from 2002 to 2021. Multiple tests are performed to guarantee the validity of the variable indices. The institutions interaction on environment is analysed using dynamic model, with the best trustworthy estimators found using tests like Hausman and Breusch-Pagan. The dynamic model, GMM estimation is advised in order to handle unobserved heterogeneity and prevent biased estimates. The results confirmed the existence of influence relationship between institutional quality and environmental sustainability via the six index used for the analysis. Similarly, the moderator's variables indicated their impact on environmental except that of FDI that displayed neutrality to environment in SSA

The government should, above all, increase public knowledge because then more people would demand a clean environment, which might lead to improved institutional performance. By reducing CO2 emissions, strengthening the institutional, legal, and policy framework can help to mitigate climate change. Reducing corruption, bolstering the rule of law, and improving government efficiency can all improve institutional effectiveness. Strong institutional quality can more successfully promote environmental sustainability by igniting public interest in and support for environmental issues as well as a desire for a clean environment. And equally to expedite boosting the economy and environmentally friendly, environmental sustainability components must also be considered.

Reference

Abdouli, M., & Hammami, S. (2017). Investigating the causality links between environmental quality, foreign direct investment and economic growth in MENA countries. *International Business Review*, *26*(2), 264–278. https://doi.org/10.1016/j.ibusrev.2016.07.004

Acheampong, A. O., Dzator, J., & Savage, D. A. (2021). Renewable energy, CO2 emissions and economic growth in sub-Saharan Africa: Does institutional quality matter? *Journal of Policy Modeling*, *43*(5), 1070–1093. https://doi.org/10.1016/j.jpolmod.2021.03.011

Ahmad, A., Abubakar, B., Seyi, H., & Akadiri, S. (2024). Towards ICT diffusion and trade liberalisation on inclusive growth in Sub - Saharan Africa. *Environment, Development and Sustainability*, *0123456789*. https://doi.org/10.1007/s10668-023-04355-x

Ahmad, U. S., Usman, M., Hussain, S., Jahanger, A., & Abrar, M. (2022). Determinants of renewable energy sources in Pakistan: An overview. *Environmental Science and Pollution Research*, *29*(19), 29183–29201. https://doi.org/10.1007/s11356-022-18502-w

Akhbari, R., & Nejati, M. (2019). The effect of corruption on carbon emissions in developed and developing countries: empirical investigation of a claim. *Heliyon*, *5*(9). https://doi.org/10.1016/j.heliyon.2019.e02516

ALAM, M. S., & KABIR, M. N. (2013). Economic Growth and Environmental Sustainability: Empirical Evidence from East and South-East Asia. *International Journal of Economics and Finance*, *5*(2), 86–97. https://doi.org/10.5539/ijef.v5n2p86

Ali, H. S., Zeqiraj, V., Lin, W. L., Law, S. H., Yusop, Z., Bare, U. A. A., & Chin, L. (2019). Does quality institutions promote environmental quality? *Environmental Science and Pollution Research*, *26*(11), 10446–10456. https://doi.org/10.1007/s11356-019-04670-9

Aziz, O. G. (2018). Institutional quality and FDI inflows in Arab economies. *Finance Research Letters*, *25*(April 2017), 111–123. https://doi.org/10.1016/j.frl.2017.10.026

Beggs, J. J., & Nerlove, M. (1988). Biases in dynamic models with fixed effects. *Economics Letters*, *26*(1), 29–31. https://doi.org/10.1016/0165-1765(88)90046-8

Bildirici, M. (2021). The impacts of governance on Environmental Pollution in some countries of Middle East and sub- Saharan Africa : The Evidence from panel Quantile Regression and Causality. *Environmental Science and Pollution Research*, 0–12. https://doi.org/https://doi.org/10.21203/rs.3.rs-190567/v1

Bournakis, I., Rizov, M., & Christopoulos, D. (2023). Revisiting the effect of institutions on the economic performance of SSA countries: Do legal origins matter in the context of ethnic heterogeneity? *Economic Modelling*, *125*(March 2022). https://doi.org/10.1016/j.econmod.2023.106332

Buanawaty, P., & Faisal Hastiadi, F. (2017). The Impact of Kyoto Protocol on Environment Quality in the Free Trade Era: Case of G20 Countries. *International Journal of Economics and Financial Issues*, *7*(3), 36–42. http:www.econjournals.com

Chomen, M. T. (2022). Institutions – Economic Growth Nexus in Sub-Saharan Africa. *Heliyon*, *8*(December).

