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The Impact of Economic Growth, Natural Resources, Urbanization and Biocapacity on the Ecological Footprint: The Case of Turkey

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Abstract: This study investigated the impact of natural resources, urbanization, biological capacity, and economic growth (EG) on the ecological footprint (EFP) in Turkey between 1970 and 2018. The Autoregressive Distributed Lag (ARDL) method was used to investigate the short- and long-term effects. The findings indicate that EG and biological capacity increase the EFP in both the short and long term. In addition to these results, the long-term results show that the Environmental Kuznets Curve (EKC) hypothesis is valid for Turkey and that urbanization has a negative impact on the EFP. The Vector Error Correction Model (VECM) applied to determine the relationship between the variables reveals that, in the short term, unilateral causalities exist from EG to the EFP, from urbanization to economic growth, and from biological capacity to EG. The long-term causality results show a bidirectional causality relationship between the EFP, urbanization and biological capacity. In light of these findings, important policy recommendations are provided for policymakers in Turkey to achieve sustainable growth and improve environmental quality.

Keywords: economic growth; natural resources; urbanization; biocapacity; ecological footprint

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1. Introduction

In the last fifty years, significant economic, social and political developments have taken place [1]. However, along with these positive developments, it is observed that there have been significant increases in climate change, global warming and environmental pollution. In this context, Greenhouse gas (GHG) emissions, which were balanced for a short period between 2014 and 2016, have increased by 1.5% in the last decade [2]. The total GHG emissions reached 52.8 gigatons of carbon dioxide ($GtCO_2$) in 2021 due to changes in land use. Fossil CO_2 emissions from energy use and industry reached 37 $GtCO_2$ in 2020 [3]. The greatest challenge facing global sustainable development is seen as environmental degradation caused by increasing GHG emissions.

The indicator of environmental degradation, GHG emissions, has been widely used in the literature due to its high share in environmental degradation and the easy availability of data [4–11]. However, Ulucak and Apergis [12] proposed the use of EFP as an environmental degradation indicator, as CO_2 emissions alone would not be sufficient for the stocks of mining, land, fishing, forestry and petroleum resources. Thus, the ecological impact of humanity under prevailing management and production practices is measured as the biologically productive land and water area needed to produce the resources consumed and absorb the waste generated by humanity in any given year [13]. The EFP, which measures the intensive and complex impact of humanity on the environment, has been used in academic studies in recent years [1,4,14–21]. In the literature, studies have examined the effect of EG and the validity of the Environmental Kuznets Curve (EKC) Hypothesis [22–25], the effects of renewable and non-renewable energy consumption [26–28], the effect of foreign direct investment (FDI) [6,29,30], the effect of globalization [31] and the effect of tourism [32–34] on EFP.

The impact of various factors on environmental degradation has been studied by several researchers, but it can be seen that the effects of natural resource use and urbanization on EFP have not been sufficiently examined and the few studies that have been conducted are for specific countries or groups of countries [22,35,36]. EG, which is one of the most basic objectives of countries, directs countries towards industrialization, thereby increasing energy demand and leading to the use of the natural resources that countries possess [37]. While the use of natural resources has a positive impact on EG, other activities can have negative effects on the environment. Therefore, negative consequences such as the loss of or decrease in the capacity of productive land and the reduction in water capacity occur [38]. On the other hand, EG leads to rapid urbanization which, in turn, increases transportation and energy demand. Meeting the increasing demand for transportation and energy with fossil sources creates negative pressure on the biological capacity and leads to an increase in the EFP [39]. On the other hand, urbanization enables greater efficiency and energy savings in the use of resources per unit of production. Urbanization is one of the major driving forces of EG. No country has moved from poverty to middle-income status without rapid urbanization. However, the effective management of the urbanization process will help achieve the sustainable development goals [2]. According to the Emissions Gap Report 2019, G20 member countries account for approximately 78% of global GHG emissions [including land use]. Therefore, the policies that these countries implement are considered important for the future trend of global emissions and how much the emissions gap will be closed in the coming years. Within the scope of the nationally determined contributions (NDCs) of G20 member countries, it is estimated that China, the European Union 28, India, Mexico, Russia and Turkey will reach their targets with their current policies, and India, Russia and Turkey will have emission levels 15% lower than their targets [2].

