frontiers | Frontiers in Environmental Science

TYPE Review
PUBLISHED 05 March 2024
DOI 10.3389/fenvs.2024.1368125

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RECEIVED 10 January 2024
ACCEPTED 19 February 2024
PUBLISHED 05 March 2024

CITATION
Amer EAAA, Meyad EMA, Meyad AM and Mohsin AKM (2024), The impact of natural resources on environmental degradation: a review of ecological footprint and CO_2 emissions as indicators.
Front. Environ. Sci. 12:1368125.
doi: 10.3389/fenvs.2024.1368125

The impact of natural resources on environmental degradation: a review of ecological footprint and CO_2 emissions as indicators

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Environmental degradation resulting from the overexploitation of natural resources has become a pressing global concern. This review paper aims to investigate the relationship between natural resources and environmental degradation, with a specific focus on carbon dioxide (CO_2) emissions and ecological footprint (EF) as indicators. The study method involved an exhaustive search across prominent research databases, including ScienceDirect, Web of Science, Scopus, and Springer, using carefully defined search terms. A total of more than 160 research papers related to the search terms were obtained from the four sources of the database during the initial search. After applying sorting, filtering, and removing duplication and repetitions, we were left with 75 research papers that had a direct link to the topic under investigation. From these 75 papers, we further applied inclusion criteria to identify the most relevant studies for our review, resulting in the final inclusion of 50 research papers. The selected papers were thoroughly assessed for their methodological robustness, relevance, and adherence to the research questions. The review encompasses studies from diverse geographical regions and periods, shedding light on both positive and negative associations between natural resources and the two key indicators of environmental degradation (CO_2 emissions and EF). The review identified diverse findings in the literature, highlighting both positive and negative associations between natural resources and environmental degradation indicators (CO_2 and EF). The results of this comprehensive review will contribute to a better understanding of the complex interplay between natural resources and environmental sustainability and will offer valuable insights for policymakers and researchers alike.

KEYWORDS

natural resources, environmental degradation, ecological footprint, CO_2 emissions, review paper

1 Introduction

Human activities of all kinds are considered a significant threat to the environment on this planet, as these activities contribute directly or indirectly to climate change and environmental degradation (Joshua and Bekun, 2020; Magazzino et al., 2020). The effects of climate change on the quality of the environment have become of interest to scientists and researchers because the continuation of various human activities accompanied by continuous environmental degradation describes the extent of the danger that afflicts creatures on planet Earth (Nathaniel et al., 2021a). Natural resources are the primary source of human activities in terms of providing services and raw materials necessary to develop and improve economic activities. Therefore, depletion, extraction, processing, and mining of natural resources degrade the environment and affect ecological systems by diminishing environmental quality, causing air, water, land pollution, desertification, soil and rock destabilization, landscape degradation, climate change, and carbon dioxide emissions (Gutti and Aji, 2012). But natural resources, on the other hand, work on improving ecological quality in terms of helping to recycle waste and emissions from human activities (Kongbuamai et al., 2020). Where agricultural land, grazing land, and forests (as one of the most essential natural resources) reduce the amount of carbon dioxide emitted by human activities, while other types of natural resources such as coal, natural gas, and petroleum are degrading the environment (Danish and Khan, 2020; Ahmed, 2021a). Although the expansion in the consumption and use of natural resources leads to an increase in income, it is accompanied by an increase in the ecological footprint and a decrease in biological capacity. The accessibility of natural resources in any piece of the earth is viewed as a vital pointer of the national strength of this country, as well as one of the main determinants of economic improvement in the modern era (Ahmad, 2021b)

Because of the growing global concern about environmental degradation, many studies used different indicators to measure the quality of the environment, such as SO_2, PM10, coal consumption, biological oxygen demand, and environmental pressure, (Akbostanci et al., 2009; Thompson, 2012; Hao et al., 2016; Zhao et al., 2016; Danish et al., 2019; Badeeb et al., 2020; Majeed, Wang, et al., 2021). But ecological footprint (EF) and carbon dioxide emissions (CO_2) considered as a comprehensive measure for assessing environmental deterioration and human activity. ecological footprint has been developed by (Wackernagel and Rees, 1996), which measured the bio-productive territory required to aid a certain population. Furthermore, EF as an aggregate measurement and CO_2 emission as a percentage is used to assess environmental deterioration (Destek and Sarkodie, 2019). The EF has recently become famous as a proxy for environmental deterioration (Solarin and Opeyemi Bello, 2018; Ulucak and Bilgili, 2018; Zafar, 2019). Kongbuamai et al. (2021) presented that the demand-driven of EF calculates how much humans use natural resources and how much pollution is produced as a result. Khan. (2021a); Khan and Hou (2021) determine individual's EF by calculating how quickly nature can absorb trash and develop new resources. Global Footprint Network (2020) reported that carbon footprint, Land, forests, farmland, grazing land, and seas are the six bio-productive land use classifications included in the EF. As a result, climatic change is reflected in a broader land use pattern, deforestation, and carbon emissions in the EF (Bilgili, Ulucak, and Koçak, 2019).

Balsalobre-Lorente et al. (2018) Concluded in the study he conducted on five European countries; the natural resources positively impact carbon dioxide emissions and other gases harmful to nature. This means that countries with abundant natural resources are working to decrease their imports of unclean energy sources. He pointed out that econometrics outcomes provision the idea that the natural resources diminish carbon dioxide emissions *per capita* in the five European Union (EU) countries. Communities in the five EU nations with rich natural resources may decrease fossil fuel imports, helping to limit carbon emissions. Danish et al. (2019) carried out in the BRICS countries reveal that in Brazil, China, and India, the wealth of natural resources has minimal impact on carbon dioxide emissions. On the contrary, the plenty of natural resources in Russia aids in the reduction of pollution owing to the abundance of natural resources. He also discovered that because of the excessive use of natural resources in South Africa, natural resources are not environmentally friendly. Badeeb et al. (2020) concluded that there is no direct positive effect of dependence on natural resources on environmental deterioration. The outcomes of the study on five provinces in China show that natural resources are closely related to environmental deterioration in three regions. This degradation effect is significant in Xinjiang, Shaanxi, and Gansu provinces. This association is adverse but not significant for Ningxia Province (Ahmed et al., 2020a). The extraction and use of natural resources might positively impact the environmental quality in some provinces. Ahmad. (2021b) indicated that the significant and negative Qinghai Province's coefficient leads to the conclusion that the availability of natural resources in this province improves the quality of the environment and reduces the productions of CO_2 and further unwanted gases.

