sustainability

Article

Investigating the Impact of Green Natural Resources and Green Activities on Ecological Footprint: A Perspective of Saudi Vision 2030

Ghazala Aziz [1], Rida Waheed [2,*] and Majid Ibrahim Alsaggaf [3]

[1] Department of Business Administration, College of Administrative and Financial Sciences, Saudi Electronic University, Jeddah 23445, Saudi Arabia; g.aziz@seu.edu.sa
[2] Department of Finance and Economics, College of Business, University of Jeddah, Jeddah 23445, Saudi Arabia
[3] Department of Finance and Economics, College of Business, University of Jeddah, Jeddah 21959, Saudi Arabia
* Correspondence: ridawaheed.sdu@gmail.com

Abstract: The purpose of this study was to develop a deep understanding of the interactions between the ecological footprint, forest resources, land resources, environmental technology, and renewable energy consumption in Saudi Arabia. The study uses the data from 1980 to –2019 for econometric analysis. The findings of nonlinear ARDL estimates have reported the significance of forest and land resources to curtail the ecological footprint. Environmental technology and renewable energy empirical outcomes are insignificant in pre-Vision 2030 analyses, but become negative and significant in positive shock analyses. These results underscore that Saudi Vision 2030 has proposed workable and practical policies to address environmental challenges. Considering these findings, policymakers should implement beneficial policies that manage the country's natural resources to reduce the ecological footprint and achieve the goals of Vision 2030.

Keywords: ecological footprint; green natural resources; green factors; nonlinear ARDL

Citation: Aziz, G.; Waheed, R.; Alsaggaf, M.I. Investigating the Impact of Green Natural Resources and Green Activities on Ecological Footprint: A Perspective of Saudi Vision 2030. *Sustainability* **2023**, *15*, 8639. https://doi.org/10.3390/su15118639

Academic Editor: Oz Sahin

Received: 12 February 2023
Revised: 22 May 2023
Accepted: 23 May 2023
Published: 26 May 2023

1. Introduction

Currently, the primary goal of any country is to achieve long-term economic growth. The rapidly increasing use of energy for economic growth leads to a deterioration of the environment. It is imperative that we make an effort to use resources wisely and keep the economy growing at a pace that does not harm the environment [1]. According to EPC 2021, environmental pollution affects social life, increases the death ratio, and affects natural life. Environmental degradation encourages us to think how effectively we can use our natural resources. Concurring to the International Energy Agency report, presented in 2022, environmental pollution has been increasing over the years. One of the causes of environmental pollution is the use of fossil fuels in the energy sector, which represents two-thirds of total greenhouse gas emissions. Nonetheless, global energy consumption, investments in energy sources, and initiatives to mitigate the negative consequences of economic expansion on the environment must be considered [2]. The 26th UN Climate Change Conference (COP26) focused on reducing demand for fossil fuels in the energy sector, preventing deforestation, and investing in renewable resources to stabilize global temperatures. The importance of this study stems from emissions caused by the combustion of fossil fuels, which pollute the environment. According to [3], fossil fuels are the main contributors to environmental deterioration because of their high carbon emission levels. Saudi Arabia is the largest oil-producing country in the Middle East, with about three million barrels a day [4]. Despite several efforts, the Saudi economy is not entirely reoriented towards non-oil resources to reach the Sustainable Development Goals and Saudi Vision 2030. The large quantity of energy consumption in transportation, electricity, industrialization, etc., creates problems for the country's environment [5]. In 2021, Saudi Arabia emitted 586.4 million metric tons of carbon dioxide from fossil fuels and manufacturing activities, or about 19 metric tons per inhabitant. Saudi Aramco, one of the biggest carbon producers in the world, is based in Saudi Arabia and is a state-owned oil and gas company [6]. Saudi Aramco has emitted more than 60 billion metric tons of carbon emissions into the environment since the 1960s [7]. To achieve sustainability goals, it is necessary to change the country's current energy mix and provide new, environmentally friendly energy sources. However, to address these environmental concerns, Saudi Arabia has announced sustainable environmental policies, which have launched around 60 programs in October 2021 with an approximate 600 billion Saudi Riyals [8]. The importance and adoption of circular carbon economy has been highlighted and is being considered for implementation in the coming years. Following that, the Saudi public investment fund concluded the auction of a 3 billion US dollar green bond with an auction of 1.4 million tons of carbon. A target of 1 trillion dollars by 2026 has been set by the sovereign fund with a further increase of 10 billion dollars by 2025 [8]. In terms of energy, Saudi Vision 2030 aimed to be a world leader in exporting blue and green hydrogen [9]. In concise, Saudi Vision 2030 aimed to move towards a green economy by 2026.

The ecological footprint is a method to compare the sustainability of natural resource consumption by the population. Mathis Wackernagel and Bill Rees developed this method in the early 1990s. In traditional ecological footprint calculations, the amount of "bio productive" space appropriated by different nations is measured in hectares per person. The ecological footprint is a planning and policy tool for sustainability. Ecological footprint and energy consumption growth increase the world's resource shortage. According to statistics, worldwide energy consumption and production process account for 25% of environmental pollution [10]. As a result, failure to meet the United Nations Sustainable Development Goals (SDGs) pollution reduction targets would result in an ecological deficit. Thus, the main objective is to achieve economic growth without compromising the environmental quality by balancing energy demands and exploring more sustainable means to prevent socio-ecological disasters [11].

As a consequence of high energy usage and waste, combined with the loss of natural resources, the goal of sustainable development has been continuously affected by the rise in global warming [12–15]. Natural resources such as agriculture and forests are assumed as significant contributors to economic development, but their depletion is also the leading factor of ecological degradation [16–18]. Additionally, economic expansion drives industrialization, which boosts the use of natural resources [19]. Agriculture and deforestation that consume natural resources can negatively impact the ecosystem [15]. The pace of resource depletion in areas such as agriculture and forests will decrease if sustainable management techniques are incorporated into consumption and production, as a result allowing resources to repopulate. A successful strategy for improving the environmentally friendly use of land resources is fiscal decentralization. Local governments with effective fiscal decentralization have more influence when it comes to developing policies for using land for environmental goals [20].

Environmental technology helps to minimize the negative ecological impact on the environment. Production processes utilize environmental technologies to use resources efficiently and to reduce environmental pollution [21]. Additional resources should be put into environmental technologies involved in production processes to reduce their ecological footprint and carbon footprint levels [22]. The development of new technologies is helpful for improving energy efficiency and the industrial sector's ability to reduce environmental pollution [23].

Renewable energy is a main element in transforming a more sustainable environment due to its fewer greenhouse gases emissions, high power, and fast electricity generation capacity with less land area [24]. Renewable energy sources provide considerable advantages in terms of an energy structure optimization, ecological stability, and pollution reduction [25,26]. Additionally, renewable energy increases the industry's production and energy efficiency, lowers electricity costs, and reduces energy dependence, which contributes to achieving a green environment [27,28]. Hence, to support environmental policies aiming to achieve ecological stability and green growth, renewable energy is the ideal solution [29].

This study adds to the body of literature in several ways. A primary contribution of this research is the development of a mechanism to manage natural resources to reduce environmental pollution. To our knowledge, this is the first study to use "natural and semi-natural land" as a proxy for land recourse. There is a plethora of prior writing on natural resources using the proxy of "total natural resource rent." The use of "total natural resources" or "agriculture value added" can mislead policymakers [30]. The total natural resource rent includes the sum of all natural resources such as oil, coal, gas, forest land, minerals, water. However, the extraction of some natural resources increases the ecological footprint, whereas the depletion of some natural resources increases the ecological footprint. To counter this issue, we use the natural and semi-natural vegetated land that consists of the green proportion of land. Additionally, the second proxy is the forest to reexamine the role of green natural resources on the environmental footprint. The second objective of this study was to improve the established ecological footprint model by considering green activities such as renewable energy consumption and environmental technology. The addition of such factors would contribute towards environmental quality. Lastly, this study looks at the factors influencing the accomplishment of the Sustainable Development Goals (SDGs) and the goals of Saudi Vision 2030 from the standpoint of reducing Saudi Arabia's ecological footprint. This study is primarily concerned with nonlinear Autoregressive Distributed Lag [31].

In light of the contributions, the study's four main objectives were as follows. The first objective of this study was to check the impact of economic growth on the ecological footprint. The second objective was to examine the role of natural resources (forest resource and land resource) on the ecological footprint. The third objective of the study was to check the impact of green factors (environmental technology and renewable energy resources) on the ecological footprint. The fourth and last objective of the study was to check the role of Vision 2030 in the green environment.

The remaining sections are organized as follows: Section 2 contains a review of the literature, while Section 3 contains the data and methodology. Section 4 analyzes and explains the study's findings, and Section 5 summarizes the findings by outlining any policy implications.