When evaluated in terms of its economic performance over the past 20 years, Turkey has achieved significant positive developments in GHG emissions. Its per capita gross national income has increased by more than two-fold, from USD 4200 in 2000 to USD 9505 in 2018 [40]. However, due to consecutive quarterly declines in 2019, the country's EG rate was only 0.9% [41]. In 2022, Turkey returned to a growth trend and recorded an annual growth rate of 5.6% [40]. On the other hand, Turkey's urbanization rate has also increased significantly during its 20-year EG process. The urbanization rate in Turkey, which was 25% in the 1950s, increased to 44% in 1980, 65% in 2000 [42], 70.83% in 2010 and 74.64% in 2017 [43]. According to the United Nations World Urbanization Prospects report, the world's rural population, which was 3.4 billion in 2018, is expected to decrease to 3.1 billion by 2050 and, as part of this expectation, Turkey's rural population is expected to decrease by 6.927 million in 2050. Additionally, according to the World Sustainable Development 2020 report, 98% of the population in Turkey uses basic drinking water services, the loss of freshwater to available freshwater sources is 42%, the protected average area in marine areas important for biological diversity is 4.1%, the clean water score for the Ocean Health Index is 50, the protected average area in terrestrial areas important for clean biological diversity is 2.5% and the permanent deforestation rate [percentage of forest area, last five-year average] is 0.020% [44].

In this study, the EFP, which takes into account cultivated land, pasture land, fishing grounds, forested areas and carbon footprint, will be used as an environmental degradation indicator instead of CO_2 emissions to more comprehensively determine environmental degradation. The main objective of the study is to investigate the impact of EG, natural resources, urbanization and biological capacity on the EFP in Turkey between 1970 and 2018. The ARDL method is used in the study to examine the short- and long-term effects.

This study aims to fill gaps in the literature and present new perspectives. (i) Most of the environmental studies conducted in Turkey have focused on carbon emissions. Therefore, identifying factors that affect the EFP, which has a limited number of studies, would contribute to expanding the environmental literature. (ii) Turkey's per capita income increased steadily between 2001 and 2008, but has been declining steadily since 2009. According to the EKC hypothesis, environmental degradation and pollution first increase with increasing per capita income and then decrease after reaching a sufficiently high income level. Significant fluctuations have occurred in Turkey's per capita income over the past 40 years. Therefore, it is important to determine the short- and long-term effects of Turkey's EG on environmental quality, as there is considerable variability in per capita income in Turkey. (iii) Developing countries may allow the use of natural resources to accelerate economic development and relax environmental regulations to attract relatively dirty industries in developed countries. Although natural resource abundance has negative effects on the environment, it also has the potential to improve environmental quality [45]. In other words, natural resource abundance has the potential to be a significant catalyst for improving environmental quality, but the excessive and inefficient use of natural resources can have adverse environmental effects. Therefore, the impact of natural resources on environmental quality in developing Turkey is uncertain, and this is a strong motivation for researchers to define the relationship between natural resources and EFP. (iv) As a developing country, Turkey is experiencing intense rural-to-urban migration and the inevitable consequences of urbanization are environmental problems. In other words, both the urbanization rate and per capita EFP have been steadily increasing in Turkey since 1970. Therefore, the impact of these variables on the environment in Turkey must be concretely addressed. (v) There is very limited research on biological capacity and environmental quality, and these studies have not been conducted on a sample from Turkey. This study will present the first empirical findings on the impact of biological capacity on the EFP. (vi) Identifying factors that affect the EFP in Turkey can contribute to the development of policies aimed at improving environmental quality, one of Turkey's Sustainable Development Goals. Additionally, the findings from this study can help policymakers regulate environmental quality strategies more realistically and accurately.