The significance of our study lies in its direct alignment with the pressing global imperative of achieving environmental sustainability within the framework of sustainable development, a paramount objective for policymakers worldwide. As such, there is a critical need to consolidate and synthesize the extensive body of empirical research addressing the intricate relationship between natural resources and key environmental indicators, namely, ecological footprint (EF) and carbon dioxide emissions (CO_2). By focusing specifically on these indicators, our review distinguishes itself from broader environmental studies, offering a targeted analysis that delves deep into the nexus between natural resource utilization and environmental degradation.

What sets our review apart is its nuanced examination of contextual and regional variations in findings, recognizing the diverse and sometimes contradictory nature of this relationship. By providing a comprehensive synthesis of existing literature, we not only lay the groundwork for future research but also offer valuable insights for policymakers and stakeholders striving towards sustainable development. In addition, by consolidating and summarizing the vast body of empirical research in this area, our study serves as a valuable resource for researchers, policymakers, and stakeholders alike. By distilling complex findings into accessible insights, we aim to facilitate informed decision-making and promote evidence-based interventions that prioritize environmental sustainability.

Our paper makes several notable contributions to the field. Firstly, it fills a crucial gap by providing the first comprehensive summary of research on the relationship between natural resources and environmental quality. This original focus sets our study apart

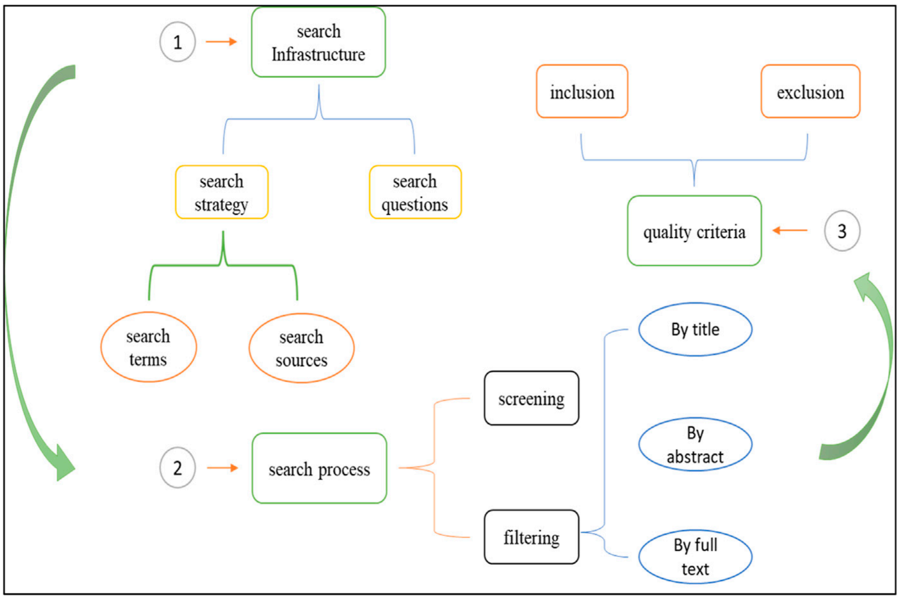

FIGURE 1
Flowchart illustrating the stages of the study methodology.

TABLE 1 Research questions and descriptions of the search process.

Search questions	Description
Is there a relationship between the abundance of natural resources and an increase or decrease in the rate of the ecological footprint?	This question is designed to differentiate the hypothesis that natural resources serve to balance an ecosystem. When natural resources are explored and used sustainably, natural resources are constantly replenished, thus increasing biocapacity and reducing ecological footprint. And its counter hypothesis is that the overexploitation of natural resources mainly contributes through unsustainable practices to environmental degradation
Does the abundance of natural resources improve the quality of the environment by reducing carbon dioxide emissions, or *vice versa*?	This question aims to looking for studies that confirm the hypothesis that states the extraction and sustainable use of natural resources helps reduce the import and use of fossil fuels and non-renewable energy, which in turn helps reduce carbon dioxide emissions

from previous reviews. Secondly, by concentrating on EF and CO_2 emissions as primary indicators, we ensure a thorough exploration of the most globally significant metrics for assessing environmental health. By centering our analysis on these indicators, we not only contribute to a more thorough understanding of environmental degradation but also provide a basis for comparison and benchmarking across different regions and contexts. Through these contributions, our study aims to provide a clear and comprehensive understanding of the complex interplay between natural resources and environmental quality, thus guiding future research endeavors towards more informed and impactful interventions.

We have dedicated the second part of this paper to a detailed explanation of this paper's methods. We devoted the third section to a detailed explanation of this paper's results. The fourth section reports the discussions related to this paper. Finally, the fifth section talks about the conclusions and suggestions that illuminate the way for future studies.

2 Study methodology

The search methodology for this paper consists of three main stages. The first stage is the search Infrastructure, which includes the search questions and strategy, as search strategy includes search terms and the search source. The second stage is screening and filtering. finally, the third stage includes the inclusion and exclusion. Figure 1 shows study methodology protocol for this paper.

2.1 Search infrastructure

2.1.1 Search questions

As shown in Table 1, the search questions focus on knowing whether the abundance of natural resources has a bad or good effect on the environment in terms of increasing or decreasing both carbon dioxide and the ecological footprint. The questions are posed in an uncluttered manner as they can be presented simultaneously.

TABLE 2 Criteria for inclusion and exclusion of studies.

Inclusion criteria	Exclusion criteria
Papers written in English	Papers written in other languages
Papers contain more than three pages	Papers contain less than three pages
Papers published after 2010	Papers published before 2010
Papers published in any of the four databases ScienceDirect, Web of Science, Scopus, and Springer	Papers published on other databases. Papers published in workshops, conferences, symposiums, and parts from books. Papers that have not yet been published, i.e., those that are still under publication procedures
Papers that study the relationship between natural resources and the ecological footprint	All papers that contain only one of these two variables (natural resources or ecological footprint). papers that do not clearly define the relationship between natural resources and the ecological footprint
Papers that examine the association between natural resources and carbon dioxide	Papers examining the connection between natural resources and other gases emissions. Papers that did not specify the ecological footprint and carbon dioxide as indicators of environmental quality, i.e., papers that studied the relationship between natural resources, SO2 emissions, coal consumption, *etc.*, were excluded
Papers that included natural resources as a controlling variable in their model with ecological footprint or carbon dioxide as a dependent variable	Papers that did not include natural resources as an independent or controlled variable in their model, with the ecological footprint or carbon dioxide as a dependent variable

Notes: The choice of 2010 as the cutoff year was based on several factors. Firstly, we aimed to ensure that our review included recent and up-to-date research findings in the field of natural resources and environmental degradation. By including papers published after 2010, we aimed to capture the most current research and avoid outdated information that may not reflect the current state of knowledge.