2. Literature

Studies on energy, the environment, and economic growth have utilized several proxies to gauge environmental quality. For example, studies [32–35] utilized carbon dioxide emissions, [36] used sulfur dioxide (SO_2), and [14] used two proxies (carbon dioxide and NH_4). In comparison, rare studies employed the ecological footprint as a proxy for the environmental deterioration. Analyzing ecological footprint variables has become crucial for establishing environmental sustainability [37]. The effects of human activity on ecosystems have persistently worried academics over the years. It is obvious that human activities have risen on Earth after a surge in the world's population. Despite calling for countries to maintain natural boundaries, 80% of the world's population live in ecological deficit countries. Therefore, identifying the factors that influence environmental quality became essential in the context of the sustainable development targets for 2030 [38]. Ref. [33] used the ARDL model to examine the relationships between economic growth and environmental quality in Qatar from 1980 to 2011 utilizing an ecological footprint variable as a proxy for environmental quality. The outcomes of their long-run estimations showed that economic expansion significantly reduces environmental quality by raising the ecological footprint.

Numerous empirical studies have shown how economic growth affects the environment. It included a wide range of studies that covered several countries, elements, and approaches. Prior research [39–41] utilized the EKC analytic approach to study the relationship between economic growth and environmental deterioration and hypothesized an inverted U-shaped relationship between them. According to [42], South Africa's economic growth and coal use have caused environmental pollution. Ref. [43] discovered that economic growth in Mexico has a positive significant impact on the environment by employing ARDL, FMOLS, and DOLS estimation methods on annual data from 1971 to 2016. Similarly, using the ARDL technique and data from 1985 to 2018, researchers found that economic growth has a positive impact on the environment in OECD member countries [44]. The same results obtained using the STIRPAT and ARDL methodologies [45] reported that economic growth had a positive impact on the environment in GCC countries from 1980 to 2017.

By absorbing excess atmospheric carbon dioxide and maintaining it in tree biomass, a process known as carbon sequestration, forests have significantly contributed to climate change mitigation [12]. The demand for food, shelter, agriculture, transportation, and other infrastructure has increased along with the global population, placing pressure on the world's forests. The Southeast Asian region has lost its forest cover due to clearing forests for oil palm, industrial, farming, agricultural fires, and rubber plantations, as well as other types of agriculture [17]. Ref. [13] examined how Malaysian forests could help achieve environmental sustainability by reducing carbon dioxide emissions. The empirical results supported the hypothesis that the coefficient of forested area has a significant negative impact on carbon dioxide emissions, suggesting that a 1% increase in the forested area resulted in a 3.86% decrease in carbon dioxide emissions. Ref. [18] demonstrated a negative connection between forested areas and environment degradation using country-specific panel data ranging from 1990 to 2014 for 86 countries. Furthermore, analyzing data for Indonesia from 1990 to 2020 using the DOLS, FMOLS, and CCR methodologies, Ref. [46] confirmed the negative effects of forest on the environment.

Recently, experts have focused on environmental degradation and land resources [47], and few studies in recent time conducted on the land resources impact on the environment. For instance, when examining the relationship between income and the environment in the EU-5 countries, Ref. [48] included land resources as a control variable. They proposed a negative relationship between environment and land resources. According to [20], analysis based on data collected on fiscal decentralization, land resource usage, and environmental emissions in China from 2011 to 2018, fiscal decentralization has proven to be a useful tool for promoting the environmentally friendly use of land resources. According to [49], the study results revealed that land resources in the United States help to reduce the ecological footprint. Ref. [19] found a similar correlation between land resources and an environment in the BRICS economic bloc countries. Another study investigated how to reduce the waste of natural resources by educating people about consumption patterns, deforestation, careful use of water and energy resources, and energy-efficient luxury products in daily life [14].

The results from the study [50] revealed that when we have a sustainable structure, technology, and a suitable environment, that stage can make prudent judgments regarding the climate. According to research on the EU-5 countries by [48], innovation positively influences environmental quality. The same result was obtained by [51], which reported that energy innovation policies have a favorable impact on reducing environmental pollution. One study [52] found technology advancement crucial for reducing the usage of fossil fuels. According to the findings, a strong correlation existed between electricity usage, economic growth, technological advancement, and environmental protection.

Numerous studies have attempted to examine how total energy consumption (the sum of all renewable and nonrenewable energy) affects the environment. The majority of these projects have indicated that overall energy consumption has a positive impact on environmental pollution [53–55]. However, Refs. [56,57] pointed out that the positive impact of energy usage on environmental deterioration only becomes applicable when the overall energy consumption divides into renewable and nonrenewable energy. In Algeria, China, and India, Refs. [56,58,59] found that renewable energy had a negative and significant impact on the environment. The AMG approach was employed in the study by [15] to examine the relationship between emissions and renewable energy in the

BRICS. The panel analysis of data using the AMG approach demonstrated that renewable energy negatively impacted emissions. However, Ref. [60] asserted that renewable energy causes a rise in environmental pollution in five Middle East and Northern African nations (MENA). However, as the renewable energy contains flammable and waste, the study results contradicted previous ones. Similarly, Ref. [61] studied the process of decarbonization in Europe and its challenges. According to the findings, low-emissions energy has been viewed essentially at the highest decision-making levels. By using the DOLS, FMOLS, and CCR methodologies with data spanning 1990–2018, Ref. [16] revealed a negative correlation between the utilization of renewable energy and black footprint in Peru.

While reviewing the literature, few studies have investigated the role of land resources in addressing the environmental footprint. However, based on our limited knowledge, none of the studies are about the Saudi context. Moreover, the previous literature has not addressed the Vison 2030-based estimations, which are quite important to evaluate the performance, implementation, and consequences to counter the environmental degradation process. Furthermore, past studies used basic linear estimations, quantile estimations, and threshold estimations, but asymmetric empirical estimation is missing in previous studies, particularly in the context of Saudi Arabia. Nonetheless, the current work is an attempt to address the lacking gaps.

3. Methodology

3.1. Data and Models

To examine the significant factors of environmental footprint, we have employed the ecological footprint (EFP) as a dependent variable. Previously, academia used carbon emissions as a proxy for environmental degradation. The use of such a metric as an environmental degradation indicator may be invalid in some situations when it comes to resource stocks [30]. The independent variables are divided into two subsets: (i) natural resource indicators that include forest resource (FR) and land resource (LR). A study by [30] used total natural resource rent as a proxy for natural resources. We are using natural and seminatural land as a proxy for the land resource. The second is green, indicating the usage of environmental technology (ET) and renewable energy resources (RE). Gross domestic product (GDP) represents the economic growth and is used as a control variable. We collected the data from the World Development Indicators (WDI), International Renewable Energy Agency (IREA), Global Footprint Network, and Organization for Economic Cooperation and Development (OECD). We used the data from 1980 to 2019 for empirical analysis. To simulate the data series with missing data, we used the Markov Chain Monte Carlo (MCMC) algorithm, which is one of the best approaches. Following are the empirical equations that are used to examine the relationship between the variables individually:

(1) Model 1 for the natural resources role towards the ecological footprint of Saudi Arabia is as follows:

$$\text{EFP} = \text{f (GDP, FR, LR)} \quad (1)$$

(2) Model 2 for the green variables impact on the ecological footprint in Saudi Arabia is as follows:

$$\text{EFP} = \text{f (GDP, ET, REC)} \quad (2)$$

Table 1 presents the definitions of all the variables and detail of sources.

The natural logarithm of all variables is used to stabilize the variance and to linearize the nexus between variables. The empirical equations after log are as follows:

$$\text{lnEFP} = \alpha_0 + \beta_1\text{lnGDP} + \beta_2\text{lnFR} + \beta_3\text{lnLR} + \varepsilon t \quad (3)$$

$$\text{lnEFP} = \alpha_0 + \beta_1\text{lnGDP} + \beta_2\text{lnET} + \beta_3\text{lnREC} + \varepsilon t \quad (4)$$

where lnEFP, lnGDP, lnFR, lnLR, lnET, and lnREC, respectively, stand for the natural logarithm of ecological footprint, GDP, forest resource, land resource, environmental technology, and renewable energy consumption. The β_0 is the intercept that shows when there is no variation in other variables, and the ecological footprint is equal to this autonomous value. The parameters β_i = 1, 2, and 3 are the coefficients and represent the long-run elasticity. Moreover, εt represents error term.

Table 1. Definition and source.

Indication	Variable	Definition	Measure	Source
EFP	Ecological footprint	EFP measures human demand from agriculture, construction, grazing, fishing and forest land, and CO_2 absorption from fossil fuel combustion.	Global hectares Per person	Global Footprint Network
GDP	Economic growth	Gross domestic product	(Constant 2015 US dollars)	WDI
FR	Forest resource	Forest resource stocks	Cubic Metrics, Millions	WDI
LR	Land resource	Natural and seminatural vegetated land, % total	Percentage	OECD
ET	Environmental Technology	Development of environment-related technologies, % of all technologies	Percentage	OECD
REC	Renewable energy consumption	Renewable energy consumption	Gigawatt hours	IRENA

Further, we distributed the data into two subsets, before-Vision and after-Vision, to examine the effects of models towards Saudi Vision 2030. This helped to identify future plans and orientations that lead to a green environment by assessing the effects of plans developed under the framework of Vision 2030.