2. Literature Review

Globally, the biggest problem facing the world is seen as the environmental degradation caused by global warming and climate change. The aim is to reduce this pressure on the environment and ensure the sustainability of resources. In this context, sustainable development is built on three main elements: social, economic and environmental [46]. Studies examining the relationship between environmental degradation and EG have been developed within the framework of the EKC hypothesis proposed by Grossman and Krueger [47]. The EKC hypothesis argues that the relationship between per capita income and environmental pollution indicators takes the form of an inverted U-shape. There are many studies over the past twenty years that have examined the EKC hypothesis using carbon emissions as an indicator of environmental pollution [5,6,17,23,32,48–55]. Al-Mualli et al. [5] examined the validity of the EKC hypothesis on ninety-three countries divided by income. The study found that the EKC was valid for middle-high and high-income countries, but not for low-middle and low-income countries. Uddin et al. [24] examined the validity of the EKC on twenty-two countries and found that it was valid for ten of them. The findings of Destek et al. [56], in their study of the EU countries, support the inverse U-shaped relationship between income and EFP. In another study, Destek and Sinha [26] analyzed the validity of the EKC for twenty-four OECD countries between 1980 and 2014. The findings showed that the EKC was invalid for these countries, and that there was a U-shaped relationship between EG and EFP. Ulucak and Erdem [14] examined the impact of EFP on income in seven developed and seven developing countries. The analysis found that environmental factors had a significant impact on the EG of countries. Specifically, the impact of EFP on income was higher than that of other production factors in developing countries. Similarly, Liu et al. [29] found a U-shaped EKC curve for 125 countries; Sun et al. [57] for China; Jahanger et al. [58] for 78 developing countries; and Hossain et al. [59] for India. However, Gao et al. [60] confirmed the N-shaped

EKC hypothesis for high-polluting economies, whereas Fakher et al. [61] confirmed it for OPEC countries.

Human activities have led to environmental degradation, ultimately affecting the quality of the environment due to the depletion of natural resources, species expansion, changes in air and ecological scarcity [30,62]. In other words, natural resource use can lead to problems such as the degradation of ecological environments and landscapes, global warming and desertification [63]. In this context, authors such as Bekun et al. [64], Khan et al. [65], and Zhang et al. [66] have examined the relationship between natural resources and carbon emissions. Dagar et al. [67] have argued that natural resources can help reduce environmental degradation in 38 OECD countries. Additionally, authors such as Zallé [68], González-Val and Pueyo [69], Cui et al. [70], Zahoor et al. [63] and Wu et al. [71] have found a positive relationship between natural resource abundance and environmental sustainability. Gao and Tian [72] have found that natural resource consumption has a one-way causality with EF and that excessive natural resource consumption leads to ecological deficits and overshoots. Hassan et al. [15] have found a positive effect of natural resources on EFP in Pakistan and a bidirectional causality relationship between natural resources and EFP. However, Zafar et al. [4] have concluded, in the United States sample, that natural resources help decrease the level of EFP and that there is a one-way causality relationship between natural resources EFP. Similarly, Azam et al. [73] found a negative relationship between natural resources and CO_2 emissions in the French sample.

