Heliyon 9 (2023) e17133

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

What is the role of remittance and education for environmental pollution? - Analyzing in the presence of financial inclusion and natural resource extraction

Syed Qasim Ali Shah [a], Umra Waris [b], Sheraz Ahmed [b], Ephraim Bonah Agyekum [c], Abdelazim G. Hussien [d,e,f,*], Mustafa Kamal [g], Masood ur Rehman [h], Salah Kamel [i]

[a] *Department Riphah School of Business and Management (RSBM), Riphah International University Islamabad, Lahore, Pakistan*
[b] *Department of Economics and and Quantitative Methods, HSM, University of Management and Technology, Lahore, Pakistan*
[c] *Department of Nuclear and Renewable Energy, Ural Federal University Named After the First President of Russia Boris, 19 Mira Street, Ekaterinburg, 620002, Yeltsin, Russia*
[d] *Department of Computer and Information Science, Linköping University, Linköping, Sweden*
[e] *Faculty of Science, Fayoum University, Fayoum, Egypt*
[f] *MEU Research Unit, Middle East University, Amman, Jordan*
[g] *Department of Basic Sciences, College of Science and Theoretical Studies, Saudi Electronic University, Dammam, 32256, Saudi Arabia*
[h] *Department of Information Technology, College of Computing and Informatics, Saudi Electronic University, Dammam, 32256, Saudi Arabia*
[i] *Electrical Engineering Department, Faculty of Engineering, Aswan University, 81542, Aswan, Egypt*

A R T I C L E I N F O

Keywords:
Sustainability development
G-11 countries
NPARDL
Environmental quality

A B S T R A C T

This study assessed the impact of gross domestic product (GDP), education, natural resources, remittances, and financial inclusion on carbon emissions in G-11 countries from 1990 to 2021. Based on the negative impact of pollution and the need for sustainable development, this study examined factors affecting CO_2 emissions in G-11 countries using non-linear panel ARDL model. The study found that a positive GDP shock increases CO_2 emissions in the short and long term, while a negative shock decreases emissions in the short term and increases emissions in the long term. Education was found to increase CO_2 emissions in the long term but decrease them in the short term, emphasizing the need for education on combating emissions. Natural resources were also found to increase emissions in the long term, highlighting the need for government-defined institutions to minimize extraction effects and enforce transparency and accountability. Positive changes in personal remittances and financial inclusion were found to increase emissions in both the short and long term, suggesting the need for policies that encourage renewable energy sources and energy efficiency improvement. The study concludes that policymakers should prioritize efficient resource allocation, promote renewable energy usage, and enhance environmental awareness to achieve sustainable development goals in G-11 countries. The possible applications of this study include the use of the models to investigate the asymmetric effects on CO_2 emissions. This model can be applied in future studies to examine the relationship between GDP, education, natural resources, personal remittances, financial inclusion, and CO_2 emissions in other countries.

* Corresponding author. Department of Computer and Information Science, Linköping University, Linköping, Sweden.
E-mail addresses: umrawaris@gmail.com (U. Waris), abdelazim.hussien@liu.se (A.G. Hussien).

https://doi.org/10.1016/j.heliyon.2023.e17133
Received 10 March 2023; Received in revised form 1 June 2023; Accepted 8 June 2023
Available online 10 June 2023
2405-8440/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Policymakers are considering realigning the energy-led pattern of economic expansion in response to the increasing environmental deterioration. This goal unquestionably requires a worldwide policy shift. Some of these policy initiatives might be the key to achieving sustainable growth. In order to realize this dream, the Sustainable Development Goals (SDGs) were created. Action on climate is addressed in SDG 13, one of the 17 Sustainable Development Goals. Goal 13.1 of SDG 13 is to ensure that economies can withstand and adapt to climate change, while goal 13.2 is to improve human capital's quality (target-13.3). Investing in the growth of innovative capability is crucial to accomplishing these two goals. In that lies the rub of actual execution. The current Progress Report of SDG [60] demonstrates that when compared to wealthy economies, emerging and least developed ones fall short of the SDG targets. In 2021, a report about the financing for sustainable development provides one potential explanation for this situation [3].

The two most evident issues that the entire globe is currently confronted with are climate change and environmental pollution [48]. Economies and the wellbeing of humanity are negatively impacted by the increase in the emission of greenhouse gases (GHG). Environmental preservation and energy independence are emphasized as important concerns for both developed and developing countries in the 2030 Sustainable Development Goals [66]. Developing nations need more financial strength to achieve the goals for Sustainable Development. Whiles the objective of 13.an of SDG 13 pledges to help poor nations have access to funds for mitigation efforts, this still needs to be accomplished. At the COP26 summit, officials emphasized the need to keep their pledge to divert $100 billion into developing countries' for their climate resilience program [47]. This controversy in the international sphere has been sparked due to the apparent non-fulfillment of this commitment [75]. It may be challenging for emerging countries to realign their economic development pattern and tackle environmental pollution without financial assistance from the developed world.

The global economy is attempting to address environmental issues such as increasing loss of biodiversity, rising energy and resource demands, and greenhouse gas emissions in the twenty-first century [75]. Population growth is one major cause of the world's high energy consumption, and the sources of this energy are limited and nonrenewable. High energy use and economic expansion rates are to blame for the world's current environmental crisis. The fight against poverty via environmental improvement may be hampered as a result of this circumstance [38]. Most countries have challenges with industrial production and environmental restrictions that need to be addressed in order to accomplish these SDGs. Many countries still rely on fossil fuels for economic development despite international pressure to decrease pollution due to agreements like the Paris Agreement and COP26 [9,72].

The ecosystem has deteriorated over the last half-century due to human's over reliance on fossil fuels. Worldwide use of fossil fuels in 1965 stood at 40,553 TW h, while RE accounted for 2614 TW h. Estimates show a 96% rise in use of fossil fuels since 1965 [16]. Despite environmental safeguards, fossil fuel use remains high worldwide. As a result, rising industrial output is contributing to environmental degradation, which undermines SDG 13's emphasis on combating climate change [21]. For decades, the issue of carbon dioxide emissions has been a major worry on a worldwide scale [36]. Ecological consciousness helps raise standards as the economy grows. To begin with, economies destroy their environments by using natural resources in order to expand economically. People's concern for the environment grows in tandem with their disposable money. As a result, the world has reached a tipping point where strict environmental laws are required. There are several upsides to implementing low-carbon legislation, such as improved environment and more employment opportunities. By improving people's health, it also contributes to social justice. Including renewable energy sources in the overall energy consumption improves efficiency [14]. Improving the quality of the environment also helps sustain species [30]. Since developed nations established environmental sustainability standards, the majority of developing nations now follow them. The fast economic expansion caused by the use of fossil fuels is destroying the environment. A consortium of eleven (G-11) nations is experiencing significant economic growth. Morocco, Georgia, Honduras, Jordan, Indonesia, Sri Lanka, El Salvador, Croatia, Pakistan, and Paraguay are among the 11 developing countries represented in this category. These countries formed the G-11 to reduce debt burdens in the face of increased economic development. These emerging nations rely on nonrenewable energy and lack stringent environmental safeguards. As a result, these countries prioritize economic expansion above environmental damage. The unsustainable use of natural resources is bad for the environment [64]. G-11 nations are struggling with the same problem. Because they continue to depend on nonrenewable energy sources, and they are experiencing increased growth in their energy consumption [49]. This could result in natural resource reduction and a slowdown in the economic growth of the G-11 nations. G-11 countries consumed a lot of natural resources from 1990 to 2020. Their natural resources usage and the gross domestic product have grown exponentially throughout time. It's also crucial to remember that in certain countries, ecological footprints shrink as GDP rises. This fact supports the conclusions of [16]. As they maintained that both positive and negative changes in the availability of natural resources would have diverse climatic effects. The attainment of SDG 7 for cleaner energy and a better climate is difficult for nations. As a result, these nations will need help to achieve SDG 13 on climate action [12]. To reduce pollution, it is crucial to investigate alternative energy sources in this environment. If the SDGs are to be achieved, then all available financial resources and foreign direct investment (FDI) must be used to combat climate change [10]. External investment is required by developing nations for industrial production and environmental sustainability [18]. The hypotheses analyze the link between the Gross Domestic Product, education, natural resources, remittances and financial inclusion, and CO_2 emissions.