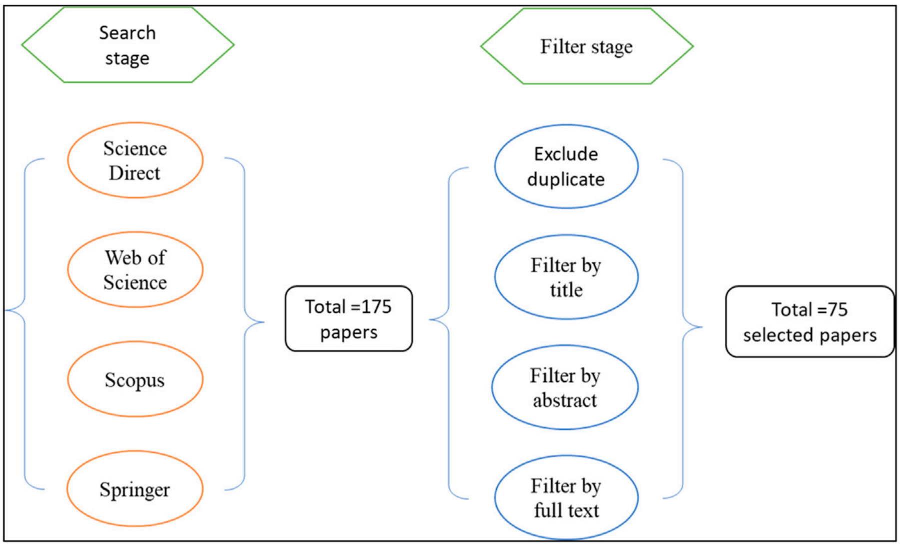

FIGURE 2
Diagram presenting the search results of the study.

2.1.2 Search strategy

This stage consists of search sources and search terms. This paper relies on the most famous search databases, namely, ScienceDirect, Web of Science, Scopus, and Springer to search for all articles related to natural resources and the environment. Through the topic that this paper seeks to investigate, we have defined the search terms, which are natural resources, environmental quality, carbon dioxide and ecological footprint, where the final form of the search terms was as follows: ['natural resources' OR 'Abundance of natural resources' OR 'extraction of natural resources']; ['Environment' OR 'environmental quality' OR 'environmental degradation' OR 'carbon dioxide emissions' OR 'CO_2' OR 'Ecological footprint'].

2.2 Screening and filtering

By searching the four sources of the database, more than 160 papers related to the search terms were obtained. The sorting and filtering process was carried out by scanning the titles and abstracts and then reading the full text to ensure its relevance with the topic under study, thus excluding all articles not directly related to this study. After removing duplication and repetitions, and then

TABLE 3 Checklist for assessing the quality of papers included in the review.

Quality criteria	Result
Whether the purpose of the paper is clearly stated	No papers have been excluded
Whether the framework or theory of the paper is clearly described	No papers have been excluded
Whether the methodology used in the paper is appropriate in terms of its effectiveness in solving econometric problems	No papers have been excluded

applying some quality criteria to these articles, 75 papers with a direct link to the topic under investigation were selected. From these 75 papers, we further applied inclusion criteria to identify the most relevant studies for our review, resulting in the final inclusion of 50 papers. Figure 2 shows the results of the search in numbers, then sorting and filtering until reaching the last number of scientific papers related to this work.

2.3 Inclusion and exclusion criteria

This stage includes some criteria that have been applied to all articles so that articles do not meet these criteria are excluded and papers that meet these criteria are included. First, only papers written in the English language were relied upon. Secondly, articles published in any of the four databases that had been identified in advance were selected. Thirdly, papers that examined the relationship between natural resources, carbon dioxide or the ecological footprint were selected as the main indicators of environmental quality, thus excluding studies which examines the relationship between natural resources and other indicators of the environment. Tables 2, 3 shows the most important inclusion and exclusion criteria that were adopted in this paper. As shown in Table 4, which shows the most important quality standards that were adopted during reading the full text from the filtering process to exclude some papers that do not meet these standards.

3 Study results

3.1 Positive relationship between natural resources and ecological footprint

Some studies have demonstrated the positive relationship between natural resources and the EF. For example, Ahmed et al. (2020b) utilized the ARDL approach to study the impact of economic growth, urbanization, human capital, and natural resources on the EF in China for the period 1970–2016. Their findings show that natural resources and EF are positively associated. M. Ahmad et al. (2020) utilized the CS-ARDL and AMG approaches to study the impact of natural resources, economic growth, and technology progress on the EF in emerging countries for the period 1978–2016, their findings show that natural resources positively associated with EF. Wang et al. (2020)'s results also showed that natural resources increase the EF in the G7 countries. Erdoğan et al. (2021) used the Cup-BC and Cup-FM long-run techniques to investigate the relationship between natural resources and the environmental quality in the Saharan Africa countries from 1980–2016. This study found that abundance of natural resources led to an decrease in environmental sustainability in this period, which means that there is a positive correlation between the abundance of natural resources and ecological footprint in the long run. Nathaniel et al. (2021a) investigated the impact of natural resources and renewable energy on the EF in 13 MENA countries using the FMOLS and DOLS models, this study found that natural resources positively correlate with MENA's EF. Using the ARDL, FMOLS, DOLS, and CCR methods, Nathaniel. (2021a) concluded in their study result on South Africa countries that natural resources increase the EF from 1970–2016. Nathaniel et al. (2020) In their study of ten most visited countries, they concluded that natural resources and the EF have a positive relationship in China, France, Spain, Britain, and Germany. Using the BH cointegration and causality method, Ahmed et al. (2020a) concluded in their study result on China that natural resources increase the EF. Langnel et al. (2021) also concluded the same outcome on ECOWAS countries that natural resources increase the EF in Cameroon and Nigeria. Using AMG and DOLS methods, Solomon Prince Nathaniel (2021a) concluded in his study result on ASEAN countries that natural resources increase the EF from 1990–2016. M. K. Khan et al. (2021b), In their research on Malaysia using the ARDL model, proved that natural resources have a positive impact on the EF during the study period 1980–2019.