Duodu, E., Kwarteng, E., Oteng-Abayie, E. F., & Frimpong, P. B. (2021). Foreign direct investments and environmental quality in sub-Saharan Africa: the merits of policy and institutions for environmental sustainability. *Environmental Science and Pollution Research*, *28*(46), 66101–66120. https://doi.org/10.1007/s11356-021-15288-1

Gao, X., & Fan, M. (2023). The role of quality institutions and technological innovations in environmental sustainability: Panel data analysis of BRI countries. *PLoS ONE*, *18*(6 June), 1–19. https://doi.org/10.1371/journal.pone.0287543

Hassan, S. T., Danish, Khan, S. U. D., Xia, E., & Fatima, H. (2020). Role of institutions in correcting environmental pollution: An empirical investigation. *Sustainable Cities and Society*, *53*, 101901. https://doi.org/10.1016/j.scs.2019.101901

Hosseini, H. M., & Kaneko, S. (2013). Can environmental quality spread through institutions? *Energy Policy*, *56*(2006), 312–321. https://doi.org/10.1016/j.enpol.2012.12.067

Jahanger, A., Usman, M., & Balsalobre-Lorente, D. (2022). Autocracy, democracy, globalization, and environmental pollution in developing world: Fresh evidence from STIRPAT model. *Journal of Public Affairs*, *22*(4). https://doi.org/10.1002/pa.2753

Kamah, M., Riti, J. S., & Bin, P. (2021). Inclusive growth and environmental sustainability: the role of institutional quality in sub-Saharan Africa. *Environmental Science and Pollution Research*, *28*(26), 34885–34901. https://doi.org/10.1007/s11356-021-13125-z

Karim, S., Appiah, M., Naeem, M. A., Lucey, B. M., & Li, M. (2022). Modelling the role of institutional quality on carbon emissions in Sub-Saharan African countries. *Renewable Energy*, *198*(July), 213–221. https://doi.org/10.1016/j.renene.2022.08.074

Kiviet, J. F. (2020). Microeconometric dynamic panel data methods: Model

specification and selection issues. *Econometrics and Statistics*, *13*, 16–45. https://doi.org/10.1016/j.ecosta.2019.08.003

Kyung So Im, M. Hashem Pesaran, and Y. S. (2023). *CAMBRIDGE WORKING PAPERS IN ECONOMICS Reflections on " Testing for Unit Roots in Heterogeneous Panels*.

Lau, L.-S., Choong, C.-K., & Ng, C.-F. (2018). Role of Institutional Quality on Environmental Kuznets Curve: A Comparative Study in Developed and Developing Countries. *Advances in Pacific Basin Business, Economics and Finance*, *6*, 223–247. https://doi.org/10.1108/s2514-465020180000006007

Leszczensky, L., & Wolbring, T. (2022). How to Deal With Reverse Causality Using Panel Data? Recommendations for Researchers Based on a Simulation Study. *Sociological Methods and Research*, *51*(2), 837–865. https://doi.org/10.1177/0049124119882473

Mohsin, M., Kamran, H. W., Atif Nawaz, M., Sajjad Hussain, M., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. *Journal of Environmental Management*, *284*(January), 111999. https://doi.org/10.1016/j.jenvman.2021.111999

Phuc Canh, N., Schinckus, C., & Thanh, S. D. (2019). Do economic openness and institutional quality influence patents? Evidence from GMM systems estimates. *International Economics*, *157*(October), 134–169. https://doi.org/10.1016/j.inteco.2018.10.002

Qader, M. R., Khan, S., Kamal, M., Usman, M., & Haseeb, M. (2022). Forecasting carbon emissions due to electricity power generation in Bahrain. *Environmental Science and Pollution Research*, *29*(12), 17346–17357. https://doi.org/10.1007/s11356-021-16960-2

R. Alaganthiran, J., & Anaba, M. I. (2022). The effects of economic growth on carbon dioxide emissions in selected Sub-Saharan African (SSA) countries. *Heliyon*, *8*(11). https://doi.org/10.1016/j.heliyon.2022.e11193

Rahman, M. M., & Sultana, N. (2022). Impacts of institutional quality, economic growth, and exports on renewable energy: Emerging countries perspective. *Renewable Energy*, *189*, 938–951. https://doi.org/10.1016/j.renene.2022.03.034

Renyong, H., & Sedik, A. A. (2023). Environmental Sustainability and Foreign Direct Investment in East Africa: Institutional and Policy Benefits for Environmental Sustainability. *Sustainability (Switzerland)* , *15*(2). https://doi.org/10.3390/su15021521

Riti, J. S., Riti, M. K. J., & Oji-Okoro, I.