The G11 countries were selected because they represent diverse range of economic and social characteristics, including different levels of development, sizes, and regions. This provides a unique opportunity to analyze the interrelationships between economic growth, CO_2 emissions, and energy consumption in a diverse set of countries, which can help policymakers develop more targeted and effective policies to promote sustainable development. Furthermore, a fact is also highlighted that the G11 countries are facing similar challenges related to sustainable development, such as poverty, inequality, and environmental degradation. By analyzing the interrelationships between economic growth, CO_2 emissions, and energy consumption in these countries, the authors aim to provide insights that can help address these challenges and promote sustainable development. Overall, the selection of the G11 countries for this study appears to be driven by the desire to provide a comprehensive and diverse analysis of the interrelationships between economic growth, CO_2 emissions, and energy consumption in the context of sustainable development, and to provide insights that can inform policy-making efforts in these countries. In conclusion, the study provides insights into the interrelationship between various factors and CO_2 emissions in G-11 countries and highlights the importance of sustainable development, policy, and management studies. The findings suggest that policymakers should prioritize enhancing efficiency in resource allocation, encouraging renewable energy solutions, and promoting transparency and accountability in natural resource extraction. This could help to reduce emissions during periods of economic expansion and achieve SDG 7, clean and affordable energy.

This research adds to the current body of knowledge by examining the relationships between the G-11 nations' GDP, education, natural resources, remittances and financial inclusion, and CO_2 emissions. Consequently, it applies the (NPARDL) non-linear panel autoregressive distributed lag method to produce disparate outcomes. This study improves prior studies by using the NPARDL approach to the asymmetric impact of GDP on CO_2 emissions in the G-11 countries, where positive and negative GDP shocks have different effects on the environment. It also employs the Panel EGLS (Cross-section random effects), To improve parameter dependability, totally modified ordinary least squares (FMOLS) and ordinary least squares (DOLS) estimators were developed.

The design of the study is as follows. An overview of recent empirical literature that is relevant to all research variables is presented in Section 2. The approach is described in Section 3 along with a description of the dataset and model. Empirical findings are presented and discussed in section 4. The study and debate linked to the paper are concluded in the last section.

2. Literature review

Various research that focused on the relationship between natural resources, GDP, education, remittances, and financial inclusion are summarized in this section.

2.1. Financial inclusion and GDP

Financial inclusion (FI) is an important measure of financial development since it affects the performance of economic sectors and institutions. Financial development is seen as a complicated and essential component of the growth process [59]. A study of [80] discovered that financial inclusion is expected to affect environmental quality due to its importance in enhancing a nation's economic status. In addition [83], indicated that financial inclusion may assist families in surpassing credit restrictions and enhancing financial stability. This improves the accessibility of finance for SMEs, enabling them make investments that are more profitable. Smaller businesses and families who have better access to credit may spend more, driving up energy demand and carbon emissions [61]. This environmental pollution will reduce environmental quality and sustainability. Financial inclusion may thus have fostering and adverse impacts on climatic quality [59,61,65]. [46] found that financial incorporation decreases carbon dioxide (CO_2) emissions, hence enhancing environmental quality. Proponents of the same perspective claim that decreasing barriers to financial participation reduces the negative environmental impacts of economic expansion and aids in ecosystem restoration [61]. In this context, inclusionary financial mechanisms promote a green, sustainable environment by improving the availability, accessibility, and implementation of eco-friendly strategies to lessen the consequences of global warming and climate change [40]. Financial inclusions (FI) also provide organizations and individuals with simple, low-cost access to beneficial financial programs, enabling them to invest in green infrastructure [42]. However, improved financial access accelerates industrial production processes while increasing CO_2 emissions, resulting in higher atmospheric temperatures and global warming [74]. This is explained by the theory proposed by Ref. [61]; which indicates that an increase in financial inclusion increases the gross fixed capital ratio, hence increasing the demand for energy resources. This link has an adverse effect on the environment's quality as a result of emissions associated with energy production. Contradictory data, however, suggests that financial inclusion affects environmental quality in both good and harmful ways [42,83]. Increasing financial inclusion also enables customers to purchase cars, air conditioners, and refrigerators, examples of energy-intensive devices emitting greenhouse gases (GHGs), which are extremely dangerous for the environment [74]. Financial inclusion also promotes economic growth, increasing the need for dirty energy sources and greenhouse gas emissions. Using the (DCCE) dynamic common correlated effects estimator [59], in a recent research of OECD countries examined the potential impact of financial involvement on environmental quality. The outcomes revealed that financial involvement had adverse short- and long-term effects on environmental quality. While analyzing the variable of education, research indicate that knowledge of climate and environmental education are crucial to any state's efforts to improve environmental quality [26]. There is a great deal of evidence in the scholarly literature that environmental consciousness is essential for energy conservation and improved air quality [49].

2.2. GDP and remittance

The continuous burning of fossil fuels releases toxic levels of carbon dioxide into the atmosphere. Previous studies by Ref. [28] confirmed the EKC and looked into the connection between GDP and pollution. Several studies [25,39,79] looked into the EKC as it relates to climatic quality and GDP. Between 1980 and 2003 [44], analyzed Turkey's energy consumption and carbon dioxide emissions. From 1960 to 2004, the authors of the study analyzed data on CO_2 emissions in the US to see how they varied with GDP and energy consumption. After analyzing the data, they were able to draw conclusions about the relationships between the variables [71]. BRIC also had a correlation between CO_2 emissions and energy consumption [55]. As part of their investigation into the EKC in Ref. [44] used a customized dynamic ARDL. By analyzing the effects of energy consumption and tourism on the model's total load capacity, they were able to confirm the EKC hypothesis using yearly statistics from 1965 to 2017. Due to the detrimental effects of nonrenewable energy sources on the environment, economies around the world have been compelled to adopt RE sources for sustainable long-term growth. Sustainable and non-depletable energy promote environmental sustainability by reducing carbon dioxide emission [35]. Energy consumption and carbon dioxide emissions have been the subject of several studies, but the role of renewable energy in maintaining ecosystems has received much less attention [65,80]. For instance, studies on the effects of energy innovation and renewable energy on climate quality have been conducted on OECD countries [5]. Recent research by Ref. [56] investigated the impact of renewable and nuclear energy in France's overall load capacity along with climatic quality. Cointegration and causality tests were conducted on yearly data from 1977 to 2017. Their findings demonstrated that nuclear energy eliminates air pollution more efficiently and boosts the country's load capacity, supporting the EKC theory. Additionally, Renewable energy has no long-term environmental effects. They advocated for nuclear energy usage in order to increase environmental sustainability. According to several research, RE has minimal impact on climatic quality [50]. It was researched how renewable energy and GDP affect CO_2 emissions [17]. In 27 European nations, the researchers showed relationships between RE and CO_2 emissions. It investigated how US energy sources and CO_2 emissions are related. It has been shown that there is a significant relation between solar energy and CO_2 emissions, as well as those between coal consumption and carbon dioxide emissions, natural gas energy and carbon dioxide emissions, and nuclear energy and CO_2 emissions [51]. The research examined the relationship between emissions of CO_2 and RE in nations in Sub-Saharan Africa, Europe, and MENA. It discovered that renewable energy had a negligible effect on global CO_2 emissions. The links between renewable energy, GDP, CO_2 and nuclear energy were explored in the United States. The evaluated data from 1960 to 2007 discovered no correlation between RE and CO_2 emissions.