3.2 Negative relationship between natural resources and ecological footprint

On the contrary, other studies confirmed the negative connection between natural resources and the EF. For example, Zafar, (2019) used the ARDL technique to investigate the relationship between natural resources and the ecological footprint in the United States. This study found a negative link between natural resources and EF in the long run. Hassan et al. (2019a) investigated the impact of natural resources on the EF in Pakistan using the ARDL models. This study found that natural resources have a long-term positive influence on Pakistan's EF. Using the ARDL model, Zhang et al. (2021) investigated the impact of natural resources, economic growth, and human capital on the EF in Pakistan, they found that natural resources negatively connected with Pakistan's EF. Khan. (2021c) used the GMM, GLM, and RLS techniques to investigate the relationship between natural resources, energy consumption, biocapacity, population, and the ecological footprint in the United States. This study found a negative link between natural resources and EF. Solomon Prince Nathaniel (2021b) studied the dynamic links between human capital, natural resources, globalization, and EF in 11 ASEAN countries from 1990 to 2016. Used the AMG, CS-ARDL, and PCSE models;

TABLE 4 Summary of previous studies investigating the relationship between NR, EF, and CO2 emissions.

Author	Study period	Country	Variables	Methods	Results
Natural resource and EF Positive relationship studies					
Ahmad et al. (2020)	1984–2016	emerging economies	EF, NR, GDP, and TI	CS-ARDL and AMG	NR increase EF
Ahmed et al. (2020a)	1970–2016	China	EF, NR, GDP, HC, U, and CF	Bayer-Hanck test and ARDL	NR increase EF
Erdoğan et al. (2021)	1980–2016	Sub-Saharan African countries	EF, NR, HC, GLO, BIO, and U	CUP-FM and CUP-BC	NR increase EF
Nathaniel et al. (2021a)	1990–2016	13 MENA countries	EF, NR, GDP, GDP^2, U, and RE	PCSE, FMOLS, and DOLS	NR increase EF
Nathaniel. (2021a)	1970–2016	South Africa countries	EF, NR, GDP, GDP2, HC, EC, and U	ARDL, FMOLS, DOLS, and CCR	NR increase EF
Nathaniel, (2021b)	1990–2016	ASEAN countries	EF, NR, HC, GDP, and GDP^2	AMG and DOLS	NR increase EF
Khan. (2021a)	1980–2019	Malaysia	EF, NR, GDP, GDP^2, and FD	ARDL	NR increase EF
Langnel et al. (2021)	1984–2016	ECOWAS countries	EF, NR, GDP, HC, GINI, EC, U, and IQ	AMG and (D-H) panel causality test	NR increase EF
Wang et al. (2020)	1980–2016	G7 countries	EF, NR, GDP, BIO, and GLO	DSUR, FMOLS, and DOLS	NR increase EF
Nathaniel et al. (2020)	1995–2016	ten most visited countries	EF, NR, U, EI, GDP, and TO	AMG, D-K, PCSE, FMOLS, and DOLS	NR increase EF
Jahanger et al. (2022)	1990–2016	73 developing countries	EF, NR, TE, HC, TGL, GDP, FD	PCT	NR increase EF
Majeed and Chengang. (2022)	1990–2018	BRI countries	EF, NR, TI and GLO	AMG	NR increase EF
Awosusi et al. (2022)	1992–2018	BRICS countries	EF, NR, BIO, GLO and GDP	FMOLS, DOLS and FE-OLS	NR increase EF
Nathaniel et al. (2021g)	1990–2016	BRICS countries	EF, NR, HC, GDP and RE	AMG, CCEMG, and PMG	NR increase EF
Zuo et al. (2022)	1991–2018	BRI countries	EF, NR, TI and FD	AMG	NR increase EF
Usman, Balsalobre-Lorente, et al. (2022)	1990–2018	resource-rich countries	EF, NR, FD, RE, NRE and GLO	AMG and CCE-MG	NR increase EF
Boukhelkhal. (2022)	1980–2017	ALGERIA	EF, NR, EC, GDP, I and EX	ARDL	NR increase EF
Hossain et al. (2022)	1980–2018	Mexico	EF, NR, FDI, EC, GDP and TI	ARDL	NR increase EF
Roy. (2023)	1990–2016	India	EF, NR, FDI, RE, NRE and TA	ARDL	NR increase EF
Ali et al. (2022)	1990–2016	ECOWAS	EF, NR, FI, URB and GDP	AMG, CCEMG, and PMG	NR increase EF
Li et al. (2022)	1990–2020	Arctic countries	EF, NR, GDP and GI	FMOLS, DOLS and FE-OLS	NR increase EF
Xie et al. (2022)	1990–2018	top ten resource-rich countries	EF, NR, GDP, GDPS, FM and FI	Granger technique	NR increase EF
Elma et al. (2023)	1990–2018	most innovative countries	EF, NR, GDP, GDPS, TI and TEC	Quantile Regression (MMQR)	NR increase EF
Adebayo. (2023)	1990–2018	BRICS countries	EF, NR, GDP, FF, REC and TGLO	ARDL and EMG	NR increase EF

(Continued on following page)

TABLE 4 (*Continued*) Summary of previous studies investigating the relationship between NR, EF, and CO2 emissions.