Another variable that affects EF is urbanization. With urbanization, the development of nations and improvement in living standards require higher energy demand and intensify CO_2 emissions [74–76]. Industrial development ultimately promotes EG by accelerating energy demand and CO_2 emissions through inter-sectoral events, thus encouraging environmental degradation [22,77,78]. On the other hand, urbanization can lead to lower environmental degradation by offering opportunities for innovation, research and development [79,80]. In their study, Al-Mualli and Ozturk [22] examined the relationship between urbanization and EFP for 14 MENA countries and found that urbanization increased the EFP level. Long et al. [36] investigated the effects of urbanization on EFP for low, middle and high-income countries and revealed that urbanization had a decreasing effect on EFP with increasing income. Danish and Wang [81] explored the relationship between energy consumption, urbanization, EG and EFP in developing countries. Their study found that urbanization increased EFP, while EG and urbanization had a reducing effect on EFP. Nathaniel et al. [82] found that urbanization had an increasing effect on environmental pollution in CIVETS countries. Ahmed et al. [83] determined that urbanization increased EFP and that there was a one-way causality relationship from urbanization to EFP in G7 countries. Similarly, Nathaniel and Khan [84] found that urbanization had a negative impact on EFP in ASEAN countries, Nathaniel et al. [37] found the same in MENA countries, and Nathaniel [85] found it in Indonesia. However, Yasin et al. [18] asserted in their study that urbanization had a decreasing effect on EFP in both developed and developing countries among 110 countries. Likewise, Ulucak and Khan [46] found that urbanization decreased EFP levels in BRICS countries. Yang and Khan [86] identified that urbanization has an adverse effect on long-term environmental sustainability for 30 countries that are members of the International Energy Agency [IEA].

In scientific terms, ecological overshoot occurs when a country's EF exceeds its biological capacity, indicating that the country is importing biological capacity from other countries, depleting its ecological assets, or emitting carbon dioxide into the atmosphere [87]. The decline of countries' biological capacities has become an increasingly pressing environmental issue, leading to a growing body of research on the relationship between biological capacity and the environment. For example, Hasan et al. [38] found that, in the case of Pakistan, biological capacity increased EFP. Similarly, Pandey et al. [88] confirmed, in the context of Asia, Marti and Puertas [89] in Africa and Nathaniel [85] in G7 countries, that biological capacity promotes environmental pollution. Unal and Aktug [90] divided their study into two groups: G20 developed and developing economies. They found that biological capacity increased EF in both the short and long term for developing economies, but only in the short term for developed economies. Yang and Khan [91] found that biological capacity increased EF in both the short and long term for 30 countries belonging to the International Energy Agency (IEA).

Upon evaluating studies on environmental pollution, it can be seen that empirical studies using different environmental indicators are available, especially focusing on testing the validity of the EKC hypothesis. Moreover, the EFP, which is considered to more comprehensively determine environmental degradation, has been included in many studies as an environmental indicator. Recently, the impact of factors such as energy consumption, EG, FDI, financial development, globalization and tourism, which are thought to play a decisive role in the EFP, have been extensively researched. Nonetheless, there are limited studies on the impact of biological capacity, natural resources and urbanization on environmental quality. It is observed that, in developing countries, industrialization has increased with the aim of rapid EG, leading to an increase in the rate of urbanization and natural resource use, creating pressure on the environment. In this sense, the study of the effects of urbanization, biological capacity and natural resource income on the environment, as well as the use of the EFP as an environmental degradation indicator, differentiates the Turkish sample from the literature. The obtained results will expand the environmental literature and provide the first empirical findings on the Turkish sample.

3. Data and Econometric Method

3.1. Data

The EFP provides comprehensive information about environmental degradation as it consists of carbon sequestration footprint, grazing land footprint, fishing ground footprint, cropland footprint, forest footprint and built-up land footprint components. The variables used in the study are shown in Table 1.

Table 1. Data description.

Variable(s)	Pictogram	Unit Measurement(s)	Source
Ecological footprint	lnEFP	The EFP of Consumption (Global hectares per capita)	Global Foodprint Network
Economic Growth	lnGDP	GDP per capita (constant 2015 USD)	Worldbank
Natural Resources	lnNR	Total natural resource income (% of GDP)	Worldbank
Urbanization	lnURB	Urbanization (% of GDP)	Worldbank
Biocapacity	lnBIO	Biocapacity per person	Global Foodprint Network