2.3. Education

A previous study by Ref. [26] suggested that at a certain level of economic growth, the state of the ecosystem begins to improve as a result of responsible energy consumption due to environmental awareness. This is mostly attributable to greater education, which increases people's knowledge and motivates them to care about their surroundings and the environment. As a consequence of having a greater understanding of their surroundings, individuals are able to utilize energy resources more effectively, hence reducing emissions and preserving environmental quality [70]. Environmental sensitivity may be fostered via education [26]. In this context, educational materials have the ability to influence the use and growth of renewable energy, hence impacting climatic quality [14,80]. Furthermore, [67] explains that education is essential for enhancing environmental quality and consciousness, which pushes legislators to enact effective environmental policies. Education contributes significantly to environmental quality since it educates people about environmental issues and may be useful for achieving long-term objectives [63]. As a result, education, economic development, and climatic know-how are critical to maintaining a healthy ecosystem [26].

2.4. Natural resources and CO_2 emissions

The relationship between natural resources (NR) and environmental quality has been the subject of several research [2,4,53]; and some others took CO_2 emissions [18] as a stand-in for environmental contamination Natural resources reduce environmental pollution, according to some studies [13,53,77]. In contrast, other studies [33,80] discovered that NR cause climate pollution. In Ref. [58]; a new dynamic ARDL technique was proposed, which was then applied to yearly data from China, to determine the effects of human capital, natural resources, load capacity and income characteristics. The study found that the ecology suffered from natural resources consumption. The study advocated for more consumption of renewable resources in China's economic zones. Also, research by Ref. [57]; from 1992 through 2016, looked at yearly statistics for top 10 nations. Using the panel co-integration and the AMG technique, they evaluated the effects of RE, human development, natural resources, and globalization on pollution. Despite the fact that human growth coupled with RE are ecologically viable, they discovered that natural resources taint both. The study promoted the use of RE in those nations in order to maintain a sustainable environment [73]. In Ref. [82]; the authors examined how Chinese energy resources and investments affected climate in 44 African countries. They studied annual data from 1992 to 2018 and found that although Chinese investment enhances environmental quality in African countries, ER contribute to climate contamination. Experts suggested more Chinese investment in African nations in terms of the environment. In the study of [9] on three nations with the largest emissions, the impact of nuclear and alternative energy on CO_2 emissions was studied. They discovered that alternative energy, particularly nuclear energy, is more ecologically benign than traditional energy, but government spending causes CO_2 emissions to rise, using data from 1981 to 2016. Their data supported the EKC hypothesis. They proposed tying government spending to environmental externalities to create a better environment. The influences of natural resources, urban population, FDI, trade, and GDP on China's environmental sustainability were studied [9]. Their research indicates that natural resources are safe for the environment, but that urbanization, trade, and economic growth exacerbate environmental harm. They stressed the need to understand the governmental structure in terms of natural resource policy. A study by Ref. [31]; investigated the significance of RE and NR in promoting climatic sustainability [72]. They discovered that, whereas natural resources boost economic progress, RE hampers it after analyzing data from 1990 to 2016. Moreover, natural resources are detrimental to the ecosystem.

The authors of [31] examined the relationship between Pakistan's NR, GDP, human capital, and urbanization. Annual data from 1980 to 2018 was examined using various ARDL types. The test of robustness and ARDL methodologies shows Pakistan's natural resources, GDP and human capital, were wreaking havoc on the nation's climate. According to the results, urbanization should be kept to a minimum to ensure environmental sustainability. In Ref. [24] total rents are frequently substituted for the availability of natural resources in studies that either focus on or benefit from the notion of the "natural resource curse." Additionally, most empirical research published in journals employ conventional prediction techniques. The panel quantile regression with fixed effects method was used in this study to examine the link between financial development and four natural resource rents (oil rents, coal rents, forest rents, and natural gas rents) using data from a group of industrialized nations. Their research demonstrated how rents from natural gas, coal, wood, and oil contribute to economic growth, further demonstrating how fortunate industrialized nations are to have access to such a variety of resources. To do a thorough inspection, the Canay two-step procedure was also employed. The findings corroborate the key principles even though forest rents have a greater impact on economic growth than the other three proxies [23]. utilized the unique hybrid nonparametric quantile causality approach, their work attempted to add to the modest but expanding corpus of research on nonlinear causation. For seventeen African nations, the study took into the nonlinear relationship between total factor production, energy use, and carbon emissions. The results showed strong causal relationships between variables in the middle quantiles (those between the lowest and highest). Thus, total factor output, environmental degradation, and energy consumption are all related in African nations. The examples of Angola, Benin, Botswana, Cote d'Ivoire, Egypt, Nigeria, Tunisia, Kenya, and Morocco in particular demonstrate the connection between total factor output and energy consumption. Nearly all nations studied showed a bidirectional causal ordering when studying the association between median total factor output and emissions. Significant bidirectional ordering exists between the two variables in Angola, Benin, Cote d'Ivoire, Cameroon, Kenya, Morocco, Egypt, Mozambique, Nigeria, Senegal, and Tunisia, among other countries. This has to do with the relationship between energy use and carbon emissions. It is obvious that these countries must make significant economic growth investments, and that doing so necessitates a plethora of new legislations to address issues like energy usage and pollution.

According to the available literature, the aforementioned studies are yet to look at how different NR affect climate in the G-11 nations. This research adds to the flood of literature by examining the nonlinear effects of natural resources on climate. Growing urbanization and various industrial process expansions have led to increased natural resource (NR) waste, resulting in significant environmental harm [12]. The main causes of GHG emissions that have a negative impact on climate and atmosphere are human activities, which include burning biomass and fossil fuels [29]. Furthermore [81], looked at factors contributing to the consumption of NR, trade liberalization and use of fossil fuels have a substantial adverse effect on the environment, but renewable energy sources have the opposite impact. According to Ref. [6]; NR includes all energy sources used by humans, whether renewable and nonrenewable, which increases greenhouse emissions. Natural resource depletion has a variety of negative effects on the environment, including decreased air quality in industrialized and developing nations. According to proponents of this idea, reckless use of NR, which has a harmful impact on climatic standards, is the cause of all environmental concerns, including ozone (O_3) layer depletion, climate change, and growing climatic destruction [54]. Additionally, the advancement of technology has accelerated deforestation, a serious danger to air quality [9,56,68,69]. The rapid speed of development worsens GHG emissions by increasing CO_2 releases into the atmosphere. These GHGs deplete the NR and have a negative effect on the ecosystem.

According to Ref. [37]; the link between energy usage and environmental degradation was inversely proportional to the utilization of natural resources. In the OECD, it was however, found that this connection favored renewable energy sources over nonrenewable one [37,56]. Similarly [52], examined the pattern of resource use in a number of areas and documented the link between resource depletion and environmental deterioration. According to the authors, as a result of their desire for a greater quality of life, people in developed regions had a larger consumption demand than was necessary for a minimum reasonable existence. In order to satisfy their desires, people all around the globe deplete natural resources, which harm the ecosystem. On the other hand, due to their simpler lifestyles, people in developing nations have fewer resource consumption demands, but the lack of awareness and increasing population have led to irresponsible NR use, which degrades environmental quality [8]. Consequently, industrialized and developing nations share equal responsibility for the depletion of natural resources and population growth, both of which contribute to environmental degradation [22]. In the study of [76] the authors analyzed the yearly data from 2000 to 2017 to investigate the relationship between energy transition, economic development, CO_2 emissions, and information and communications technology (ICT) in the BRICS nations using a novel GMM-PVAR approach. Their study demonstrated that energy transition is significantly and favorably impacted by carbon emissions, and that demand for the energy transition increases in line with economic growth. It is obvious that ICT can aid in accelerating the energy transition and addressing environmental issues.

3. Methodology

3.1. Data

From 1990 through to 2020, this study analyses the annual data for the countries of the G-11 i.e., Pakistan, Honduras, Croatia, Paraguay, Indonesia, Sri Lanka, Jordan, El Salvador, Morocco, and Georgia. A fair panel displays the empirical, natural resources,

Table 1
List of indicators.