Author	Study period	Country	Variables	Methods	Results
Ali et al. (2023)	2001–2018	BRI countries	EF, NR, TIN, HCT, RQL, GEF and FNI	GMM and ARDL	NR increase EF
Qian and Ghulam. (2022)	1995–2020	BRI countries	EF, NR, GDP, GI and GLO	FGLS and PCSE	NR increase EF
Pata et al. (2021)	1992–2016	top ten countries with the largest EF	EF, NR, GDP, RE, HD and GLO	AMG	NR increase EF
Natural resource and EF negative relationship studies					
Danish et al. (2020)	1992–2016	BRICS countries	EF, NR, U, RE, Y, and Y^2	FMOLS and DOLS	NR decrease EF
Hassan et al. (2019a)	1970–2014	Pakistan	EF, NR, GDP, GDP^2, HC, U, and BIO	ARDL and VECM grange causality	NR decrease EF
Khan et al. (2021b)	1971–2016	United States	EF, NR, RE, NRE, POP, and BIO	GMM, GLM, and RLS	NR decrease EF
Khan et al. (2021c)	1990–2015	OECD countries	EF, NR, ENTR, RE, NRE, GDP, and U	FGLS and Granger causality test	NR decrease EF
Kongbuamai et al. (2020)	1995–2016	ASEAN countries	EF, NR, GDP, GDP^2, EC, and T	The D-K Model and D-H causality test	NR decrease EF
Nathaniel et al. (2021a)	1990–2016	11 ASEAN countries	EF, NR, BIO, GLO, FD, HD, and U	AMG, D-K Model, CS-ARDL, PCSE, and D-H causality test	NR decrease EF
Zhang et al. (2021)	1985–2018	Pakistan	EF, NR, HC, GDP, and GDP^2	DARDL	NR decrease EF
Nathaniel. (2021b)	1995–2016	top ten tourist destinations	EF, NR, GDP, U, TO, and EI	Westerlund's cointegration, CUP-FM, and CUP-BC	NR decrease EF
Nathaniel. (2020)	1995–2016	ten most visited countries	EF, NR, U, EI, GDP, and TO	AMG, D-K, PCSE, FMOLS, and DOLS approaches	NR decrease EF
Usman and Balsalobre-Lorente. (2022)	1990–2019	newly industrialized countries	EF, NR, RE and FD	AMG	NR decrease EF
Amer and Abbas. (2022)	1995–2017	GCC countries	EF, NR, URB, HC, GDP, and EC	FGLS and PCSE	NR decrease EF
Dagar et al. (2022)	1995–2019	OECD countries	EF, NR, RE, FD, TR and INDV	GMM	NR decrease EF
Gupta et al. (2022)	1990–2016	Bangladesh	EF, NR, GDP, URB and POPU	ARDL	NR decrease EF
Zafar. (2019)	1970–2015	United States	EF, NR, FDI, HC, EC and GDP	ARDL	NR decrease EF
Zhou et al. (2022)	1980–2018	Pakistan	EF, NR, GDP, HC and URB	ARDL	NR decrease EF
Liu et al. (2023)	1992–2018	G7 countries	EF, NR, HD and FI	(cup-FM) (cup-BC)	NR decrease EF
Natural resource and CO_2 Positive relationship studies					
Shen et al. (2021)	1995–2017	China	CO_2, NR, GIO, EC, and FD	ARDL, CCEMG, and AMG	NR increase CO_2
Ulucak and Bilgili. (2018)	1980–2016	OECD countries	CO_2, NRR, Y, Y^2, RE, and NRE	AMG	NR increase CO_2
Khan. (2021a)	1990–2016	BRI countries	CO_2, NR, Y, TRI, EU, CF, and RE	GMM	NR increase CO_2
Ahmad et al. (2020a)	1995–2017	China	CO_2, NR, GDP, GDP^2, RE, NRE, POP, T	FMOLS, Co-integration, and Granger causality	NR increase CO_2
Hassan et al. (2019b)	1971–2017	Pakistan	CO_2, NR, Y, Y^2, U, and TR	ARDL and VECM	NR increase CO_2

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TABLE 4 (*Continued*) Summary of previous studies investigating the relationship between NR, EF, and CO2 emissions.

Author	Study period	Country	Variables	Methods	Results
Kwakwa et al. (2019)	1971–2013	Ghana	CO_2, NR, U, TO, ODA, Y, and ENER	STIRPAT	NR increase CO_2
Bekun et al. (2019)	1996–2014	EU economies	CO_2, NR, GDP, RE, NRE	PMG, ARDL, and Dumitrescu-Hurlin causality	NR increase CO_2
Nathaniel et al. (2021a)	1990–2017	Latin American and Caribbean countries	CO_2, NR, U, HC, GDP, and GLO	AMG, Driscoll Kraay, and CCEMG	NR increase CO_2
Danish et al. (2019)	1990–2015	BRICS countries	CO_2, NR, Y, Y^2, and RE	AMG and DH non-causality	NR increase CO_2
Joshua and Bekun. (2020)	1970–2017	South Africa	CO_2, NR, GDP, CC	ARDL and Granger block exogeneity	NR increase CO_2
Li et al. (2022)	2003–2014	China	CO_2, TR, GDP, T	STIRPAT	NR increase CO_2
Usman et al. (2022)	1990–2017	Arctic countries	CO_2, NR, FD, GDP, NREC, REC, GLO	PCT	NR increase CO_2
Bosah et al. (2023)	2000–2019	159 countries	CO_2, NR	ARDL	NR increase CO_2
Li et al. (2023)	1984–2021	upper-middle-income economies	CO_2, NR, GDP and REC	FMOLS and DOLS	NR increase CO_2
Jiang et al. (2022)	1995–2018	BRI countries	CO_2, NR, GDP, RE, NRE, FD and URB	STIRPAT	NR increase CO_2
Natural resource and CO_2 negative relationship studies					
Dong et al. (2017)	1985–2016	BRICS countries	CO_2, NR, GDP, GDP^2, and RE	AMG and VECM Granger causality	NR reduce CO_2
Khan. (2021a)	1971–2016	United States	CO_2, NR, BIO, RE, NRE, and POP	GMM, GLM, RLS, and pairwise granger causality	NR reduce CO_2
Badeeb et al. (2020)	1970–2016	Malaysia	CO_2, NR, GDP, and GDP^2	ARDL, CCR, and FMOLS	NR reduce CO_2
Wang et al. (2019)	2003–2016	China	CO_2, NR, rational, advanced, and GDP	Slacks-Based Measure with windows analysis	NR reduce CO_2
Balsalobre-Lorente et al. (2018)	1985–2016	EU-5 countries	CO_2, NR, GDP, GDP^2, GDP^3, RE, and TO, and EI	PLS	NR reduce CO_2
Yu et al. (2016)	2007–2015	China	CO_2, NR, and NRE	bio-perspective method-emergy analysis	NR reduce CO_2
Majeed et al. (2021)	1990–2018	GCC countries	CO_2, NR, EG, RE, NRE, U, and Y	CS-ARDL and AMG	NR reduce CO_2
Zhang et al. (2021)	1985–2018	Pakistan	CO_2, NR, GDP, GDP^2, and HC	ARDL	NR reduce CO_2
Ahmad et al. (2022)	1995–2017	China	CO_2, NR, GDP, URB, EC, POPU, II, T and INDU	PMG and FMOLS	NR reduce CO_2
Xiaoman et al. (2021)	1980–2018	MENA countries	CO_2, NR, GDP, URB, TO and, EG	(Cup-FM) (Cup-BC)	NR reduce CO_2
Amin et al. (2023)	1990–2020	South Asian countries	CO_2, NR, GDP, URB, TO, ER and NRE	ARDL	NR reduce CO_2