3.2. Autoregressive Distributed Lag (ARDL)

For empirical estimations, current study uses the autoregressive distributed lag (ARDL)-bound cointegration technique to assess the short-term elasticities and long-term cointegration. We used the above linear equations for this purpose.

The ARDL form of above Equations (3) and (4) are as follows:

$$\Delta \ln EFP_t = \alpha_0 + \sum_{i=1}^{n} \mu_1 \Delta \ln EFP_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ln GDP_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ln FR_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ln LR_{t-i} + \gamma_0 \ln EFP_{t-1} + \gamma_1 \ln GDP_{t-1} + \gamma_2 \ln FR_{t-1} + \gamma_3 \ln LR_{t-1} + \omega_t \quad (5)$$

$$\Delta \ln EFP_t = \alpha_0 + \sum_{i=1}^{n} \mu_1 \Delta \ln EFP_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ln GDP_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ln ET_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ln REC_{t-i} + \gamma_0 \ln EFP_{t-1} + \gamma_1 \ln GDP_{t-1} + \gamma_2 \ln ET_{t-1} + \gamma_3 \ln REC_{t-1} + \omega_t \quad (6)$$

where Δ is the first difference operator, μ_1 to μ_4 are short-run elasticity operators, Υ_1 to Υ are long-run elasticity operators, α_0 is the constant, and ε_t is the noise. The decision of acceptance or rejection of the hypothesis is based on F-statistics and critical values. The critical values presented by [62,63] are used for cointegration test results.

3.3. Nonlinear ARDL

Though cointegration tests can verify the linearity of the relationships among variables, Ref. [64] recommended a nonlinear ARDL strategy to further investigate whether the association is positive or negative. This method is used in the current paper to ascertain the direction. The concise equation is as follows:

$$K = \varphi_0 + \varnothing^+ IK_t^+ + \varnothing^- IK_t^- + \varepsilon_{it} \text{ and } \Delta IK_t = k_t$$

where K_{jt} and IK_t represent scalar I (1). K_{jt} is the return of ith at time t and split up into positive and negative shocks. IK_t^+ and IK_t^- propose the positive and negative shocks in

IK (independent variable). ε_{it} and k_t are the random distribution term. The equations are transformed according to this study and are mentioned from Equation (7) to Equation (11).

$$\begin{cases} \mathrm{POS(GDP)_t} = \sum_{i=1}^{t} \mathrm{lnGDP_i^+} = \sum_{i=1}^{t} \mathrm{MAX(\Delta lnGDP_i, 0)} \\ \mathrm{NEG(GDP)_t} = \sum_{i=1}^{t} \mathrm{lnGDP_i^-} = \sum_{i=1}^{t} \mathrm{MIN(\Delta lnGDP_i, 0)} \end{cases} \quad (7)$$

$$\begin{cases} \mathrm{POS(FR)_t} = \sum_{i=1}^{t} \mathrm{lnFR_i^+} = \sum_{i=1}^{t} \mathrm{MAX(\Delta lnFR_i, 0)} \\ \mathrm{NEG(FR)_t} = \sum_{i=1}^{t} \mathrm{lnFR_i^-} = \sum_{i=1}^{t} \mathrm{MIN(\Delta lnFR_i, 0)} \end{cases} \quad (8)$$

$$\begin{cases} \mathrm{POS(LR)_t} = \sum_{i=1}^{t} \mathrm{lnLR_i^+} = \sum_{i=1}^{t} \mathrm{MAX(\Delta lnLR_i, 0)} \\ \mathrm{NEG(LR)_t} = \sum_{i=1}^{t} \mathrm{lnLR_i^-} = \sum_{i=1}^{t} \mathrm{MIN(\Delta lnLR_i, 0)} \end{cases} \quad (9)$$

$$\begin{cases} \mathrm{POS(ET)_t} = \sum_{i=1}^{t} \mathrm{lnET_i^+} = \sum_{i=1}^{t} \mathrm{MAX(\Delta lnET_i, 0)} \\ \mathrm{NEG(ET)_t} = \sum_{i=1}^{t} \mathrm{lnET_i^-} = \sum_{i=1}^{t} \mathrm{MIN(\Delta lnET_i, 0)} \end{cases} \quad (10)$$

$$\begin{cases} \mathrm{POS(REC)_t} = \sum_{i=1}^{t} \mathrm{lnREC_i^+} = \sum_{i=1}^{t} \mathrm{MAX(\Delta lnREC_i, 0)} \\ \mathrm{NEG(REC)_t} = \sum_{i=1}^{t} \mathrm{lnREC_i^-} = \sum_{i=1}^{t} \mathrm{MIN(\Delta lnREC_i, 0)} \end{cases} \quad (11)$$

The variables are decomposed into positive and negative shocks in the above equations.

3.4. Vector Error Correction Model

Additionally, there should be a causal relationship between the variables if there is a long-term association between the variables [65]. To determine the causal relationships between ecological footprint, natural resources, and green variables, we employed the Vector Error Correction Model (VECM). VECM will aid in determining the causal relationships between the study's independent and dependent variables.

4. Results

Descriptive statistics for all variables are shown in Table 2. It can be noted that forest resource has the highest mean value, and renewable energy consumption has the lowest mean value. In the case of standard deviation, economic growth displays the highest standard deviation, whereas land resource is less volatile. As the values of the skewness statistics are different from zero, it can be argued that the variables under study are not symmetric and normally distributed. The Kurtosis value is less than 3 in most cases, suggesting that the series have low tails.

It is critical to check for structural breaks in the data. Hence, we used the Chow structural break test. The null hypothesis states no structural break in the data, whereas the alternative hypothesis reflects the presence of structural break. The result of the Chow structural break test is shown in Table 3. The value of F-statistics is insignificant, indicating that there is no evidence of structural break in the data series. To confirm the results of the Chow structural break test, we further used the Quandt–Andrews structural break test. The null hypothesis of the Quandt–Andrews breakpoint test shows no structural break [66,67]. The findings are reported in the second section of Table 3, which confirms the results of the Chow structural break test.

Table 2. Summary of statistics.

	EFP	GDP	FR	LR	ET	REC
Obs	40	40	40	40	40	40
mean	4.977	1.362	7.456	5.784	2.707	−2.268
max	6.134	3.969	7.429	5.842	3.301	−1.186
min	3.812	−2.674	7.645	5.655	1.783	−4.93
sd	0.033	1.343	0.031	0.015	0.267	1.059
variance	0.002	1.78	0.016	0.021	0.061	1.122
skewness	0.121	−1.32	0.47	0.107	−0.648	−0.945
kurtosis	1.712	5.241	2.238	1.697	4.785	2.376

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resources and land resource, respectively, which are natural resources. ET and REC represent the environmental technology and renewable energy consumption, which reflects the green factors.

Table 3. Structural break test.

Chow Structural Break			
F-Statistics	2.371	Prob. F (7,15)	0.064
Quandt–Andrews structural break test	Maximum LR	Expected LR	Average LR
F-Statistics	128.365	120.541	100.637

Note: The null hypothesis represents that coefficients are constant across the sample (no structural breakages). Null hypothesis for the Quandt–Andrews test is "no breakpoint". As the insignificant results of maximum LR, expected LR, and average LR are insignificant, however, null hypothesis is accepted.

We used two unit root tests to check the stationarity of data: DF-GLS and KSUR, which are shown in Table 4. According to the results, unit root is presented at a level for GDP, LR and ET. Environmental technology is stationary at a level for the DF-GLS unit root test. In the KSUR unit root test, economic growth and land resource are stationary at level. Hence, the first difference is applied. However, all variables are stationary at the first difference at a 1% significance level. Due to the mixed results of unit root, we must use the bond cointegration test. It is used to confirm the long-run existence of models under study.

Table 4. Unit root test.

	DF-GLS				KSUR			
DF-GLS	Level		Diff		Level		Diff	
Variable	Stat		Stat		*p*-Value		*p*-Value	
EFP	−1.264	IS	−4.615 ***	Sig	0.911	IS	0.003 ***	Sig
GDP	−2.414	IS	−8.021 ***	Sig	0.005 ***	Sig	0.004 ***	Sig
FR	−2.501	IS	−5.498 ***	Sig	0.336	IS	0.000 ***	Sig
LR	−1.541	IS	−4.215 ***	Sig	0.001 ***	IS	0.005 ***	Sig
ET	−4.474 ***	Sig	−6.756 ***	Sig	0.937	Sig	0.001 ***	Sig
REC	−1.834	IS	−4.813 ***	Sig	0.932	IS	0.003 ***	Sig

Note: DF-GLS does not assume stationary nonlinear, whereas the KSUR unit root test presented by Kapetanios and Shin (2008) considers stationary nonlinear. The null hypothesis assumes the presence of a unit root. ***, represents the level of significance at 1%.