Variables identifiers	Study variables	Units of tools	Sources
CO_2	Carbon Emissions	kt	WDI
GDP	Gross Domestic Product	constant 2015 US$	WDI
ED	Education	School enrollment, secondary (% gross)	WDI
NR	Natural Resources	Total Natural Resources rents (% of GDP)	WDI
RE	Remittance	Personal Remittances received (current US$)	WDI
FI	Financial Inclusion	Domestic credit to the private sector by banks (% of GDP)	WDI

education, and remittances on CO_2 emissions. The information is obtained from data indicator data from the World Bank. Table 1 displays the variables, descriptions, and sources.

3.2. Model

According to literature study, several findings have examined the correlation between GDP and CO_2 emissions. This study, unlike previous ones, examines the unequal impact of GDP on CO_2 emissions. Despite the fact that fast economic development adds to pollution, CO_2 management becomes essential as public concern for the environment grows. Various economies are experiencing various changes, and the ethics of using natural resources are being questioned. From 1990 to 2021, this was the norm for the majority of G-11 nations.

3.3. Non-linear panel autoregressive distributed lag (NPARDL)

Using the non-linear panel autoregressive distributed lag model established by Ref. [62]; this study investigates the asymmetric influences of CO_2 on GDP. This approach has various pros in terms of delivering trustworthy results. It is a suitable method for enormous T panels [34]. Also, this technique generates nonlinear interactions between variables. It uses the heterogeneity of the data, and finally, the technique is compatible with data whose sequence of integration is inconsistent. Estimation of panel data may be performed using the pool means group (PMG) and mean group (MG) procedures. This study employs the PMG methodology. This method determines independent variables' short- and long-term impacts on dependent variables. Hence, the asymmetric equation of this study is given as Eq. (1):

$$\Delta ln\ CO2_{it} = \beta_i + \beta_i ln\ CO2_{i,t-1} + \beta_i lnGDP^{-}_{it} + \beta_i lnGDP^{+}_{it} + \beta_i ln\ ED_{it} + \beta_i ln\ NR_{it} + \beta_i ln\ RE_{it} + \beta_i ln\ FI_{it} + \sum_{n=1}^{pi-1} \partial_n \Delta ln\ CO2_{i,t-n}$$
$$+ \sum_{o=0}^{qi} \delta_o \Delta lnGDP^{-}_{t-o} + \sum_{p=1}^{q2} \varphi_p \Delta lnGDP^{+}_{t-p} + \sum_{r=1}^{q3} \mu_r \Delta ln\ ED_{t-r} + \sum_{s=1}^{q4} \varnothing_r \Delta ln\ NR_{t-s} + \sum_{u=1}^{q5} £_u \Delta ln\ RE_{t-u} + \sum_{j=1}^{q6} \rho_j \Delta ln\ FI_{t-j} + \varepsilon_t. \quad (1)$$

where, CO_2, ED, NR, RE, FI represents carbon emissions, education, natural resources, remittance, and financial inclusion respectively. Gross Domestic Product are taken as indicated in **Eq. (2)**:

$$lnGDP_T = Ln\ GDP^{+}_t + Ln\ GDP^{-}_t \quad (2)$$

With **Eq. (3)** and **Eq. (4)** explaining the various terms of **Eq. (2)**.

$$Ln\ GDP^{-}_t = \sum_{i-1}^{t} \Delta lnGDP^{-}_i = \sum_{i-1}^{t} \min\left(\Delta lnGDP^{-}_i, 0\right) \quad (3)$$

$$Ln\ GDP^{+}_t = \sum_{i-1}^{t} \Delta lnGDP^{+}_i = \sum_{i-1}^{t} \max\left(\Delta lnGDP^{+}_i, 0\right) \quad (4)$$

Δ shows the first difference operator, ε_t is the error term. β_i shows the coefficient values. After the testing for co-integration, the next test is to determine the short and long-run coefficient values.

4. Results and discussion

In general, it is assumed that the absence of CD is necessary for the outcomes to be consistent and reliable. Table 2 indicates a strong interdependency among the countries provided by Pesaran CD outputs. All indicators are pointing in the direction of the CD. This outcome is consistent with recent investigations by Refs. [45,72]. This may be due to similar socioeconomic trends.

The test in Table 3 demonstrates no homogeneity among the panel of G-11 countries. The dataset's prevalence of these problems necessitates using additional stationarity assumptions.

The stationarity of the variables considered need to be established for cointegration analysis. The indices CO_2, ED, NR, RE, and FI are stationary in Table 4 at their current levels, while GDP is stationary at the first difference. The cointegration in the G-11 countries is

Table 2
Tends of Cross-sectional dependence analysis.

Variables	Pesaran-CD Test	*P*-value
$ln\ CO_{2t}$	23.80673	0.000
$lnGDP_t$	36.41488	0.000
$lnED_t$	21.44165	0.000
$lnNR_t$	8.223781	0.000
$lnRE_t$	25.18907	0.000
$lnFI_t$	12.16839	0.000

Table 3
Specification tests of hsiao (1986).

	Hsiao Test
F-Statistics	2588.212
P-Value	0.000

Table 4
Tend of ADF unit root test.

Variables	Unite root at I (0)	Unite root at I (1)
$ln\ CO_{2t}$	−6.461[a]	–
$lnGDP_t$	−1.196	−8.405[a]
$lnED_t$	2.563[b]	–
$lnNR_t$	−2.477[a]	–
$lnRE_t$	−5.430[a]	–
$lnFI_t$	−3.376[a]	–

Note: *P*-values are enclosed in parentheses.
[a] → p-value <1% of Significance Level.
[b] → p-value <5% of Significance Level.

revealed by the ADF (LLP) unit root test, which implies mixed integration.

It is noticeable that the cointegration method's evidence is relevant to both heterogeneity and CD. The Westerlund bootstrap approach [41] is used to verify the long-run equilibrium relationship. It can arrive at reliable conclusions by minimizing the effects of the CSD's bias. From Table 5 second-generation panel cointegration approach, we find that Ga, Pt, and Pa are statistically insignificant, whereas Gt is significant at the 5% level, proving the cointegration evidence's validity and ultimately advancing toward it.

The G-11 countries' single environmental challenge is CO_2 emissions, and with this, these parameters must consider GDP, ED, NR, RE, and FI in both the long and short term. Internal socioeconomic policies require time to become sustainable, but once they do, they can eventually achieve equivalent environmental goals using these estimations. As a result, the NPARDL model meets this requirement by providing both positive and negative short- and long-run parameter estimates. Furthermore, the method considers the heterogeneity of the data before generating reliable results.

Table 6 elucidates the impact of GDP on CO_2 emissions, implying that positive and negative GDP have highly significant consequences from 2004 to 2020. The GDP positive shock explains that a 1% unit increase in GDP will increase the CO_2 emission by 0.65%, and negative shock in GDP depicts that if there is a 1% decrease in GDP, CO_2 emission will be increased by 1.58%. In the short run, a positive impact to GDP raises CO_2 emissions by 0.3%, whereas a negative shock indicates a decrease in CO_2 emissions by 0.8% in G-11 economies. This result is in line with the following studies [21,56,73]. The relationship between GDP and CO_2 emissions is statistically supported at the highest level of significance, and GDP increases the emission of CO_2 according to Ref. [19]. The aforementioned study suggests that a higher income significantly reduces CO_2, such as [7] for fourteen Asian countries [27], for underdeveloped nations, and [2] for ten MENA countries.

Following that, long-term education outcomes indicated that a 0.1% increase in CO_2 occurs from a 1% expansion in education, revealing that G-11 countries' education increases CO_2. In the short run, the coefficient of education demonstrated that a 0.02% reduction in CO_2 emissions is linked with a 1% rise in education. For the given era, the short- and long-term periods exhibit statistically insignificant associations with CO_2 emissions. Previous research findings are consistent with one another and show that education increases CO_2, according to Ref. [45] furthermore [2] for China nation. Education appears to play a vital role in reducing energy consumption and carbon emissions, ultimately increasing the G-11 environmental quality. The negative relationship between education and CO_2 is valid even in the short run. As education is intended to be associated with environmentalism, the negative effect of education on CO_2 is more comprehensible [14].