Note; CO2 = carbon dioxide, EF, ecological footprint; NR, natural resource; GDP, gross domestic product, GDP2 = square of gross domestic product, U = urbanization, RE, renewable energy; NRE, Non-Renewable Energy, Y = economic growth, Y2 = square of economic growth, GLO, globalization; EG, economic globalization; EI, energy intensity; TO, trade openness; POP, population; BIO, biocapacity; TO, tourism; CC, coal consumption, T = technology, HC, human capital; ODA, official development assistance; ENER, energy use; TR, trade; CF, capital stock; TRI, tourism index; EU, energy use; FD, financial development; HD, human development; IQ, institution quality; GINI, gini index; CF, carbon footprint, and TI, technological innovations. ARDL, autoregressive distributed lag; AMG, augmented mean group; PCT , panel cointegration test; LMBM , lagrange multiplier bootstrap method; FGLS, feasible generalized least squares; PQR, panel quantile regression; CCEMG, common correlated effect mean group; CS-ARDL, Cross-Sectional ARD; MMQR, Methods of Moments-Quantile-Regression; CUP-FM, Continuously Updated-Fully Modified; CUP-BC, Continuously Updated-Bias Corrected; DOLS, dynamic ordinary least squares; FMOLS, fully modified ordinary least squares; GMM, generalized method of moments; OLS, ordinary least squares; STIRPAT, stochastic impacts by regression on population, Affluence, and Technology; PCSE, panel corrected standard error model.

this study outcome support that natural resource has a positive impact on environmental quality. Danish et al. (2020) relied on the DOLS and FMOLS models to investigate the impacts of economic growth and natural resource on EF in the BRICS from 1992 to 2016. According to the findings, Natural resources are negatively connected with EF. By using Wasteland's panel cointegration to examine the influence of natural resources, energy transitions, Urbanization, and energy consumption on the EF of OECD nations, I. Khan, (2021a) outcome presented that natural resources improve the environment throw decrease the EF. Kongbuamai et al. (2020) used the Driscoll-Kraay panel regression model to investigate the relationship between tourism, natural resources, and the EF in ASEAN countries. This study result showed a negative association between natural resources and ASEAN's EF. Using the FMOLS and DOLS models, Danish et al. (2020) concluded in their study on the BRICS countries that natural resources reduce the EF. Nathaniel et al. (2021d) used the Westerlund's cointegration, CUP-FM, and CUP-BC techniques to investigate the relationship between natural resources tourism, energy intensity, urbanization, and the ecological footprint in the top ten tourist destinations, this study found a negative connection between natural resources and EF in the period of 1995–2016. Nathaniel et al. (2020) In their study of ten most visited countries, they concluded that natural resources and the EF have a negative relationship in Thailand, Italy, Turkey, Mexico, and America.

3.3 Positive relationship between natural resources and CO_2 emissions

In this section, we will seek to list and summarize the existing empirical studies that discussed the association between natural resources and CO_2 emissions as indicator for environmental deterioration. Some of these studies have demonstrated the positive relationship between natural resources and the CO_2 emissions. For example, Shen et al. (2021) utilized the ARDL approach to study the impact of natural resources on the CO_2 emissions in China for the period 1995–2017. Their findings confirms a positive relationship between natural resources and carbon dioxide emissions, which means that natural resources increase the rate of carbon dioxide emissions in this period. Ulucak and Bilgili, (2018) investigated the impact of natural resources on the CO_2 emissions in OECD countries using the AMG model from 1980–2016. This study states that the extraction of natural resources in these countries contributes significantly to increased CO_2 emissions. Khan, (2021c) studied the dynamic links between natural resources and CO_2 emissions in Belt & Road Initiative (BRI) countries from 1990 to 2016. Used the GMM model; this study found a positive link between natural resources and CO_2 emissions. Using the FMOLS method Ahmad et al. (2020) In their study of northwestern China for the period 1995–2017, they concluded that natural resources and the CO_2 emissions have a positive relationship in three provinces Gansu, Xinjiang, and Shaanxi, while they have a negative association in Ningxia and Qinghai Province. Using the (PMG) techniques, Bekun et al. (2019) concluded in their study result on sixteen EU economies that the abundance of natural resources led to the deterioration of the environmental quality of the EU countries from 1996–2014.

Using AMG model for the period 1990–2015, Danish et al. (2019) also concluded the same outcome on their paper of BRICS countries that natural resources increase the CO_2 emissions in Brazil, China, and India. On the same time, the natural resources help reduce pollution in Russia because of the large number of resources. Using the STIRPAT model, Li et al. (2022) In their study of China for the period 2003–2014, they concluded that the increased use of natural resources leads to environmental pollution in China. Using the ARDL model, Joshua and Bekun. (2020) In their study of South Africa for the period 1970–2017, they concluded that the increased use of natural resources leads to increase CO_2 emissions. Using the ARDL and VECM models, Hassan et al. (2019b) In their study of Pakistan for the period 1971–2017, they also concluded that the increased use of natural resources leads to increase CO_2 emissions. Kwakwa et al. (2019) studied the dynamic links between natural resources and CO_2 emissions in Ghana from 1971 to 2013. Used the STIRPAT model; this study found a positive link between natural resources and CO_2 emissions. Nathaniel et al. (2021e) found a positive connection between natural resources and CO_2 emissions.

3.4 Negative relationship between natural resources and CO_2 emissions

On the contrary, other studies confirmed the negative connection between natural resources and the CO_2 emissions. For example, Dong et al. (2017) used the AMG long-run techniques to investigate the relationship between gas natural resources and the environmental quality in BRICS countries from 1985–2016. This study found that abundance of renewable-gas natural resources led to an increase in environmental sustainability in this period, which means that there is a negative correlation between renewable-gas natural resources and CO_2 emissions in the long run. Khan, (2021a) investigated the impact of natural resources on the environmental degradation in United States using the GMM models. This study showed that the abundance of natural resources leads to increased environmental sustainability from 1971–2016. Badeeb et al. (2020) relied on the ARDL model to investigate the impacts of natural resource on CO_2 emissions in Malaysia from 1970–2016. This study tested the hypothesis that reliance on natural resources has a direct positive impact on environmental degradation. However, the experimental results of this study did not support this theory and thus showed the negative relationship between natural resources and environmental degradation during the study period. By using Slacks-Based Measure with windows analysis approach to examine the influence of natural resources on the CO_2 emissions of China from 2003–2016, Wang et al. (2019) outcome presented a negative relationship between the abundance of natural resources and the efficiency of CO_2 emissions. Thus, they concluded that the greater the plenty of natural resources, the lower the efficiency of CO_2 emissions.