3.2. Model and Econometric Strategy

The empirical model demonstrating the relationship between the variables is as follows:

$$lnEFP_{it} = \beta_0 + \beta_1 lnGDPPC_{it} + \beta_2 lnGDPPCK_{it} + \beta_3 lnNR_{it} + \beta_4 lnURB_{it} + \beta_5 lnBIO_{it} + \vartheta_t \quad (1)$$

The natural logarithm of variables in the model (lnEFP) represents per capita EFP, (lnGDPPC) [92] per capita GDP, (lnGDPPCK) square of per capita GDP, (lnNR) natural resource income, (lnURB) [92] urbanization rate, (lnBIO) per capita biological capacity and ϑ_t represents the error term. We expect the increase in natural resource use and urbanization, due to the revitalization in industrialization for the realization of EG targets, to have a positive effect on the EFP. Grossman and Krueger's [47] study suggests a non-linear relationship between EG and environmental pollution; therefore, for the EKC hypothesis to be valid, it is expected that $\beta_1 lnGDPPC_{it} > 0$ and $\beta_2 lnGDPPCK_{it} < 0$.

An ARDL boundary test was used in this study and this test has some advantages. This test allows for the search of potential long-term relationships between an integrated series of different levels and also distinguishes between short- and long-term relationships [93]. Additionally, the advantages of this test include estimating a cointegration relationship using OLS and then making forecasts after determining the appropriate lag for the model [94].

$$\begin{aligned} dlnEFP_t = c_0 + \quad & \sum_{i=1}^{n} \beta_0 dlnGDPPC_{t-i} \sum_{i=1}^{n} \beta_{1,i} dlnGDPPCK_{t-i} \\ & + \sum_{i=0}^{n} \beta_{2,i} dlnNR_{t-i} \\ & + \sum_{i=0}^{n} \beta_{3,i} dlURB_{t-i} \\ & + \sum_{i=0}^{n} \beta_{4,i} dlnBIO_{t-i} + \delta_0 lnGDPPC_{t-1} + \delta_1 lnGDPPCK_{t-1} \\ & + \delta_2 lnNR_{t-1} + \delta_3 lnURB_{t-1} + \delta_4 lnBIO_{t-1} + \mu_t \end{aligned} \tag{2}$$

Equation (2) represents the lag operator (n) and the difference operator (d). To apply the ARDL test, the first step is to determine the existence of a cointegration relationship between the series. The null hypothesis of the test assumes no cointegration relationship, $H_0 : \delta_0 \neq \delta_1 \neq \delta_3 \neq \delta_4 \neq 0$, while the alternative hypothesis assumes the presence of a cointegration relationship, $H_1 : \delta_0 = \delta_1 = \delta_3 = \delta_4 = 0$ [94]. The optimal lag lengths were also determined using the Schwarz information criterion (SIC).

The results of the ARDL bounds test allow us to make short-term and long-term predictions, but do not provide information about the direction of causality needed to improve policy applications. Therefore, the Granger causality-based VECM is used to determine the direction of the causality relationships between variables. The VECM causality testing is a method applied to variables that are stationary at I (1) and have co-integration. The VECM can eliminate the losses resulting from the difference operation applied to non-stationary series [9,95]. The model used in the VECM method is formed as follows:

$$\begin{aligned} (1-L)\begin{bmatrix} lnEFP \\ lnGDPPC_t \\ lnGDPPCK_t \\ lnNR_t \\ lnURB_t \\ lnBIO_t \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ \alpha_6 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} b_{11i} & b_{12i} & b_{13i} & b_{14i} & b_{15i} & b_{16i} \\ b_{21i} & b_{22i} & b_{23i} & b_{24i} & b_{25i} & b_{26i} \\ b_{31i} & b_{32i} & b_{33i} & b_{34i} & b_{35i} & b_{36i} \\ b_{41i} & b_{42i} & b_{43i} & b_{44i} & b_{45i} & b_{46i} \\ b_{51i} & b_{52i} & b_{53i} & b_{54i} & b_{55i} & b_{56i} \\ b_{61i} & b_{62i} & b_{63i} & b_{64i} & b_{65i} & b_{66i} \end{bmatrix} \\ X \begin{bmatrix} lnEFP_{t-1} \\ lnGDPPC_{t-1} \\ lnGDPPCK_{t-1} \\ lnNR_{t-1} \\ lnURB_{t-1} \\ lnBIO_{t-1} \end{bmatrix} + \begin{bmatrix} a \\ \beta \\ \delta \\ \varphi \\ \vartheta \\ \theta \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \end{aligned} \tag{3}$$