Natural resources have distinct effects, with a 1% boost in natural resources resulting in a statistically significant rise in CO_2 emissions of 0.02% in the long run. On the other hand, the short-run coefficient demonstrated that a statistically insignificant 1% positive change in natural resources enhanced CO_2. These findings indicated that any governmental action or economic implications that increased reliance on natural resources resulted in a significant increase (0.02%) in CO_2. According to Higón, Gholami, and [32] for China and [35] for Pakistan, natural resources increase CO_2 over time. As a result, policies to protect the environment and limit

Table 5
Westerlund ECM panel cointegration tests.

Statistics	Value	Z-value	*P*-value	Robust *P*-value
Gt	−3.248	−2.096	0.018	0.00
Ga	−3.406	4.655	1.00	0.38
Pt	−4.349	3.258	0.999	0.62
Pa	−3.295	3.192	0.999	0.24

Table 6
Tends to estimate NPARDL.

Parameters	Coefficient	t-Statistic
Long-run outcomes		
$lnGDP\_pos_t$	0.658	7.357[a]
$lnGDP\_neg_t$	−1.588	−5.784[a]
$lnED_t$	0.110	0.884
$lnNR_t$	0.022	2.332[b]
$lnRE_t$	0.389	1.692[c]
$lnFI_t$	0.351	6.045[a]
Short-run outcomes		
C	1.204	2.455[a]
$\Delta lnGDP\_pos_t$	0.316	1.677[a]
$\Delta lnGDP\_neg_t$	0.870	3.001[a]
$\Delta lnED_t$	−0.027	−0.235
$\Delta lnNR_t$	0.021	1.005
$\Delta lnRE_t$	0.247	0.506
$\Delta lnFI_t$	0.068	1.661[C]
ECT_{t-1}	−0.213	−2.935[a]

Note: *P*-values are enclosed in parentheses.
[a] → p-value <1% of Significance Level.
[b] → p-value <5% of Significance Level.
[c] → p-value <10% of Significance Level.

natural resource mining are needed to reduce environmental degradation. The above positive link highlights that the G-11 economies rely heavily on natural resource exploitation, particularly oil, mining, and gases, to meet their energy needs. This pollutant natural resource contributes to increased environmental contamination in the G-11 region. This is because G-11 nations prioritize boosting economic growth to alleviate poverty, and climate concerns are considered secondary in the continent.

The effect of remittance on CO_2 means that a change in remittance raises CO_2 emissions by 0.3% in the long run and statistically insignificantly increases emissions of CO_2 in the short run. These findings are aligned with the results of [1] for [2] for BRICS, and [78] on a worldwide scale. The latest findings are reasonable since remittances improve people's income and give them additional choices for increasing their expenditures. Furthermore, rising remittances contribute to increased business activity, increasing emissions. As a result, appropriate rules governing remittances are required to reduce CO_2 emissions in the G-11 countries.

Lastly, the financial inclusion outcome in Table 6 elucidates that 0.35% CO_2 is enhanced with a positive change of financial inclusion in the long term, and 0.06% CO_2 is increased with a 1% positive impact on financial inclusion in the short run. These statistical outcomes relate to the findings of [81] for OECD [20], for OIC nations, and [43] for Asia. Financial constraints, according to Ref. [15]; impede the growth of a sustainable and green sector. As a result, financial inclusion encourages developing green technologies and using green energy, reducing CO_2. In the scenario of any short-run deviation, the negative value 0.21% of ECT_{t-1}, indicating long-term conversion to a stable equilibrium, persuades the model's stability.

In this study, various econometric methods were used to test the robustness of the results. Table 7 presents a summary of the findings obtained from the use of EGLS with random effects, FMOLS, and DOLS estimators. The results of the Hausman test suggest that the random effects approach is the most suitable for the analysis of the given framework. Additionally, the results of the alternative estimators provide further support for the findings of the study, indicating that the variables of GDP and education have a positive impact on CO_2 emissions, while natural resources and financial inclusion have a negative effect on CO_2 emissions. Furthermore, the use of DOLS showed that GDP has an adverse effect on CO_2 emissions, which is consistent with the long-term findings of NPARDL. In contrast, the short-term results obtained from the analysis of remittances using NPARDL show that it is highly insignificant in explaining CO_2 emissions during the given period of the study. These findings suggest that the impact of remittances on CO_2 emissions may be limited to the short term.

Overall, the results of this study provide insights into the factors that contribute to CO_2 emissions and suggest that policies targeting education, natural resources, and financial inclusion may be effective in reducing CO2 emissions, while those targeting GDP may have

Table 7
Robustness check.

Variables	FMOLS	DOLS	EGLS
$lnGDP\_pos_t$	0.741[a]	0.745[a]	0.654[a]
$lnGDP\_neg_t$	0.299	−0.716	1.041[a]
$lnED_t$	0.491[a]	0.295[c]	0.698[a]
$lnNR_t$	−0.031	−0.066[c]	−0.053[a]
$lnRE_t$	0.160	0.343	0.174
$lnFI_t$	−0.050	0.144[c]	−0.012

Note: a, b & c explain the significance level at 1%, 5%, and 10%, respectively.

adverse effects on the environment in the long term. The use of different econometric methods also highlights the importance of testing the robustness of results to ensure the validity of the findings.

4.1. Implications for policy makers, researchers, investors, and the public in general

The empirical analysis provides valuable insights into the relationship between various factors and CO_2 emissions, it is important to provide intuitive explanations and practical implications for various stakeholders. For policymakers, the study highlights the need to prioritize efficiency in resource allocation and adopt instruments that guide consumers towards renewable energies. The findings also suggest the importance of identifying the factors that directly impact climate change and global warming and the need for improved pollutant emissions and waste management. Additionally, policymakers must set the right policies to reduce emissions during periods of economic expansion and demonstrate that higher income levels lead to a greater demand for ecological sustainability. The study also recommends imposing carbon taxes and expanding financial access to finance renewable energy solutions. For researchers, the study provides a useful empirical framework for analyzing the factors that affect CO_2 emissions. It also highlights the need for further research into the relationship between education and CO_2 emissions and the impact of personal remittances on ecological degradation. For investors, the study emphasizes the importance of investing in companies that prioritize ecological sustainability and reduce non-renewable energy use. It also highlights the potential for financial institutions to lend to companies based on their ecological footprint, encouraging cleaner companies, and reducing emissions. The study emphasizes the importance of environmental awareness and the negative consequences of non-renewable energy use for the general public. It highlights the need for education programs that raise awareness of these issues and promote the generation and development of renewable energy solutions. Overall, the study provides practical implications for policymakers, researchers, investors, and the public in general, emphasizing the need for a comprehensive approach to reduce CO_2 emissions and achieve sustainable development goals.

5. Conclusions and policy framework

This study utilizes the non-linear panel ARDL model to investigate the asymmetric effects on CO_2 emissions. In response to the global concerns surrounding pollution and its detrimental effects on the environment, several international meetings have been held to propose solutions that can alleviate environmental problems and achieve sustainable development goals. The focus of this study is to contribute to these efforts by assessing the various factors that influence CO_2 emissions in G-11 countries. To investigate the asymmetric effects on CO_2 emissions, this study employs the non-linear panel ARDL model. This model is an advanced econometric technique that is capable of examining the long-run relationship between variables while accounting for short-run dynamics and the presence of asymmetry. This model allows for a more comprehensive analysis of the factors that influence CO_2 emissions in G-11 countries, which can help identify the most effective policy interventions.