For the presence of mixed level of significance, we applied the bound cointegration test, which is considered to examine the long-run relationship between the studied models. Table 5 shows the results of ARDL-bound cointegration tests, and all models show the existence of cointegration as the value of F-status is higher than the upper bound critical value. EFP = f (GDP, FR, LR) is cointegrated at 10% and EFP = f (GDP, ET, REC) at 1%, which is presented in Table 5. Therefore, nonlinear ARDL models can be applied in our statistics.

Table 5. ARDL bound cointegration test.

ARDL Bounds Cointegration Test	F-Stat	EFP
EFP = f (GDP, FR, LR)	5.931 *	Exist
EFP = f (GDP, ET, REC)	9.454 ***	Exist
Lower-bound critical value at 10%		3.34
Upper-bound critical value at 10%		4.65
Lower-bound critical value at 1%		4.87
Upper-bound critical value at 1%		5.65

Note: ***, * represent the level of significance at 1% and 5%, respectively.

Afterward, it is essential to determine whether nonlinearity exists in the data series. As a result, we used the BDS nonlinearity test with the null hypothesis that "series are linearly dependent" recommended by [68]. Table 6 verifies the significance of the series at each dimension while pointing out the nonlinear dependence of the variables. Hence, we rejected the null hypothesis "series are linearly dependent". However, it is essential to use the nonlinear ARDL test rather than the ARDL test to eliminate the asymmetric analysis, which provides the individual impact of positive and negative shocks.

Table 6. BDS test.

Dimensions	2	3	4	5	6
EFP	0.141 ***	0.336 ***	0.528 ***	0.512 ***	0.609 ***
GDP	0.165 ***	0.128 ***	0.411 ***	0.738 ***	0.023 ***
FR	0.220 ***	0.453 ***	0.517 ***	0.015 ***	0.511 ***
LR	0.183 ***	0.864 ***	0.253 ***	0.303 ***	0.482 ***
ET	0.148 ***	0.574 ***	0.625 ***	0.526 ***	0.417 ***
REC	0.325 ***	0.234 ***	0.434 ***	0.481 ***	0.213 ***

Notes: *** represents the level of significance at 1%.

4.1. Estimation

4.1.1. Nonlinear ARDL Estimates

We used the nonlinear ARDL approach to check the positive and negative shocks of independent variables, which are presented in Tables 7 and 8. After the full-sample analysis, we divided the data into two groups: before and after the implementation of Saudi Vision 2030, in order to examine the impact of the Vision 2030 policies on reducing environmental consequences.

Long-run and short-run results of nonlinear ARDL estimation are presented in Table 7. The long-run results show a positive and significant relationship between economic growth and ecological footprint. Forest resources and land resource represent the natural resources of the country, which show that positive shocks of natural resources have a negative and significant relationship with ecological footprint. These findings are in line with the previous research, suggesting that natural resources can help to improve environmental performance, as reported in [69,70]. The negative coefficients of forest and land resources indicate that the higher green cover is useful to minimize the environmental footprint in Saudi Arabia, as concluded by [71,72].

The coefficient of environmental technology and renewable energy consumption are insignificant. These factors ultimately play no role in achieving a green environment in Saudi Arabia. The results of environmental technology are similar to the results of [73]. The reason for the insignificant effect of renewable energy consumption could be that Saudi Arabia is the major oil producer, and mainly using oil for power generation [74].

Table 7. Nonlinear ARDL estimation.

Long Run	Model 1	Model 2
EFP	−0.709 ***	−0.105
GDP^{+}_{t-1}	0.003 **	0.061 *
GDP^{-}_{t-1}	0.011	0.031
FR^{+}_{t-1}	−0.036 **	
FR^{-}_{t-1}	0.351	
LR^{+}_{t-1}	−0.046 **	
LR^{-}_{t-1}	0.391	
ET^{+}_{t-1}		−0.042
ET^{-}_{t-1}		−0.057
REC^{+}_{t-1}		0.217
REC^{-}_{t-1}		0.104
Short Run		
ΔEFP_{t-1}	0.142	−0.296
ΔGDP^{+}_{t-1}	0.239 **	0.269 **
ΔGDP^{-}_{t-1}	4.162 **	3.166 **
ΔFR^{+}_{t-1}	0.042	
ΔFR^{-}_{t-1}	0.033	
ΔLR^{+}_{t-1}	−0.061 *	
ΔLR^{-}_{t-1}	0.342	
ΔET^{+}_{t-1}		0.025
ΔET^{-}_{t-1}		−0.107
ΔREC^{+}_{t-1}		0.091
ΔREC^{-}_{t-1}		0.082
Constant	−1.169	7.638 ***

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resource and land resource, respectively, which are the natural resources. ET and REC represent the environmental technology and renewable energy consumption, respectively, which reflects the green indicators. Δ is the difference. ***, **, and * represent the level of significance at 1%, 5%, and 10%, respectively.

Table 8. Asymmetric and model diagnostics.

	Long Run (+)	Long Run (−)	Long-Run Asymmetry (*p*-Value) W_{LR}	Short-Run Asymmetry (*p*-Value) W_{LR}
		EFP = f (GDP, FR, LR)		
GDP	2.135 **	1.743 *	0.482	0.371
FR	−2.042 *	0.971	0.541	0.135
LR	2.034	2.467	0.342	0.196
Cointegration			F-Stat	1.645
Portmanteau			*p*-value	0.642
Heteroskedasticity			*p*-value	0.513
Ramsey test			*p*-value	0.158
J–B test			*p*-value	0.661
EFP = f (GDP, ET, REC)				
GDP	0.237 *	1.995	0.372	0.427
ET	−0.215	0.291	0.835	0.331
REC	−2.137	0.732	0.472	0.167
Cointegration			F-Stat	2.319
Portmanteau			*p*-value	0.747
Heteroskedasticity			*p*-value	0.161
Ramsey test			*p*-value	0.216
J–B test			*p*-value	0.001

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resource and land resource, respectively, which are the natural resources. ET and REC represent the environmental technology and renewable energy consumption, respectively, which reflects the green indicators. **, and * represent the level of significance at 5%, and 10%, respectively.

The results concerning the short-run analysis reveal that negative and positive shocks in economic growth heighten the ecological footprint in model 1 and model 2, as the coefficients of economic growth are significant and positive. This result is aligned with the results of [74,75]. While focusing on the resources, forest resource has resulted in an insignificant coefficient, concluding that forest resources have no impact on ecological footprint, in the case of Saudi Arabia. The positive shocks of land resources demonstrate a negative and significant relationship with ecological footprint, confirming that higher-end resources are useful in controlling the environmental degradation process. While emphasizing green variables, the results of environmental technology and renewable energy consumption have reported insignificant coefficients, implying that green variables, such as environmental technology and renewable energy consumption, have no impact on reducing the environmental footprint in the short run.

Before Vision 2030 Analysis

Tables 9 and 10 display the findings for the nonlinear ARDL prior to Vision 2030. For economic growth, positive shocks in the long-run and positive and negative shocks in short-run estimates show a significant impact on ecological footprint. This means that an increase in economic growth increases ecological footprint. These results are similar to previous studies [76,77]. The coefficients of forest resource are insignificant in the short run and in the long run. These results contradict the results of some previous researchers, such as [78,79]. The positive shocks in land resource in the short run have a significant and negative impact on ecological footprint.

Table 9. Nonlinear ARDL estimation (Before Vision 2030).

Long Run	**Model 1**	**Model 2**
EFP_{t-1}	−0.003 ***	−0.004 ***
GDP^{+}_{t-1}	0.006 ***	−0.005
GDP^{-}_{t-1}	−0.002	0.004 ***
FR^{+}_{t-1}	−0.013	
FR^{-}_{t-1}	0.042	
LR^{+}_{t-1}	−0.033	
LR^{-}_{t-1}	−0.056	
ET^{+}_{t-1}		−0.054
ET^{-}_{t-1}		0.032
REC^{+}_{t-1}		−0.031
REC^{-}_{t-1}		0.045
Short Run		
ΔEFP_{t-1}	0.845 ***	0.945 ***
ΔGDP^{+}_{t-1}	0.456 ***	0.024 **
ΔGDP^{-}_{t-1}	0.316 ***	0.006
ΔFR^{+}_{t-1}	0.029	
ΔFR^{-}_{t-1}	−0.024	
ΔLR^{+}_{t-1}	−0.042 ***	
ΔLR^{-}_{t-1}	−0.091	
ΔET^{+}_{t-1}		−0.043 *
ΔET^{-}_{t-1}		0.051
ΔREC^{+}_{t-1}		0.043
ΔREC^{-}_{t-1}		−0.031
Constant	0.046 ***	0.021 ***

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resource and land resource, respectively, which are the natural resources. ET and REC represent the environmental technology and renewable energy consumption, respectively, which reflects the green indicators. Δ is the difference. ***, **, and * represent the level of significance at 1%, 5%, and 10%, respectively.