(2022). Renewable energy consumption in sub-Saharan Africa (SSA): Implications on economic and environmental sustainability. *Current Research in Environmental Sustainability*, *4*(September 2021). https://doi.org/10.1016/j.crsust.2022.100129

Rizk, R., & Slimane, M. Ben. (2018). Modelling the relationship between poverty, environment, and institutions: a panel data study. *Environmental Science and Pollution Research*, *25*(31), 31459–31473. https://doi.org/10.1007/s11356-018-3051-6

Salahuddin, M., Alam, K., Ozturk, I., & Sohag, K. (2018). The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO2 emissions in Kuwait. *Renewable and Sustainable Energy Reviews*, *81*(June 2017), 2002–2010. https://doi.org/10.1016/j.rser.2017.06.009

Salman, M., Long, X., Dauda, L., & Mensah, C. N. (2019a). The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea and Thailand. *Journal of Cleaner Production*, *241*. https://doi.org/10.1016/j.jclepro.2019.118331

Salman, M., Long, X., Dauda, L., & Mensah, C. N. (2019b). The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea and Thailand. *Journal of Cleaner Production*, *241*, 118331. https://doi.org/10.1016/j.jclepro.2019.118331

Sarkodie, S. A., & Adams, S. (2018). Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa. *Science of the Total Environment*, *643*, 1590–1601. https://doi.org/10.1016/j.scitotenv.2018.06.320

Shoukat Iqbal Khattak, Manzoor Ahmad, Z. U. K. & A. K. (2020). Exploring the impact of energy consumption, food security on CO2 emissions: A piece of new evidence from Pakistan. *Environmental Science and Pollution Research*, *20*(2), 115–127. https://doi.org/https://doi.org/10.1007/s11356-020-07876-4

Sinha, A., Gupta, M., Shahbaz, M., & Sengupta, T. (2019). Impact of corruption in public sector on environmental quality: Implications for sustainability in BRICS and next 11 countries. *Journal of Cleaner Production*, *232*(94357), 1379–1393. https://doi.org/10.1016/j.jclepro.2019.06.066

Suki, N. M., Suki, N. M., Sharif, A., Afshan, S., & Jermsittiparsert, K. (2022). The role of technology innovation and renewable energy in reducing environmental degradation in Malaysia: A step towards sustainable

environment. *Renewable Energy*, *182*, 245–253. https://doi.org/10.1016/j.renene.2021.10.007

Tan, M., Yang, D., & Yang, Q. (2023). Institutional quality, asset specificity, and foreign direct investment. *Journal of International Money and Finance*, *134*(59). https://doi.org/10.1016/j.jimonfin.2023.102845

Transparency International. (2019). *Corruption perceptions Index 2019 96. International Secretariat Alt-Moabit, p. 10559. Berlin, Germany.*

Ulucak, Z. Ş., İlkay, S. Ç., Özcan, B., & Gedikli, A. (2020). Financial globalization and environmental degradation nexus: Evidence from emerging economies. *Resources Policy*, *67*(March). https://doi.org/10.1016/j.resourpol.2020.101698

Wang, B., Wang, Q., Wei, Y. M., & Li, Z. P. (2018). Role of renewable energy in China's energy security and climate change mitigation: An index decomposition analysis. *Renewable and Sustainable Energy Reviews*, *90*(July 2016), 187–194. https://doi.org/10.1016/j.rser.2018.03.012

Wooldridge, J. M. (2012). Introductory Econometrics: A modern approach. In *South Western Cengage Learning*. https://doi.org/10.1201/9781315215402-43

Xu, J., Moslehpour, M., Tran, T. K., Dinh, K. C., Ngo, T. Q., & Huy, P. Q. (2023). The role of institutional quality, renewable energy development and trade openness in green finance: Empirical evidence from South Asian countries. *Renewable Energy*, *207*(February), 687–692. https://doi.org/10.1016/j.renene.2023.03.015

Yamineva, Y., & Liu, Z. (2019). Cleaning the air, protecting the climate: Policy, legal and institutional nexus to reduce black carbon emissions in China. *Environmental Science and Policy*, *95*(August 2018), 1–10. https://doi.org/10.1016/j.envsci.2019.01.016

Yan, C., Li, H., & Li, Z. (2022). Environmental pollution and economic growth: Evidence of SO2 emissions and GDP in China. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.930780

Zakaria, M., & Bibi, S. (2019). Financial development and environment in South Asia: the role of institutional quality. *Environmental Science and Pollution Research*, *26*(8), 7926–7937. https://doi.org/10.1007/s11356-019-04284-1

Zhang, H., & Kim, H. (2022). Institutional quality and FDI location: A threshold model. *Economic Modelling*, *114*(June). https://doi.org/10.1016/j.econmod.2022.105942