The study found that a positive shock to GDP increases CO_2 emissions in both the short and long run. In contrast, a negative shock to GDP leads to an increase in CO_2 emissions in the long run, but a decrease in CO_2 emissions in the short run. These findings are statistically significant at the highest level. Based on these results, the study recommends that the governments of G-11 countries prioritize improving resource allocation efficiency and adopt policies that encourage the use of renewable energies. Policymakers must also be aware of the factors that directly impact climate change and global warming, and improve pollutant emissions and waste management. The study emphasizes the need for policymakers to implement appropriate policies during economic expansions to reduce emissions, and to demonstrate that higher income levels are associated with greater demand for ecological sustainability.

The findings of this study have significant policy implications, as they highlight the need for policies that strike a balance between economic growth and environmental sustainability. Policymakers must develop and implement policies that encourage the efficient use of resources, the adoption of renewable energies, and the reduction of CO_2 emissions during economic expansions. These policies must also address the long-term effects of climate change and global warming, and take into account the factors that directly impact these phenomena. By prioritizing sustainability and taking appropriate action, policymakers can contribute to achieving sustainable development goals and mitigating the negative effects of climate change.

The findings suggest that education can increase CO_2 emissions in the long run but decrease them in the short run. Therefore, policymakers should prioritize providing adequate education to develop the capability of combating CO_2 emissions. To generate tax revenues for this initiative, policymakers can create an operational policy framework. The proceeds generated from this framework can be used to develop the educational structure in these countries. Additionally, policymakers should consider transforming the educational program so that learners can be aware of the negative environmental consequences of non-renewable energy use. The development of renewable energy can also be included in the curriculum. At the grassroots level, policymakers can spread environmental awareness and encourage the adoption of eco-friendly behaviors. By educating individuals about the negative impacts of non-renewable energy use, policymakers can create a culture of sustainability that will benefit the environment in the long run.

The analysis also reveals that natural resources increase CO_2 emissions in the long run. Mining of natural resources and fossil fuels degrades the quality of the environment for economic gains, but it has negative environmental consequences. The government should play a role in minimizing these extraction effects on the environment and ensure sustainable natural resources extraction. One policy tool that governments can use is a carbon tax limit on fossil fuels consumption. This would encourage industries to move towards cleaner energy sources and reduce their carbon footprint. Government establishments must also ensure transparency and accountability to prevent resource exploitation and ensure that natural resources are replaced with renewable energy sources. Public awareness and consciousness to conserve natural resources is vital for the G-11 countries, and the government should enhance it through education and awareness campaigns. This is important to ensure that people understand the impact of their actions on the environment and are motivated to take actions to protect it.

Any positive change in personal remittances increases CO_2 emissions, as an increase in consumption of goods and services leads to an increase in energy demand. Personal remittances promote economic growth, which could further exacerbate environmental degradation if renewable energy solutions are not effectively implemented. The policymakers must take a holistic approach to balance economic growth and environmental protection. This requires the implementation of effective renewable energy solutions and energy efficiency measures. Policymakers can incentivize the use of renewable energy, reduce energy consumption, and promote energy-efficient technologies to achieve this goal.

This study explores the correlation between financial inclusion and CO_2 emissions, revealing that any positive change in financial inclusion results in a corresponding increase in CO_2 emissions both in the short and long term. The increased access to credit and financial resources spurs industrialization and growth, and the ensuing industrial sectors rely heavily on fossil fuels, leading to environmental pollution and degradation. Policymakers must, therefore, incorporate renewable energy solutions in their policy framework to mitigate the negative environmental effects of industrialization.

It is suggested to prioritize financing of renewable energy solutions to reduce non-renewable energy use in industrial sectors, such as lending to industries based on their ecological footprint. By doing so, the authors argue, policymakers can encourage cleaner companies and reduce non-renewable energy use, thus contributing to sustainable development. In addition, tax revenue from polluting companies can be utilized to subsidize domestic solutions, further promoting renewable energy adoption. It is also asserted that financial inclusion may foster renewable energy adoption in countries, contributing to the achievement of the Sustainable Development Goals (SDGs). The expansion of financial access can provide individuals and businesses with the necessary resources to invest in renewable energy solutions, thereby reducing emissions and promoting sustainable development.

The conclusion is that policymakers must adopt a comprehensive approach to balance financial inclusion and environmental protection, incorporating effective renewable energy solutions and energy efficiency measures. By promoting financial inclusion and renewable energy adoption, policymakers can contribute to sustainable development, enhance economic growth, and achieve global goals such as SDG 7.

5.1. Pointing out the problems

The study discusses the negative impact of CO_2 emissions and proposes policy recommendations to reduce them. However, the study focuses on G-11 countries, but it is still being determined whether the findings and recommendations can be applied to other countries or regions. The study employs a non-linear panel ARDL model to investigate the asymmetric effects on CO_2 emissions. However, whether other research methods could produce different or more accurate results is still being determined. Additionally, further research may be needed to fully understand the complex relationships between various factors and CO_2 emissions. While the study proposes various policy recommendations, it needs to address the challenges of implementing these policies. For example, how will policymakers ensure that financial institutions lend to cleaner companies or taxpayers accept to pay carbon taxes? The study primarily focuses on economic factors that contribute to CO_2 emissions, but it does not consider social factors such as cultural attitudes towards the environment, consumer behavior, or public opinion. These factors may play an important role in the success or failure of policies aimed at reducing emissions. Climate change is a global issue, and addressing it requires international cooperation. However, it needs to discuss how countries can work together to reduce emissions or whether there are any barriers to international cooperation in this area.

Furthermore, despite the rigorous nature of the approach adopted in this study, there are some limitations that can be addressed with additional research. For example, different climatic factors are not included as exogenous variables that directly impact CO_2 emissions. Future research can compare the effects of climate and socioeconomic factors on CO_2 emissions and make policy recommendations based on the parameters that significantly impact CO_2 emissions.

Author contribution statement

Syed Qasim Ali Shah; Umra Waris; Sheraz Ahmed: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Mustafa Kamal: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Masood ur Rehman: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Ephraim Bonah Agyekum; Abdelazim G. Hussien; Salah Kamel: Analyzed and interpreted the data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