For environmental technology, the coefficients are significant only in the short run. Positive shocks in environmental technology reduce the ecological footprint in the short run, while negative shocks in environmental technology are insignificant. The positive shocks and negative shocks in renewable energy consumption show an insignificant relationship with ecological footprint. This result contradicts the findings of [77].

Table 10. Asymmetric and model diagnostics (Before Vision 2030).

	Long Run (+)	Long Run (−)	Long-Run Asymmetry (p-Value) W LR	Short-Run Asymmetry (p-Value) W LR
EFP = f (GDP, FR, LR)				
GDP	1.845 ***	0.161	0.000 ***	0.251
FR	−0.042	−0.059 *	0.090 *	0.641
LR	−0.051 *	0.032	0.021	0.031
Cointegration			F-Stat	8.431
Portmanteau			p-value	0.642
Heteroskedasticity			p-value	0.182
Ramsey test			p-value	1.351
J–B test			p-value	0.161
EFP = f (GDP, ET, REC)				
GDP	0.129 **	0.161	0.034 **	0.242
ET	−0.031	0.231	0.033 ***	0.216
REC				
Cointegration			F-Stat	3.241
Portmanteau			p-value	0.531
Heteroskedasticity			p-value	0.502
Ramsey test			p-value	0.441
J–B test			p-value	0.861

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resource and land resource, respectively, which are the natural resources. ET and REC represent the environmental technology and renewable energy consumption, respectively, which reflects the green indicators. ***, **, and * represent the level of significance at 1%, 5%, and 10%, respectively.

After Vision 2030 Analysis

Results for nonlinear ARDL estimations reflecting Vision 2030 are shown in Tables 11 and 12. The positive shocks in economic growth in the long run, whereas positive and negative shocks in the short run, have a significant impact on ecological footprint. Forest resources show an insignificant result in the long run and short run, whereas positive shocks in the long run and short run show a decrease in ecological footprint.

Table 11. Nonlinear ARDL estimation (After Vision 2030).

Long Run	Model 1	Model 2
EFP_{t-1}	−0.002 ***	−0.004 ***
$GDP^{+}{}_{t-1}$	0.004 ***	−0.004
$GDP^{-}{}_{t-1}$	−0.006	0.061 ***
$FR^{+}{}_{t-1}$	−0.017	
$FR^{-}{}_{t-1}$	0.032	
$LR^{+}{}_{t-1}$	−0.056 *	
$LR^{-}{}_{t-1}$	−0.042	
$ET^{+}{}_{t-1}$		−0.034 *
$ET^{-}{}_{t-1}$		0.041
$REC^{+}{}_{t-1}$		−0.062 *
$REC^{-}{}_{t-1}$		0.052
Short Run		
ΔEFP_{t-1}	0.724 ***	0.841 ***
$\Delta GDP^{+}{}_{t-1}$	0.361 ***	0.022 **
$\Delta GDP^{-}{}_{t-1}$	0.521 ***	0.0421
$\Delta FR^{+}{}_{t-1}$	0.027	

Table 11. *Cont.*

Long Run	Model 1	Model 2
ΔFR^{-}_{t-1}	−0.041	
ΔLR^{+}_{t-1}	−0.024 **	
ΔLR^{-}_{t-1}	−0.639	
ΔET^{+}_{t-1}		−0.056 *
ΔET^{-}_{t-1}		0.063 *
ΔREC^{+}_{t-1}		−0.712 **
ΔREC^{-}_{t-1}		0.052
Constant	0.036 ***	0.012 ***

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resource and land resource, respectively, which are the natural resources. ET and REC represent the environmental technology and renewable energy consumption, respectively, which reflects the green indicators. Δ is the difference. ***, **, and * represent the level of significance at 1%, 5%, and 10%, respectively.

Table 12. Asymmetric and model diagnostics (After Vision 2030).

	Long Run (+)	Long Run (−)	Long-Run Asymmetry (*p*-Value) W_{LR}	Short-Run Asymmetry (*p*-Value) W_{LR}
EFP = f (GDP, FR, LR)				
GDP	1.713 ***	0.152	0.000 ***	0.361
FR	−0.048	−0.059 *	0.050 *	0.641
LR	−0.071 *	0.418	0.031	0.022
Cointegration			F-Stat	7.421
Portmanteau			*p*-value	0.532
Heteroskedasticity			*p*-value	0.171
Ramsey test			*p*-value	1.427
J–B test			*p*-value	0.135
EFP = f (GDP, ET, REC)				
GDP	0.149 **	0.166	0.044 **	0.421
ET	−0.031	0.371	0.041 ***	0.272
REC				
Cointegration			F-Stat	3.21
Portmanteau			*p*-value	0.431
Heteroskedasticity			*p*-value	0.423
Ramsey test			*p*-value	0.331
J–B test			*p*-value	0.642

Notes: EFP shows the ecological footprint, GDP is economic growth, FR and LR are forest resource and land resource, respectively, which are the natural resources. ET and REC represent the environmental technology and renewable energy consumption, respectively, which reflects the green indicators. ***, **, and * represent the level of significance at 1%, 5%, and 10%, respectively.

The impact of environmental technology is insignificant overall but shows significant impact in the short run. This means that an increase in environmental technology decreases the ecological footprint, which is in line with [77]. In the case of renewable energy consumption, in both short-run and long-run estimates, positive shocks decrease ecological footprint. This shift can be ascribed to the government's emphasis on renewable energy initiatives such as solar farms. Before Vision 2030, the role of renewable energy consumption is insignificant, whereas the after Vision 2030 results show a significant impact of renewable energy resources on ecological footprint.

4.1.2. Causality Analysis

Table 13 presents the bidirectional relationship with positive coefficients between economic growth and ecological footprint, indicating that an increase in economic growth causes an increase in ecological footprint. Forest resource shows the insignificant negative coefficient, whereas land resource shows a unidirectional relationship with ecological footprint. Environmental technology also shows a unidirectional relationship with negative coefficients, whereas renewable energy consumption shows a bidirectional relationship, indicating that an increase in renewable energy consumption decreases ecological footprint. The impact of environmental footprint on the use of renewable energy is positive and significant. This positive relationship implies changing the overall energy mix to include more renewable energy sources instead of nonrenewable ones.

Table 13. VECM Granger causality tests.

Model 1	**ΔEFP**	**ΔGDP**	**ΔFR**	**ΔLR**	**ECT-1**
ΔEFP	-	0.238 **	−4.424	4.317	
ΔGDP	0.341 **	-	0.921	0.840	−0.250 *
ΔFR	−0.531	0.219	-	0.215	−0.213
ΔLR	−0.632 *	0.031	0.428	-	−0.349 *
Model 2	ΔEFP	ΔGDP	ΔET	ΔREC	ECT-1
ΔEFP	-	0.928	1.574	1.781 *	−0.155
ΔGDP	6.223 **	-	1.035	1.126	−0.349 **
ΔET	−5.932 *	1.384	-	1.749	−0.501 *
ΔREC	−6.196 *	0.042	0.096	-	0.037 *

Notes: **, * indicates the significance at 5% and 10%, respectively.

4.2. Discussion

In the discussion section, we address the study's findings, compare them to the study's objectives, and provide justifications. Focusing on the economic growth, the econometric estimations have confirmed the positive and significant impact of economic growth on environmental footprint. Since Saudi Arabia is an oil-rich country, it uses a higher proportion of oil in electricity generation, and most industries rely on nonrenewable energy for processes, among other things. However, the increase in economic growth requires higher energy consumption, which leads towards environmental degradation. Similar findings are presented by [80,81].

In terms of natural resources, forest resources have reported significant and negative coefficients for the full-sample estimation, while being insignificant before and after Vision 2030. For the empirical estimation of after Vision 2030, land resources are significant and negative. In concise, while addressing the second objective of the study, it seems clear that the increase in natural resources is useful to mitigate the environmental externalities. The reason for this may be the environmental imbalance between ecological footprint and biocapacity [82]. The findings are justified through the plantation of forest, to surge the green land, and is useful to inhale the carbon emission from the atmosphere. Forest resources have a significant impact on the environment, and their depletion increases environmental pollution, while the findings after distribution of data, according to Vision 2030, show that the coefficients of forest are turning to be insignificant. The reason for our insignificant results could be the harsh environmental conditions of Saudi Arabia such as high temperatures, extreme drought, and erratic and low rainfall patterns [78,79]. After the implementation of Saudi Vision 2030, the Saudi government initiated the green Saudi campaign, which has boosted the green land. Resultantly, following Vision 2030, land resources have confirmed their significant role in mitigating environmental impact; similar results are documented by [83].