Balsalobre-Lorente et al. (2018) explored the association between GDP and CO_2 emissions in the so-called European Union 5 (EU-5) countries to investigate the EKC phenomenon from 1985–2016. This study result showed a negative relationship between the abundance of natural resources and the quality of the environment, meaning that the abundance of natural resources reduces CO_2 emissions in the five European Union countries. Because societies that enjoy abundant natural resources can reduce their imports of fossil fuels and thus control CO_2 emissions. Yu et al. (2016), In their research on 30 Chinese provinces by adopting a bio-perspective method-emergy analysis for the period 2007–2015, proved that Renewable natural resources play a prominent role in mitigating the negative impact of CO_2 emissions and other greenhouse gases in some Chinese provinces. For example, Qinghai Province ranks first in resource sustainability, which is one of the least developed provinces. Majeed et al. (2021) discussed the association between natural resources and CO_2 emission in the GCC countries. The outcome of this study presented a negative relationship between natural resources and CO_2 emissions. Thus, they concluded that the greater the plenty of natural resources, the lower the efficiency of CO_2 emissions. Zhang et al. (2021) investigated the impact of natural resources on the environmental degradation in Pakistan using the ARDL models. This study showed that the abundance of natural resources leads to decrease CO_2 emissions from 1985–2018.

4 Discussion

As shown in Table 4, 27 empirical studies on different countries containing more than 24 econometrics models and methods, proved in their results that natural resources are positively correlated with the ecological footprint. That is, the increase in the extraction of natural resources leads to an increase in the ecological footprint. On the contrary, the results of 16 empirical studies on different countries containing more than 20 econometrics models and methods proved that natural resources are negatively correlated with the ecological footprint. That is, the increase in the extraction and use of natural resources leads to a decrease in the ecological footprint.

Also as shown in Table 4, 15 empirical studies on different countries containing more than 15 models and methods of econometrics, proved in their results that natural resources are positively correlated with the CO_2 emissions. That is, the increase in the extraction of natural resources leads to an increase in the CO_2 emissions. On the contrary, the results of 11 empirical studies on different countries containing more than 14 models and methods of econometrics proved that natural resources are negatively correlated with the CO_2 emissions. That is, the increase in the extraction and use of natural resources leads to a decrease in the CO_2 emissions.

Surprisingly, and which should be noted in this study, there are many studies analyzed the same area, but they show contradictory results. For example, each of the studies (Awosusi et al., 2022 from 1992–2018; Nathaniel et al., 2021f from 1990–2016; Adebayo, 2023 from 1990–2018) analyzed the BRICS region, and they concluded, through the using of FMOLS, DOLS, FE-OLS, AMG, CCEMG, PMG, ARDL and EMG models, that the increase in the extraction and use of natural resources leads to an increase in the ecological footprint, while Danish et al. (2020)'s study on this same region, by using FMOLS and DOLS models from 1992–2016, concluded that the increase in the extraction and use of natural resources leads to a decrease in the ecological footprint. The study of (Nathaniel et al. (2021g) from 1990–2016) analyzed the ASEAN region, through the using of DOLS and AMG models, this study concluded that natural resources are positively correlated with the ecological footprint, while Kongbuamai et al. (2020) from 1995–2016 and Nathaniel et al. (2021d) from 1990–2016 studied on this same region, by using AMG, D-K Model, CS-ARDL, PCSE, and D-H causality test models, concluded that natural resources are negatively correlated with the ecological footprint. We also obtained contradictory results for each of the two studies (Wang et al. (2020) from 1980–2016; Liu et al. (2023) from 1992–2018) which were studied on G7 countries. There are many other studies whose results indicate different opinions, although they all deal with the same area. Therefore, the dispute associated with these studies must be removed by presenting them to international reviewers, weighting the strongest from the weakest, and resolving this dispute.

See Table 5, which indicates the most important studies that discussed the same area, but reached difference results. Based on our analysis of these papers, which reached different results for the same countries, we see that the most important reasons for the difference in results are: First, the different methods of estimating the parameters in the long term. There is no doubt that the different methods of estimation lead to different results, even if the data are the same in all methods. Secondly, the control variables are different. There is no doubt that increasing or decreasing one variable in the model would change the result upside down, let alone the different control variables for these studies. Third, the different analysis periods for these studies. Although the data analysis periods for these studies are close, there is no doubt that the increase or decrease of 1 year's data is enough to change the results upside down. Finally, the nature of the analyzed data. Some studies analyze the data after converting it to logarithm, and some studies analyze the original data without converting it to logarithm, and this is sufficient to change the results from one study to another on the same countries.

In conclusion, the literature reviewed in this paper suggests that there is no unanimous consensus on the relationship between natural resources and environmental degradation indicators like EF and CO2 emissions. While some studies found positive associations between natural resources and EF/CO2 emissions, others reported negative or mixed relationships. These diverse findings could be attributed to differences in methodologies, regional contexts, and varying levels of natural resource management and utilization across different countries. Further research is needed to understand the complex interplay between natural resources and environmental degradation comprehensively.

5 Conclusion

5.1 Summary and policy implication

This review on "The Impact of Natural Resources on Environmental Degradation: A Review of Ecological Footprint and CO_2 Emissions as Indicators" has provided valuable insights into the complex relationship between natural resources and environmental sustainability. The review identified diverse findings in the literature, highlighting both positive and negative associations between natural resources and environmental

TABLE 5 Overview of studies with conflicting findings on the relationship between NR, EF, and CO2 emissions in specific areas.