References

[1] Manzoor Ahmad, et al., Does the inflow of remittances cause environmental degradation? Empirical evidence from China, Econ. Res.-Ekonomska Istraživanja 32 (1) (2019) 2099–2121.
[2] Zahoor Ahmed, Muhammad Mansoor Asghar, Muhammad Nasir Malik, Kishwar Nawaz, Moving towards a sustainable environment: the dynamic linkage between natural resources, human capital, urbanization, economic growth, and ecological footprint in China, Resour. Pol. 67 (2020), 101677.
[3] Anas S. Alamoush, Fabio Ballini, I Ölçer Aykut, Revisiting port sustainability as a foundation for the implementation of the united nations sustainable development goals (UN SDGs), J. Shipp. Trade 6 (1) (2021) 1–40.
[4] Rafael Alvarado, et al., Ecological footprint, economic complexity and natural resources rents in Latin America: empirical evidence using quantile regressions, J. Clean. Prod. 318 (2021), 128585.
[5] Álvarez-Herránz Agustín, Balsalobre Daniel, José María Cantos, Muhammad Shahbaz, Energy innovations-GHG emissions nexus: fresh empirical evidence from OECD countries, Energy Pol. 101 (2017) 90–100.
[6] Hamid Amirnejad, Amir Mehrjo, Yuzbashkandi Saeid Satari, Economic growth and air quality influences on energy sources depletion, forest sources and health in MENA, Environ. Chall. 2 (2021), 100011.
[7] Nicholas Apergis, Ilhan Ozturk, Testing environmental kuznets curve hypothesis in asian countries, Ecol. Indicat. 52 (2015) 16–22.
[8] Mojtaba Ardestani, Majid Shafie-Pour, Environmentally compatible energy resource production—consumption pattern (case study: Iran), Environ. Dev. Sustain. 11 (2009) 277–291.
[9] Hafiz Muhammad Arslan, et al., Understanding the dynamics of natural resources rents, environmental sustainability, and sustainable economic growth: new insights from China, Environ. Sci. Pollut. Control Ser. 29 (39) (2022) 58746–58761.
[10] Viktoria Aust, Ana Isabel Morais, Inês Pinto, How does foreign direct investment contribute to sustainable development goals? Evidence from african countries, J. Clean. Prod. 245 (2020), 118823.
[12] Ramez Abubakr Badeeb, Hooi Hooi Lean, Muhammad Shahbaz, Are too many natural resources to blame for the shape of the environmental kuznets curve in resource-based economies? Resour. Pol. 68 (2020), 101694.
[13] Daniel Balsalobre-Lorente, Muhammad Shahbaz, David Roubaud, Sahbi Farhani, How economic growth, renewable electricity and natural resources contribute to CO2 emissions? Energy Pol. 113 (2018) 356–367.
[14] Sadia Bano, et al., Identifying the impacts of human capital on carbon emissions in Pakistan, J. Clean. Prod. 183 (2018) 1082–1092.
[15] Bob Baulch, Thuy Duong Do, Thai-Ha Le, Solar Home Systems in Ho Chi Minh City: A Promising Technology Whose Time Has Not yet Come, 2015.
[16] Abdullah Emre Caglar, Ersin Yavuz, Mehmet Mert, Emre Kilic, The ecological footprint facing asymmetric natural resources challenges: evidence from the USA, Environ. Sci. Pollut. Control Ser. (2022) 1–14.
[17] Ebru Çağlayan, Burak Güriş, Energy consumption and CO2 emissions: a threshold error correction and threshold granger causality analysis, Energy Explor. Exploit. 31 (1) (2013) 109–118.
[18] Rodrigo Caiado, Goyannes Gusmão, et al., A literature-based review on potentials and constraints in the implementation of the sustainable development goals, J. Clean. Prod. 198 (2018) 1276–1288.
[19] Jenny Cederborg, Sara Snöbohm, Is There a Relationship between Economic Growth and Carbon Dioxide Emissions?, 2016.
[20] Imran Sharif Chaudhry, Zulkornain Yusop, Muzafar Shah Habibullah, Financial inclusion-environmental degradation nexus in OIC countries: new evidence from environmental kuznets curve using DCCE approach, Environ. Sci. Pollut. Control Ser. 29 (4) (2022) 5360–5377.
[21] Fengsheng Chien, et al., The role of information and communication technology in encountering environmental degradation: proposing an SDG framework for the BRICS countries, Technol. Soc. 65 (2021), 101587.
[22] X.D. Diao, S.X. Zeng, Chi Ming Tam, Vivian W.Y. Tam, EKC analysis for studying economic growth and environmental quality: a case study in China, J. Clean. Prod. 17 (5) (2009) 541–548.
[23] Eyup Dogan, Buket Altinoz, Panayiotis Tzeremes, The analysis of 'financial resource Curse'Hypothesis for developed countries: evidence from asymmetric effects with quantile regression, Resour. Pol. 68 (2020), 101773.
[24] Eyup Dogan, Muhammad Zubair Chishti, Nooshin Karimi Alavijeh, Panayiotis Tzeremes, The roles of technology and kyoto protocol in energy transition towards COP26 targets: evidence from the novel GMM-PVAR approach for G-7 countries, Technol. Forecast. Soc. Change 181 (2022), 121756.
[25] Seyfettin Erdoğan, Demircan Çakar Nigar, Recep Ulucak, Yacouba Kassouri, The role of natural resources abundance and dependence in achieving environmental sustainability: evidence from resource-based economies, Sustain. Dev. 29 (1) (2021) 143–154.
[26] Faize, Fayyaz Ahmad, Mubeen Akhtar, Addressing environmental knowledge and environmental attitude in undergraduate students through scientific argumentation, J. Clean. Prod. 252 (2020), 119928.
[27] Sahbi Farhani, Sana Mrizak, Anissa Chaibi, Christophe Rault, The environmental kuznets curve and sustainability: a panel data analysis, Energy Pol. 71 (2014) 189–198.
[28] Gene M. Grossman, Alan B. Krueger, Economic growth and the environment, Q. J. Econ. 110 (2) (1995) 353–377.
[29] Babagana Gutti, M Aji Mohammed, Garba Magaji, Environmental impact of natural resources exploitation in Nigeria and the way forward, J. Appl. Technol. Environ. Sanit. 2 (2) (2012) 95–102.
[30] Andy Haines, Carlos Dora, How the low carbon economy can improve health, BMJ 344 (2012).
[31] Syed Tauseef Hassan, Bushra Batool, Bangzhu Zhu, Irfan Khan, Environmental complexity of globalization, education, and income inequalities: new insights of energy poverty, J. Clean. Prod. 340 (2022), 130735.
[32] Dolores Añón Higón, Roya Gholami, Farid Shirazi, ICT and environmental sustainability: a global perspective, Telematics Inf. 34 (4) (2017) 85–95.
[33] Yongming Huang, Lian Xue, Zeeshan Khan, What abates carbon emissions in China: examining the impact of renewable energy and green investment, Sustain. Dev. 29 (5) (2021) 823–834.
[34] Javed Iqbal, Misbah Nosheen, Exploring the asymmetries between trade and consumption-based carbon emissions: evidence from NPARDL approach, Environ. Sci. Pollut. Control Ser. 28 (2021) 41780–41793.
[35] Shahid Iqbal, et al., Exploring the asymmetric effects of renewable energy production, natural resources, and economic progress on CO2 emissions: fresh evidence from Pakistan, Environ. Sci. Pollut. Control Ser. 29 (5) (2022) 7067–7078.
[36] Cem Işik, Evangelia Kasımatı, Serdar Ongan, Analyzing the causalities between economic growth, financial development, international trade, tourism expenditure and/on the CO2 emissions in Greece, Energy Sources B Energy Econ. Plann. 12 (7) (2017) 665–673.
[37] Mehdi Ben Jebli, Slim Ben Youssef, Ilhan Ozturk, Testing environmental kuznets curve hypothesis: the role of renewable and non-renewable energy consumption and trade in OECD countries, Ecol. Indicat. 60 (2016) 824–831.
[38] Irfan Khan, et al., A study of trilemma energy balance, clean energy transitions, and economic expansion in the midst of environmental sustainability: new insights from three trilemma leadership, Energy 248 (2022), 123619.
[39] Shoukat Iqbal Khattak, Manzoor Ahmad, Ullah Khan Zia, Anwar Khan, Exploring the impact of innovation, renewable energy consumption, and income on CO2 emissions: new evidence from the BRICS economies, Environ. Sci. Pollut. Control Ser. 27 (12) (2020) 13866–13881.
[40] Dai-Won Kim, Yu Jung-Suk, M Kabir Hassan, Financial inclusion and economic growth in OIC countries, Res. Int. Bus. Finance 43 (2018) 1–14.

[41] Jeroen J.M. Kremers, Neil R. Ericsson, Juan J. Dolado, The power of cointegration tests, Oxf. Bull. Econ. Stat. 54 (3) (1992) 325–348.

[42] Thai-Ha Le, Anh Tu Chuc, Farhad Taghizadeh-Hesary, Financial inclusion and its impact on financial efficiency and sustainability: empirical evidence from asia, Borsa Istanb. Rev. 19 (4) (2019) 310–322.

[43] Thai-ha Le, Le Ha-chi, Farhad Taghizadeh-hesary, Does financial inclusion impact CO 2 emissions ? Evidence from asia, Finance Res. Lett. 34 (2020), 101451.

[44] Wietze Lise, Decomposition of CO2 emissions over 1980–2003 in Turkey, Energy Pol. 34 (14) (2006) 1841–1852.

[45] Haiying Liu, et al., Moving toward sustainable development of sub-saharan african countries: investigating the effect of financial inclusion on environmental quality, Sustain. Dev. 30 (6) (2022) 2015–2024.