In the model, (1 – L) represents the difference operator, while ECT_{t-1} represents the error terms ε_{1t}, ε_{2t}, ε_{3t}, ε_{4t}, ε_{5t}, ε_{6t} derived from the long-term relationship. It is assumed that the variance of the error terms ε_{it} is constant [96]. The coefficient of ECT_{t-1} in the model reveals the long-term causal relationship between variables, while short-term causality is demonstrated by the statistical significance of the F-statistic obtained by combining the independent variables in the model with their first difference and lagged differences using the Wald test [9].

4. Results

4.1. Descriptive Statistics

The descriptive statistics of the variables used in the study, and the descriptive statistics and correlation matrix of the variables used in the study, are presented in Table 2. The results show that EFP reached its maximum value in 2017 and its minimum value in 1973. When the gross domestic product (GDP) per capita is analyzed, it is seen that the GDP had a minimum value of 3583 USD in 1973 and reached its maximum value of 13,341 USD with a significant increase until 2016. Finally, it is seen that the biocapacity per capita, BIO, was at the maximum level of 2.46 kha in 1976, and decreased to the minimum level with 1.478 kha in 2019.

Table 2. Descriptive statistics and correlation matrix.

	EFP	**GDPPC**	**GDPPCK**	**NR**	**URB**	**BIO**
Correlation Matrix						
EFP	1	0.929	0.874	−0.370	−0.786	−0.871
GDPPC	0.929	1	0.988	−0.304	−0.773	−0.883
GDPPCK	0.874	0.988	1	−0.215	−0.735	−0.819
NR	−0.370	−0.304	−0.215	1	0.523	0.543
URB	−0.786	−0.773	−0.735	0.412523	1	0.755
BIO	−0.871	−0.883	−0.819	0.543	0.755	1
Descriptive Statistic						
Mean	2.724	6.812	53.633	−0.652	1.035	1.881
Median	2.678	6.022	36.274	−0.634	0.937	1.815
Maximum	3.476	13.341	178.000	0.336	1.809	2.411
Minimum	1.893	3.583	128.404	−1.938	0.311	1.478
Std. dev.	0.456	2.715	434.030	0.586	0.376	0.285
Skewness	0.159	0.806	1.229	−0.182	0.389	0.390
Kurtosis	1.671	2.480	3.414	2.112	2.686	1.919
Observations	49	49	49	49	49	49

4.2. Unit Root Analysis

Conventional unit root tests, such as Augmented Dickey–Fuller (ADF) [97,98], Dickey–Fuller—Generalized Least Squares (DF-GLS) [99], Phillips-Perron (PP) [100], Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) [101] were performed in our study, and the results are presented in Table 3. Upon examining the results of the unit root tests, it is seen that the variables are stationary at the level and first difference, which allows us to use the ARDL boundary test.

Table 3. Unit root analysis results.

	ADF		**DF-GLS**		**PP**		**KPSS**	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
lnEFP	−0.832	−10.90 ***	0.305	−8.809 ***	0.565	−12.132 ***	1.286	0.048 ***
lnGDPPC	0.508	−6.696 ***	2.365	−6.760 ***	0.473	−6.694 ***	1.299	0.129 ***
lnGDPPCK	0.732	−6.649 ***	2.491	−6.720 ***	0.808	−6.646 ***	1.294	0.169 ***
lnNR	−1.903	−7.380 ***	−1.857	−7.460 ***	−1.886	−7.408 ***	0.534 **	0.089 ***
lnURB	−1.097	−3.951 ***	−0.725	−3.620 ***	−1.071	−3.932 ***	0.929	0.079 ***
lnBIO	0.106	−10.074 ***	1.217	−3.440 ***	0.733	−11.384 ***	1.323	0.168 ***

** and *** indicate the significance level at 5% and 1%, respectively.

4.3. The Bound Testing Approach

The results of the ARDL bounds test, shown in Table 4, indicate that the F statistic value is higher than the I (1) critical value, indicating the existence of a long-term cointegration relationship.