In full-sample estimation, the insignificance of environmental technology might be possible due to the fact that Saudi Arabia has not yet achieved the technology level that can assist to overcome the environmental issues [84]. This suggests that green factors in Saudi Arabia are not mature enough to reduce ecological footprint, as reported by previous studies, such as [85,86]. Moreover, the emphasis on renewable energy sources is uncertain, and changing the energy mix to fulfill energy demand is complicated. Similar findings have been proposed in other studies, such as [72,87]. In the case of after Vision 2030, while addressing the green indicators, environmental technology has confirmed the significant and negative relationship with environmental footprint. The results of environmental technology indicate the Saudi government's efforts to enact policies that will enhance economic growth and bring Saudi Arabia closer to achieving the Vision 2030 objectives, while renewable energy has a significant and negative coefficient, in the case of after Vision 2030. The results of green indicators address the third objective of the study, confirming the role of green indicators in reducing environmental footprint. The results can be justified through a variety of channels, such as the promotion of environmental technology, which encourages the use of energy-efficient and green equipment and household products, thereby reducing energy consumption and the environmental footprint. In view of the fourth objective, the findings of natural resources and green indicators are turning positive for the environment, which depicts the significance of Saudi Vision 2030 towards the sustainable environment.

5. Conclusions

The study investigates the impact of economic growth, natural resources, and green factors on the environmental quality. For econometric estimations, we have employed the data of studied variables over the period of 1980 to 2019. For missing observations, we use the Markov Chain Monte Carlo (MCMC) algorithm, which is well known for simulating the data. Furthermore, we used the nonlinear ARDL approach, which produces asymmetric results; positive and negative shocks. Considering the ecological footprint as dependent on a variable, the results indicate the direct long-run relationship between economic growth and ecological footprint before Vision 2030 and after Vision 2030. The forest resource has shown an insignificant impact on ecological footprint, whereas land resource has confirmed the significant and negative relationship with the ecological footprint. This significant relationship after Vision 2030 can be due to the focus of policymakers towards better management of land resource to achieve sustainable environmental goals. While emphasizing the environmental technology, the coefficient is significant and negative for after Vision 2030. The second green factor in this study, renewable energy consumption, has an inverse relationship with the ecological footprint following Vision 2030, which shows the Saudi government's efforts to reduce environmental externalities. The study also found a bidirectional relationship between economic growth and ecological footprint, and renewable energy resources and ecological footprint. A unidirectional relationship was found among land resource to ecological footprint, environmental technology to ecological footprint, and renewable energy consumption to ecological footprint.

Since there is a large inverse link between natural resources and ecological footprint, effective utilization of natural resources enhances environmental quality. Therefore, the Saudi government should divert the attention to increase the forest and land resources. For this purpose, the local and provincial authorities should initiate the advertisements and campaigns, such as Saudi green campaigns. Furthermore, communities should plant trees and implement the green roof concept to increase green shade and manage the environmental degradation process. While diverting the attention towards green variable, the Saudi government should promote the advanced and green equipment, home appliances, transport means, etc., that are considered as environmental technology. These environmental technologies are effective to increase the energy efficiency, leading to the reduction in environmental footprint. As far as the renewable energy is concerned, the Saudi government should modify the energy mix by increasing the proportion of renewable energy, thus helping to limit the energy-based emissions.

Author Contributions: G.A. has reviewed the manuscript. R.W. wrote the manuscript and supervised the review of the manuscript. M.I.A. framed the idea, analyzed the results, and reviewed the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: We confirm that this manuscript describes original work and is not under consideration by any other journal. Please let us know if you need any other information.

Informed Consent Statement: Not applicable.

Data Availability Statement: All relevant data are included in the paper and in the supporting information files with added command. The codes are provided on demand.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chai, J.; Zhang, X.; Lu, Q.; Zhang, X.; Wang, Y. Research on Imbalance between Supply and Demand in China's Natural Gas Market under the Double-Track Price System. *Energy Policy* **2021**, *155*, 112380. [CrossRef]
2. Scheffran, J.; Felkers, M.; Froese, R. Economic Growth and the Global Energy Demand. *Green Energy Sustain.* **2020**, 1–44. [CrossRef]
3. Aldubyan, M.; Gasim, A. Energy Price Reform in Saudi Arabia: Modeling the Economic and Environmental Impacts and Understanding the Demand Response. *Energy Policy* **2021**, *148*, 111941. [CrossRef]
4. Kahouli, B.; Hamdi, B.; Nafla, A.; Chabaane, N. Investigating the Relationship between ICT, Green Energy, Total Factor Productivity, and Ecological Footprint: Empirical Evidence from Saudi Arabia. *Energy Strateg. Rev.* **2022**, *42*, 100871. [CrossRef]
5. Waheed, R. Energy Challenges, Green Growth, Blue Indicators, and Sustainable Economic Growth: A Study of Saudi Arabia. *Eval. Rev.* **2022**, 0193841X2211346. [CrossRef] [PubMed]
6. Krane, J.; Wilson, W.S. The Bottom of the Barrel: Saudi Aramco and Global Climate Action. 2021. Available online: https://www.bakerinstitute.org/research/bottom-barrel-saudi-aramco-and-global-climate-action (accessed on 20 December 2022).
7. Statista. Saudi Arabia: Fossil Fuel CO_2 Emissions 1970–2021 | Statista. 2022. Available online: https://www.statista.com/statistics (accessed on 20 December 2022).
8. Arab News Saudi Arabia Bolsters Its Green Initiatives amid Climate Change Concerns. 2022. Available online: https://www.arabnews.com/node/2196976/business-economy (accessed on 20 December 2022).
9. Aziz, G.; Sarwar, S.; Waheed, R.; Khan, M.S. Significance of Hydrogen Energy to Control the Environmental Gasses in Light of COP26: A Case of European Countries. *Resour. Policy* **2023**, *80*, 103240. [CrossRef]
10. Shahbaz, M.; Sinha, A.; Raghutla, C.; Vo, X.V. Decomposing Scale and Technique Effects of Financial Development and Foreign Direct Investment on Renewable Energy Consumption. *Energy* **2022**, *238*, 121758. [CrossRef]
11. Sadiq, M.; Wen, F.; Dagestani, A.A. Environmental Footprint Impacts of Nuclear Energy Consumption: The Role of Environmental Technology and Globalization in Ten Largest Ecological Footprint Countries. *Nucl. Eng. Technol.* **2022**, *54*, 3672–3681. [CrossRef]
12. Teimoory, N.; Sasaki, N.; Abe, I. Estimation of Baseline Emissions, Forest Reference Emission Level, and Carbon Removals Due to Forest Area Changes in Afghanistan between 1993 and 2030. *Clean. Prod. Lett.* **2022**, *2*, 100003. [CrossRef]
13. Raihan, A.; Tuspekova, A. Toward a Sustainable Environment: Nexus between Economic Growth, Renewable Energy Use, Forested Area, and Carbon Emissions in Malaysia. *Resour. Conserv. Recycl. Adv.* **2022**, *15*, 200096. [CrossRef]
14. Zafar, M.W.; Saeed, A.; Zaidi, S.A.H.; Waheed, A. The Linkages among Natural Resources, Renewable Energy Consumption, and Environmental Quality: A Path toward Sustainable Development. *Sustain. Dev.* **2021**, *29*, 353–362. [CrossRef]
15. Danish; Baloch, M.A.; Mahmood, N.; Zhang, J.W. Effect of Natural Resources, Renewable Energy and Economic Development on CO_2 Emissions in BRICS Countries. *Sci. Total Environ.* **2019**, *678*, 632–638. [CrossRef] [PubMed]
16. Raihan, A.; Tuspekova, A. The Nexus between Economic Growth, Renewable Energy Use, Agricultural Land Expansion, and Carbon Emissions: New Insights from Peru. *Energy Nexus* **2022**, *6*, 100067. [CrossRef]
17. Mohd Jaafar, W.S.W.; Maulud, K.N.A.; Muhmad Kamarulzaman, A.M.; Raihan, A.; Sah, S.M.; Ahmad, A.; Maizah Saad, S.N.; Mohd Azmi, A.T.; Syukri, N.K.A.J.; Khan, W.R. The Influence of Deforestation on Land Surface Temperature—A Case Study of Perak and Kedah, Malaysia. *Forests* **2020**, *11*, 670. [CrossRef]
18. Parajuli, R.; Joshi, O.; Maraseni, T. Incorporating Forests, Agriculture, and Energy Consumption in the Framework of the Environmental Kuznets Curve: A Dynamic Panel Data Approach. *Sustainability* **2019**, *11*, 2688. [CrossRef]
19. Danish; Ulucak, R.; Khan, S.U.D. Determinants of the Ecological Footprint: Role of Renewable Energy, Natural Resources, and Urbanization. *Sustain. Cities Soc.* **2020**, *54*, 101996. [CrossRef]
20. Xin, F.; Qian, Y. Does Fiscal Decentralization Promote Green Utilization of Land Resources? Evidence from Chinese Local Governments. *Resour. Policy* **2022**, *79*, 103086. [CrossRef]
21. Danish; Ulucak, R. How Do Environmental Technologies Affect Green Growth? Evidence from BRICS Economies. *Sci. Total Environ.* **2020**, *712*, 136504. [CrossRef]
22. Hussain, M.; Dogan, E. The Role of Institutional Quality and Environment-Related Technologies in Environmental Degradation for BRICS. *J. Clean. Prod.* **2021**, *304*, 127059. [CrossRef]
23. Erdoğan, S.; Yıldırım, S.; Yıldırım, D.Ç.; Gedikli, A. The Effects of Innovation on Sectoral Carbon Emissions: Evidence from G20 Countries. *J. Environ. Manag.* **2020**, *267*, 110637. [CrossRef]
24. McCombie, C.; Jefferson, M. Renewable and Nuclear Electricity: Comparison of Environmental Impacts. *Energy Policy* **2016**, *96*, 758–769. [CrossRef]
25. Lau, L.S.; Choong, C.K.; Ng, C.F.; Liew, F.M.; Ching, S.L. Is Nuclear Energy Clean? Revisit of Environmental Kuznets Curve Hypothesis in OECD Countries. *Econ. Model.* **2019**, *77*, 12–20. [CrossRef]