[46] Nan Liu, Cencen Hong, Tayyab Sohail Muhammad, Does financial inclusion and education limit CO2 emissions in China? A new perspective, Environ. Sci. Pollut. Control Ser. (2022) 1–8.

[47] Alan Matthews, Are the COP26 climate change negotiations ready to embrace agriculture? EuroChoices 20 (2) (2021) 4–10.

[48] R.B. Mbe, Met Office: Atmospheric CO2 Now Hitting 50% Higher than Pre-industrial Levels, 2021.

[49] Usman Mehmood, Contribution of renewable energy towards environmental quality: the role of education to achieve sustainable development goals in G11 countries, Renew. Energy 178 (2021) 600–607.

[50] Angeliki N. Menegaki, Growth and renewable energy in Europe: a random effect model with evidence for neutrality hypothesis, Energy Econ. 33 (2) (2011) 257–263.

[51] Kojo Menyah, Yemane Wolde-Rufael, CO2 emissions, nuclear energy, renewable energy and economic growth in the US, Energy Pol. 38 (6) (2010) 2911–2915.

[52] Amitava Mitra, K Mishra Deepak, Environmental resource consumption pattern in rural Arunachal Pradesh, For. Pol. Econ. 13 (3) (2011) 166–170.

[53] Nathaniel, Solomon Prince, Suborna Barua, Zahoor Ahmed, What drives ecological footprint in top ten tourist destinations? Evidence from advanced panel techniques, Environ. Sci. Pollut. Control Ser. 28 (2021) 38322–38331.

[54] Eric Neumayer, Scarce or abundant? The economics of natural resource availability, J. Econ. Surv. 14 (3) (2000) 307–335.

[55] Hsiao-Tien Pao, Chung-Ming Tsai, CO2 emissions, energy consumption and economic growth in BRIC countries, Energy Pol. 38 (12) (2010) 7850–7860.

[56] Ugur Korkut Pata, Daniel Balsalobre-Lorente, Exploring the impact of tourism and energy consumption on the load capacity factor in Turkey: a novel dynamic ARDL approach, Environ. Sci. Pollut. Control Ser. 29 (9) (2022) 13491–13503.

[57] Ugur Korkut Pata, Emre Caglar Abdullah, Investigating the EKC hypothesis with renewable energy consumption, human capital, globalization and trade openness for China: evidence from augmented ARDL approach with a structural break, Energy 216 (2021), 119220.

[58] Ugur Korkut Pata, Cem Isik, Determinants of the load capacity factor in China: a novel dynamic ARDL approach for ecological footprint accounting, Resour. Pol. 74 (2021), 102313.

[59] Lingui Qin, et al., Does financial inclusion limit carbon dioxide emissions? Analyzing the role of globalization and renewable electricity output, Sustain. Dev. 29 (6) (2021) 1138–1154.

[60] Rehman, Mubeen Abdur, et al., Do diversified export, agriculture, and cleaner energy consumption induce atmospheric pollution in asia? Application of method of moments quantile regression, Front. Environ. Sci. 9 (October) (2021) 1–11.

[61] Nuobu Renzhi, Yong Jun Baek, Can financial inclusion Be an effective mitigation measure? Evidence from panel data analysis of the environmental kuznets curve, Finance Res. Lett. 37 (2020), 101725.

[62] Afees A. Salisu, O Isah Kazeem, Revisiting the oil price and stock market nexus: a nonlinear panel ARDL approach, Econ. Modell. 66 (2017) 258–271.

[63] Sánchez-Llorens S, Agulló-Torres A, J Del Campo-Gomis F, Martinez-Poveda A, Environmental consciousness differences between primary and secondary school students, J. Clean. Prod. 227 (2019) 712–723.

[64] Samuel Asumadu Sarkodie, Vladimir Strezov, Empirical study of the environmental kuznets curve and environmental sustainability curve hypothesis for Australia, China, Ghana and USA, J. Clean. Prod. 201 (2018) 98–110.

[65] Rajesh Sharma, Avik Sinha, Pradeep Kautish, Do economic endeavors complement sustainability goals in the emerging economies of south and southeast asia? Manag. Environ. Qual. Int. J. 32 (3) (2021) 1–24.

[66] Rajesh Sharma, Avik Sinha, Pradeep Kautish, Examining the nexus between export diversification and environmental pollution: evidence from BRICS nations, Environ. Sci. Pollut. Control Ser. 28 (2021) 61732–61747.

[67] Philip C. Short, Responsible environmental action: its role and status in environmental education and environmental quality, J. Environ. Educ. 41 (1) (2009) 7–21.

[68] Avik Sinha, Arnab Adhikari, Ashish Kumar Jha, Innovational duality and sustainable development: finding optima amidst socio-ecological policy trade-off in post-COVID-19 era, J. Enterprise Inf. Manag. 35 (1) (2022) 295–320.

[69] Avik Sinha, Nicolas Schneider, Malin Song, Umer Shahzad, The determinants of solid waste generation in the OECD: evidence from cross-elasticity changes in a common correlated effects framework, Resour. Conserv. Recycl. 182 (2022), 106322.

[70] Avik Sinha, Tuhin Sengupta, Tanaya Saha, Technology policy and environmental quality at crossroads: designing SDG policies for select asia pacific countries, Technol. Forecast. Soc. Change 161 (2020), 120317.

[71] Ugur Soytas, Ramazan Sari, T Ewing Bradley, Energy consumption, income, and carbon emissions in the United States, Ecol. Econ. 62 (3–4) (2007) 482–489.

[72] Yunpeng Sun, Ahsan Anwar, et al., Asymmetric role of renewable energy, green innovation, and globalization in deriving environmental sustainability: evidence from top-10 polluted countries, Renew. Energy 185 (2022) 280–290.

[73] Yunpeng Sun, Qun Bao, et al., Renewable energy transition and environmental sustainability through economic complexity in BRICS countries: fresh insights from novel method of moments quantile regression, Renew. Energy 184 (2022) 1165–1176.

[74] T.-H. Le, H.-C. Le, F. Taghizadeh-Hesary, Does financial inclusion impact CO 2 emissions, Evid. Asian Finance Res. Lett. 34 (2020), 101451.

[75] Jocelyn Timperley, The broken $100-Billion promise of climate finance—and how to fix it, Nature 598 (7881) (2021) 400–402.

[76] Panayiotis Tzeremes, Eyup Dogan, Nooshin Karimi Alavijeh, Analyzing the nexus between energy transition, environment and ICT: a step towards COP26 targets, J. Environ. Manag. 326 (2023), 116598.

[77] Wu Xiaoman, et al., Natural resources abundance, economic globalization, and carbon emissions: advancing sustainable development agenda, Sustain. Dev. 29 (5) (2021) 1037–1048.

[78] Bo Yang, Atif Jahanger, Muhammad Atif Khan, Does the inflow of remittances and energy consumption increase CO 2 emissions in the era of globalization? A global perspective, Air Qual. Atmos. Health 13 (2020) 1313–1328.

[79] Zafar, Muhammad Wasif, et al., The impact of natural resources, human capital, and foreign direct investment on the ecological footprint: the case of the United States, Resour. Pol. 63 (2019), 101428.

[80] Zafar, Muhammad Wasif, Asif Saeed, Syed Anees Haider Zaidi, Abdul Waheed, The linkages among natural resources, renewable energy consumption, and environmental quality: a path toward sustainable development, Sustain. Dev. 29 (2) (2021) 353–362.

[81] Syed Zaidi, Anees Haider, Muzzammil Hussain, Qamar Uz Zaman, Dynamic linkages between financial inclusion and carbon emissions: evidence from selected OECD countries, Resour. Environ. Sustain. 4 (2021), 100022.

[82] Abdulrasheed Zakari, et al., Are abundant energy resources and Chinese business a solution to environmental prosperity in Africa? Energy Pol. 163 (2022), 112829.

[83] Xiaoyan Zhou, Jie Zhang, Junpeng Li, Industrial structural transformation and carbon dioxide emissions in China, Energy Pol. 57 (2013) 43–51.