Table 4. Results of ARDL bounding test approach.

Model	**Bound Testing Approach**			**Diagnostic Tests**		
	F Value	**Lag Order**	**Decision**	$\chi^{2\text{-ARCH}}$	$\chi^{2\text{-LM}}$	$\chi^{2\text{-RAMSEY}}$
LNEFP LNGDPPC LNGDPPCK LNNR LNURB LNBIO	3.208 ***	1, 4, 0, 2, 4, 0	Conclusive	0.278 (0.600)	0.166 (0.208)	0.005 (0.90)

*** is an indication of 1% level of significance. Number in "( )" brackets are probabilities.

4.4. Short- and Long-Term Estimates

The findings presented in Table 5 indicate that EG has a negative impact on environmental quality by increasing the EFP. These results demonstrate that the significant EG achieved in Turkey over the years has a positive and statistically significant effect both in the short and long term. The result that shows a positive relationship between EG and EFP in this study is consistent with Nathaniel [102] for Indonesia, Zafar et al. [4] for the United States, Hassan et al. [15] for Pakistan and Acar and Aşıcı [25] for Turkey. However, the long-term results show that the square of EG (GDPPCK) has a negative effect in Turkey, and that the EKC hypothesis is valid.

Table 5. ARDL long-term and short-term estimations.

Dependent Variable: lnEFP			
Independent Variables	**Coefficients**	***t*-Statistic**	**Prob.**
Long-term estimations			
lnGDPPC	7.630 *	2.100	0.000
lnGDPPCK	−0.399 *	−1.782	0.000
lnNR	0.028 **	1.194	0.024
lnURB	−0.109 ***	−1.199	0.055
lnBIO	0.652 **	2.296	0.029
C	−35.447	−3.896	0.000
Short-term estimations			
D (lnGDPPC)	5.935 **	2.100	0.044
D (lnGDPPC(−1))	−0.273 **	−2.321	0.027
D (lnGDPPCK)	−0.285 ***	−1.782	0.085
D (lnNR)	−0.001	0.084	0.932
D (lnNR(−1))	0.030 **	2.127	0.042
D (lnURB)	−0.097 **	−2.339	0.026
D (lnBIO)	0.358 **	2.473	0.019
CointEq (−1)	−0.678	−5.390	0.000
Sensitivity analysis			
R^2	0.978		
Adjusted R^2	0.966		
F statistic	20.697		
Prob (F statistic)	0.000		
Durbin-Watson stat	2.293		
Robust check			
Ramsey reset	0.005	[0.939]	
LM test	1.666	[0.208]	
ARCH test	0.278	[0.600]	

Note: Number in "( )" brackets are probabilities. *, ** and *** indicates significance at the 1%, 5% and 10%, respectively.

Another independent variable in the model, natural resources, did not show a statistically significant effect on the EFP in the short term but had a positive effect in the long term. This result is inconsistent with Balsalobre-Lorente et al. [103] for the EU-5 countries, but consistent with Bekun et al. [64] for the EU-16 countries and Khan et al. [65] for the 51 Belt and Road Initiative (BRI) countries. However, it is noted that these studies used CO_2 emissions as an environmental indicator, which could cause differences in the results. Our findings are inconsistent with Zafar et al. [4] for the USA and Ulucak and Khan [46] for the BRICS countries, but consistent with Hassan et al. [15] for Pakistan. Natural resources in a country can have a positive impact on environmental quality as they reduce dependence on traditional fossil fuels [4]. Therefore, countries with rich natural resources can reduce their dependence on fossil fuel imports and prevent environmental degradation by using natural gas and renewable energy resources that cause less pollution compared to fossil fuels [45].