26. Sarkodie, S.A.; Adams, S. Renewable Energy, Nuclear Energy, and Environmental Pollution: Accounting for Political Institutional Quality in South Africa. *Sci. Total Environ.* **2018**, *643*, 1590–1601. [CrossRef] [PubMed]
27. Danish; Ulucak, R.; Erdogan, S. The Effect of Nuclear Energy on the Environment in the Context of Globalization: Consumption vs. Production-Based CO_2 Emissions. *Nucl. Eng. Technol.* **2022**, *54*, 1312–1320. [CrossRef]
28. Lee, C.C.; Chiu, Y. Bin Oil Prices, Nuclear Energy Consumption, and Economic Growth: New Evidence Using a Heterogeneous Panel Analysis. *Energy Policy* **2011**, *39*, 2111–2120. [CrossRef]
29. Mahmood, N.; Danish; Wang, Z.; Zhang, B. The Role of Nuclear Energy in the Correction of Environmental Pollution: Evidence from Pakistan. *Nucl. Eng. Technol.* **2020**, *52*, 1327–1333. [CrossRef]
30. Altıntaş, H.; Kassouri, Y. Is the Environmental Kuznets Curve in Europe Related to the Per-Capita Ecological Footprint or CO_2 Emissions? *Ecol. Indic.* **2020**, *113*, 106187. [CrossRef]
31. Shin, Y.; Yu, B.; Greenwood-Nimmo, M. Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. In *Festschrift Honor Peter Schmidt*; Springer: New York, NY, USA, 2014; pp. 281–314. [CrossRef]
32. Ahmad, A.; Zhao, Y.; Shahbaz, M.; Bano, S.; Zhang, Z.; Wang, S.; Liu, Y. Carbon Emissions, Energy Consumption and Economic Growth: An Aggregate and Disaggregate Analysis of the Indian Economy. *Energy Policy* **2016**, *96*, 131–143. [CrossRef]
33. Mrabet, Z.; AlSamara, M.; Hezam Jarallah, S. The Impact of Economic Development on Environmental Degradation in Qatar. *Environ. Ecol. Stat.* **2017**, *24*, 7–38. [CrossRef]
34. Zaidi, S.A.H.; Danish; Hou, F.; Mirza, F.M. The Role of Renewable and Non-Renewable Energy Consumption in CO_2 Emissions: A Disaggregate Analysis of Pakistan. *Environ. Sci. Pollut. Res.* **2018**, *25*, 31616–31629. [CrossRef]
35. Zafar, M.W.; Sinha, A.; Ahmed, Z.; Qin, Q.; Zaidi, S.A.H. Effects of Biomass Energy Consumption on Environmental Quality: The Role of Education and Technology in Asia-Pacific Economic Cooperation Countries. *Renew. Sustain. Energy Rev.* **2021**, *142*, 110868. [CrossRef]
36. Danish; Baloch, M.A. Dynamic Linkages between Road Transport Energy Consumption, Economic Growth, and Environmental Quality: Evidence from Pakistan. *Environ. Sci. Pollut. Res.* **2018**, *25*, 7541–7552. [CrossRef] [PubMed]
37. Wenlong, Z.; Nawaz, M.A.; Sibghatullah, A.; Ullah, S.E.; Chupradit, S.; Minh Hieu, V. Impact of Coal Rents, Transportation, Electricity Consumption, and Economic Globalization on Ecological Footprint in the USA. *Environ. Sci. Pollut. Res.* **2022**, *1*, 1–16. [CrossRef] [PubMed]
38. Adekoya, O.B.; Oliyide, J.A.; Fasanya, I.O. Renewable and Non-Renewable Energy Consumption–Ecological Footprint Nexus in Net-Oil Exporting and Net-Oil Importing Countries: Policy Implications for a Sustainable Environment. *Renew. Energy* **2022**, *189*, 524–534. [CrossRef]
39. Ekins, P. The Kuznets Curve for the Environment and Economic Growth: Examining the Evidence. *Environ. Plan. A Econ. Sp.* **1997**, *29*, 805–830. [CrossRef]
40. Stern, D.I.; Common, M.S.; Barbier, E.B. Economic Growth and Environmental Degradation: The Environmental Kuznets Curve and Sustainable Development. *World Dev.* **1996**, *24*, 1151–1160. [CrossRef]
41. Grossman, G. Pollution and Growth: What Do We Know? In *CEPR Discussion Paper*; Centre for Economic Policy Research: London, UK, 1993.
42. Joshua, U.; Bekun, F.V. The Path to Achieving Environmental Sustainability in South Africa: The Role of Coal Consumption, Economic Expansion, Pollutant Emission, and Total Natural Resources Rent. *Environ. Sci. Pollut. Res.* **2020**, *27*, 9435–9443. [CrossRef]
43. Adebayo, T.S. Revisiting the EKC Hypothesis in an Emerging Market: An Application of ARDL-Based Bounds and Wavelet Coherence Approaches. *SN Appl. Sci.* **2020**, *2*, 1945. [CrossRef]
44. Teng, J.Z.; Khan, M.K.; Khan, M.I.; Chishti, M.Z.; Khan, M.O. Effect of Foreign Direct Investment on CO_2 Emission with the Role of Globalization, Institutional Quality with Pooled Mean Group Panel ARDL. *Environ. Sci. Pollut. Res.* **2021**, *28*, 5271–5282. [CrossRef]
45. Zmami, M.; Ben-Salha, O. An Empirical Analysis of the Determinants of CO_2 Emissions in GCC Countries. *Int. J. Sustain. Dev. World Ecol.* **2020**, *27*, 469–480. [CrossRef]
46. Raihan, A.; Muhtasim, D.A.; Pavel, M.I.; Faruk, O.; Rahman, M. An Econometric Analysis of the Potential Emission Reduction Components in Indonesia. *Clean. Prod. Lett.* **2022**, *3*, 100008. [CrossRef]
47. Ahmed, Z.; Asghar, M.M.; Malik, M.N.; Nawaz, K. Moving towards a Sustainable Environment: The Dynamic Linkage between Natural Resources, Human Capital, Urbanization, Economic Growth, and Ecological Footprint in China. *Resour. Policy* **2020**, *67*, 101677. [CrossRef]
48. Balsalobre-Lorente, D.; Shahbaz, M.; Roubaud, D.; Farhani, S. How Economic Growth, Renewable Electricity and Natural Resources Contribute to CO_2 Emissions? *Energy Policy* **2018**, *113*, 356–367. [CrossRef]
49. Zafar, M.W.; Zaidi, S.A.H.; Khan, N.R.; Mirza, F.M.; Hou, F.; Kirmani, S.A.A. The Impact of Natural Resources, Human Capital, and Foreign Direct Investment on the Ecological Footprint: The Case of the United States. *Resour. Policy* **2019**, *63*, 101428. [CrossRef]
50. Liu, H.; Khan, I.; Zakari, A.; Alharthi, M. Roles of Trilemma in the World Energy Sector and Transition towards Sustainable Energy: A Study of Economic Growth and the Environment. *Energy Policy* **2022**, *170*, 113238. [CrossRef]
51. Álvarez-Herránz, A.; Balsalobre, D.; Cantos, J.M.; Shahbaz, M. Energy Innovations-GHG Emissions Nexus: Fresh Empirical Evidence from OECD Countries. *Energy Policy* **2017**, *101*, 90–100. [CrossRef]