Author	Study period	Country	Variables	Methods	Results
Nathaniel. (2021a)	1990–2016	ASEAN countries	EF, NR, HC, GDP, and GDP^2	AMG and DOLS	NR increase EF
Kongbuamai et al. (2020)	1995–2016		EF, NR, GDP, GDP^2, EC, and T	The D-K Model and D-H causality test	
Nathaniel et al. (2021a)	1990–2016		EF, NR, BIO, GLO, FD, HD, and U	AMG, D-K Model, CS-ARDL, PCSE, and D-H causality test	NR decrease EF
Wang et al. (2020)	1980–2016	G7 countries	EF, NR, GDP, BIO, and GLO	DSUR, FMOLS, and DOLS	NR increase EF
Liu et al. (2023)	1992–2018		EF, NR, HD and FI	(cup-FM) (cup-BC)	NR decrease EF
Shen et al. (2021)	1995–2017	China	CO_2, NR, GIO, EC, and FD	ARDL, CCEMG, and AMG	NR increase CO_2
Ahmad et al. (2020b)	1995–2017		CO_2, NR, GDP, GDP^2, RE, NRE, POP, T	FMOLS, Co-integration, and Granger causality	
Li et al. (2022)	2003–2014		CO_2, TR, GDP, T	STIRPAT	
Wang et al. (2019)	2003–2016	China	CO_2, NR, rational, advanced, and GDP	Slacks-Based Measure with windows analysis	NR reduce CO_2
Yu et al. (2016)	2007–2015		CO_2, NR, and NRE	bio-perspective method-emergy analysis	
Ahmad et al. (2022)	1995–2017		CO_2, NR, GDP, URB, EC, POPU, II, T and INDU	PMG and FMOLS	
Hassan et al. (2019a)	1971–2017	Pakistan	CO_2, NR, Y, Y^2, U, and TR	ARDL and VECM	NR increase CO_2
Zhang et al. (2021)	1985–2018		CO_2, NR, GDP, GDP^2, and HC	ARDL	NR reduce CO_2
Bekun et al. (2019)	1996–2014	EU economies	CO_2, NR, GDP, RE, NRE	PMG, ARDL, and Dumitrescu-Hurlin causality	NR increase CO_2
Balsalobre-Lorente et al. (2018)	1985–2016		CO_2, NR, GDP, GDP^2, GDP^3, RE, and TO, and EI	PLS	NR reduce CO_2
Danish et al. (2019)	1990–2015	BRICS countries	CO_2, NR, Y, Y^2, and RE	AMG and DH non-causality	NR increase CO_2
Dong et al. (2017)	1985–2016		CO_2, NR, GDP, GDP^2, and RE	AMG and VECM Granger causality	NR reduce CO_2

degradation indicators. Several studies demonstrated a positive correlation between natural resources and Ecological Footprint (EF), natural resources and carbon dioxide (CO_2) emissions, indicating that the abundance of natural resources can contribute to increased EF and CO_2 emissions in various contexts. On the contrary, some studies revealed a negative connection, suggesting that an abundance of natural resources may mitigate CO_2 emissions and EF. These mixed findings underscore the importance of considering regional and contextual variations when assessing the impact of natural resources on environmental degradation.

Moreover, the comprehensive review of numerous articles sheds light on the intricate relationship between natural resources and environmental degradation. By synthesizing a breadth of studies, this review contributes to identifying patterns, trends, and inconsistencies in the existing literature, enabling a more nuanced interpretation of their relationship. The recognition of nuanced findings emphasizes the importance of tailored environmental policies that account for regional and contextual disparities. The findings of this study have important implications for several Sustainable Development Goals (SDGs), specifically SDG 7, SDG 12, SDG 13, and SDG 15. Our review highlights the relationship between natural resources and environmental indicators, such as carbon dioxide (CO_2) emissions and ecological footprint (EF). Understanding this relationship allows policymakers and stakeholders to make informed decisions to promote affordable and clean energy sources, reduce reliance on fossil fuels, and mitigate environmental degradation (SDG 7). Additionally, the review provides insights into the effects of natural resource exploitation on EF, guiding efforts towards sustainable consumption and production patterns, waste reduction, and minimizing the environmental footprint associated with resource use (SDG 12). By identifying the associations between natural resources and CO_2 emissions, the findings inform climate action strategies, mitigation efforts, and policies aimed at reducing greenhouse gas emissions and promoting sustainable resource management (SDG 13). Furthermore, the findings of the review provide insights into the impact of natural resource exploitation on terrestrial ecosystems, allowing policymakers and researchers to develop strategies for biodiversity protection, ecosystem conservation, and sustainable land use (SDG 15). These findings demonstrate the relevance of our review to these specific SDGs, providing valuable insights to guide sustainable development efforts. The identification of a positive correlation between natural resources and EF, natural resources and CO_2 emissions implies that in certain contexts, the abundance of natural resources may exacerbate environmental degradation. Conversely, the revelation of a negative connection suggests that natural resource abundance can serve as a mitigating factor for CO_2 emissions and EF in specific situations. These nuanced findings emphasize the need for tailored environmental policies that account for regional and contextual variations.

5.2 Future studies suggestions

While the review acknowledged the methodological rigor of many included studies, it also identified limitations, such as insufficient control of confounding variables in some cases. Addressing these limitations and enhancing methodological robustness in future research endeavors will bolster the reliability and accuracy of findings. Additionally, while the review encompassed studies from diverse geographical regions and time periods, it also revealed a notable lack of representation from certain regions. This emphasizes the imperative for more research in those areas to ensure a balanced representation and a more comprehensive global perspective. The divergent findings from the reviewed studies have important implications for policy and practice. Policymakers and stakeholders need to consider regional and contextual factors when formulating strategies to manage natural resources sustainably. Integrated policies that promote responsible natural resource management, environmental conservation, and emission reduction measures are essential to mitigate environmental degradation.

Future research should consider conducting longitudinal studies to assess the long-term impact of natural resource utilization on environmental degradation. This will help establish more robust cause-and-effect relationships and identify potential trends over time. To gain a holistic understanding of environmental degradation, future studies should explore multiple indicators beyond EF and CO_2 emissions. Incorporating a broader set of environmental indicators can provide a more comprehensive assessment of the impact of natural resources on the environment. Researchers should emphasize context-specific analysis when investigating the relationship between natural resources and environmental degradation. Cultural, economic, and political factors can significantly influence the outcomes, and accounting for these contextual variations will enhance the accuracy and relevance of the findings. Given the complexity of the topic, future studies should adopt multidisciplinary approaches that integrate environmental science, economics, sociology, and policy analysis. Such interdisciplinary research can offer a more comprehensive understanding of the complex interactions between natural resources and environmental degradation.

Author contributions

EA: Conceptualization, Methodology, Writing–original draft, Writing–review and editing. EM: Methodology, Writing–review and editing. AMe: Formal Analysis, Investigation, Writing–review and editing. AMo: Writing–original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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