52. Tang, C.F.; Tan, E.C. Exploring the Nexus of Electricity Consumption, Economic Growth, Energy Prices and Technology Innovation in Malaysia. *Appl. Energy* **2013**, *104*, 297–305. [CrossRef]
53. Acaravci, A.; Ozturk, I. On the Relationship between Energy Consumption, CO_2 Emissions and Economic Growth in Europe. *Energy* **2010**, *35*, 5412–5420. [CrossRef]
54. Shahbaz, M.; Kumar Tiwari, A.; Nasir, M. The Effects of Financial Development, Economic Growth, Coal Consumption and Trade Openness on CO_2 Emissions in South Africa. *Energy Policy* **2013**, *61*, 1452–1459. [CrossRef]
55. Jalil, A.; Feridun, M. The Impact of Growth, Energy and Financial Development on the Environment in China: A Cointegration Analysis. *Energy Econ.* **2011**, *33*, 284–291. [CrossRef]
56. Bélaïd, F.; Youssef, M. Environmental Degradation, Renewable and Non-Renewable Electricity Consumption, and Economic Growth: Assessing the Evidence from Algeria. *Energy Policy* **2017**, *102*, 277–287. [CrossRef]
57. Alola, A.A.; Bekun, F.V.; Sarkodie, S.A. Dynamic Impact of Trade Policy, Economic Growth, Fertility Rate, Renewable and Non-Renewable Energy Consumption on Ecological Footprint in Europe. *Sci. Total Environ.* **2019**, *685*, 702–709. [CrossRef]
58. Chen, Y.; Zhao, J.; Lai, Z.; Wang, Z.; Xia, H. Exploring the Effects of Economic Growth, and Renewable and Non-Renewable Energy Consumption on China's CO_2 Emissions: Evidence from a Regional Panel Analysis. *Renew. Energy* **2019**, *140*, 341–353. [CrossRef]
59. Sinha, A.; Shahbaz, M. Estimation of Environmental Kuznets Curve for CO_2 Emission: Role of Renewable Energy Generation in India. *Renew. Energy* **2018**, *119*, 703–711. [CrossRef]
60. Ben Jebli, M.; Ben Youssef, S. Renewable Energy Consumption and Agriculture: Evidence for Cointegration and Granger Causality for Tunisian Economy. *Dev. World Ecol.* **2016**, *24*, 149–158. [CrossRef]
61. Biresselioglu, M.E.; Demir, M.H.; Demirbag Kaplan, M.; Solak, B. Individuals, Collectives, and Energy Transition: Analysing the Motivators and Barriers of European Decarbonisation. *Energy Res. Soc. Sci.* **2020**, *66*, 101493. [CrossRef]
62. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds Testing Approaches to the Analysis of Level Relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
63. Kumar Narayan, P. An Application to the Tourism Demand Model for Fiji Terrorism and International Stock Returns. *Tour. Econ.* **2004**, *10*, 193–206.
64. Qamruzzaman, M.; Jianguo, W. Nexus between Financial Innovation and Economic Growth in South Asia: Evidence from ARDL and Nonlinear ARDL Approaches. *Financ. Innov.* **2018**, *4*, 20. [CrossRef]
65. Morley, B. Causality between Economic Growth and Immigration: An ARDL Bounds Testing Approach. *Econ. Lett.* **2006**, *90*, 72–76. [CrossRef]
66. Andrews, D.W.K. Tests for Parameter Instability and Structural Change with Unknown Change Point. *Econometrica* **1993**, *61*, 821. [CrossRef]
67. Andrews, D.W.K.; Ploberger, W. Optimal Tests When a Nuisance Parameter Is Present Only Under the Alternative. *Econometrica* **1994**, *62*, 1383. [CrossRef]
68. Broock, W.A.; Scheinkman, J.A.; Dechert, W.D.; LeBaron, B. A Test for Independence Based on the Correlation Dimension. *Econom. Rev.* **1996**, *15*, 197–235. [CrossRef]
69. Uddin, G.A.; Alam, K.; Gow, J. Ecological and Economic Growth Interdependency in the Asian Economies: An Empirical Analysis. *Environ. Sci. Pollut. Res.* **2019**, *26*, 13159–13172. [CrossRef]
70. Destek, M.A.; Ulucak, R.; Dogan, E. Analyzing the Environmental Kuznets Curve for the EU Countries: The Role of Ecological Footprint. *Environ. Sci. Pollut. Res.* **2018**, *25*, 29387–29396. [CrossRef] [PubMed]
71. Waheed, R.; Sarwar, S.; Alsaggaf, M.I. Relevance of Energy, Green and Blue Factors to Achieve Sustainable Economic Growth: Empirical Study of Saudi Arabia. *Technol. Forecast. Soc. Chang.* **2023**, *187*, 122184. [CrossRef]
72. Sarwar, S. Impact of Energy Intensity, Green Economy and Blue Economy to Achieve Sustainable Economic Growth in GCC Countries: Does Saudi Vision 2030 Matters to GCC Countries. *Renew. Energy* **2022**, *191*, 30–46. [CrossRef]
73. Samargandi, N. Sector Value Addition, Technology and CO_2 Emissions in Saudi Arabia. *Renew. Sustain. Energy Rev.* **2017**, *78*, 868–877. [CrossRef]
74. Kahia, M.; Omri, A.; Jarraya, B. Green Energy, Economic Growth and Environmental Quality Nexus in Saudi Arabia. *Sustainability* **2021**, *13*, 1264. [CrossRef]
75. Çakmak, E.E.; Acar, S. The Nexus between Economic Growth, Renewable Energy and Ecological Footprint: An Empirical Evidence from Most Oil-Producing Countries. *J. Clean. Prod.* **2022**, *352*, 131548. [CrossRef]
76. Waheed, R.; Sarwar, S.; Dignah, A. The Role of Non-Oil Exports, Tourism and Renewable Energy to Achieve Sustainable Economic Growth: What We Learn from the Experience of Saudi Arabia. *Struct. Chang. Econ. Dyn.* **2020**, *55*, 49–58. [CrossRef]
77. Waheed, R.; Chang, D.; Sarwar, S.; Chen, W. Forest, Agriculture, Renewable Energy, and CO_2 Emission. *J. Clean. Prod.* **2018**, *172*, 4231. [CrossRef]
78. Samargandi, N. Oil Exploration, Biocapacity, and Ecological Footprint in Saudi Arabia. *Environ. Sci. Pollut. Res.* **2021**, *28*, 54621–54629. [CrossRef] [PubMed]
79. Sahoo, B.; Behera, D.K.; Rahut, D. Decarbonization: Examining the Role of Environmental Innovation versus Renewable Energy Use. *Environ. Sci. Pollut. Res.* **2022**, *29*, 48704–48719. [CrossRef] [PubMed]
80. Munir, K.; Ameer, A. Effect of Economic Growth, Trade Openness, Urbanization, and Technology on Environment of Asian Emerging Economies. *Manag. Environ. Qual. Int. J.* **2018**, *29*, 1123–1134. [CrossRef]

81. Ahmad, M.; Jiang, P.; Majeed, A.; Umar, M.; Khan, Z.; Muhammad, S. The Dynamic Impact of Natural Resources, Technological Innovations and Economic Growth on Ecological Footprint: An Advanced Panel Data Estimation. *Resour. Policy* **2020**, *69*, 101817. [CrossRef]
82. Wang, Q.; Zhang, F.; Li, R.; Li, L. The Impact of Renewable Energy on Decoupling Economic Growth from Ecological Footprint–An Empirical Analysis of 166 Countries. *J. Clean. Prod.* **2022**, *354*, 131706. [CrossRef]
83. Bala, G.; Caldeira, K.; Wickett, M.; Phillips, T.J.; Lobell, D.B.; Delire, C.; Mirin, A. Combined Climate and Carbon-Cycle Effects of Large-Scale Deforestation. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 6550–6555. [CrossRef]
84. Panja, P. Deforestation, Carbon Dioxide Increase in the Atmosphere and Global Warming: A Modelling Study. *Int. J. Model. Simul.* **2019**, *41*, 209–219. [CrossRef]
85. Waheed, R.; Sarwar, S.; Wei, C. The Survey of Economic Growth, Energy Consumption and Carbon Emission. *Energy Rep.* **2019**, *5*, 1103–1115. [CrossRef]
86. Sarwar, S.; Alsaggaf, M.I. Role of Urbanization and Urban Income in Carbon Emissions: Regional Analysis of China. *Appl. Ecol. Environ. Res.* **2019**, *17*, 10303–10311. [CrossRef]
87. Li, Z.; Mighri, Z.; Sarwar, S.; Wei, C. Effects of Forestry on Carbon Emissions in China: Evidence From a Dynamic Spatial Durbin Model. *Front. Environ. Sci.* **2021**, *9*, 1–15. [CrossRef]