According to the results, there is a negative relationship between urbanization and EFP both in the short and long term. In other words, urbanization helps to increase the quality of the environment. Our findings are not consistent with Nathaniel [102] for Indonesia and Ahmed et al. [83] for G7 countries. However, our results are in line with Yasin et al. [18] for 110 developed and developing countries, Ulucak and Khan [46] for BRICS countries and Nathaniel and Khan [84] for ASEAN countries, which show a negative effect of urbanization on EFP. Urbanization is a positive source of externalities, providing opportunities for the construction and maintenance of urban environments through factors such as health management, appropriate waste management, water pipelines, and eco-friendly infrastructure [81]. In addition, high levels of education among urban residents increase environmental awareness. The relatively high incomes of urban populations and their use of energy-efficient household appliances and environmentally friendly products are also important for environmental quality [46].

When examining the effect of biological capacity, which we used to evaluate the environmental sustainability of productive land and sea areas in our study, on the EFP, it was observed to be positive both in the short and long term. The rise in sectors such as construction, electricity-gas, water and transportation in a country or region causes a decrease in biological capacity which, in turn, puts negative pressure on environmental quality [25]. Our findings are consistent with the results of Ulucak and Bilgili [103], who examined the relationship between biological capacity and EFP for high-, middle- and low-income countries, Zhang et al. [7], who studied Pakistan. In light of these results, utilizing existing biological capacity to improve EFPs, and creating production and consumption integrations that reduce the rate of depletion of natural resources, will be useful in balancing biological capacity and EFP [81].

Table 5 also presents the results of diagnostic tests. Upon examining the results of the tests, it can be seen that there is no autocorrelation problem in the model created with the Breusch–Godfrey LM test, no problem of changing variance with the ARCH test, and that the correct functional form is used in the study according to the Ramsey RESET test. As illustrated in Figure 1, it was concluded that the parameters were stable according to the CUSUM and CUSUMQ tests.

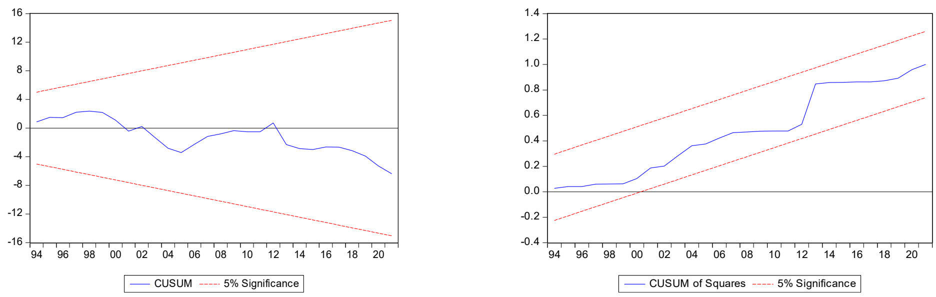

Figure 1. CUSUM and CUSUM (sq) graphs.

4.5. *VECM Granger Causality/Block Exogeneity Wald Test*

In this part of the study, the VECM Granger causality test results shown in Table 6 will be evaluated. According to the short-term results, there is a unidirectional causality from economic growth, natural resource income, urbanization and biocapacity to EFP. In addition, a unidirectional causality relationship from urbanization to economic growth in the short term is also seen in Table 6. When biological capacity is the dependent variable, it is understood that the results obtained are not statistically significant.

Table 6. VECM Granger Causality/Block Exogeneity Wald Test.

	Short-Term Causality						Long-Term
	EFP	**GDPPC**	**GDPPCK**	**NR**	**URB**	**BIO**	**ECT (−1)**
EFP	-	38.994 * (0.000)	39.782 * (0.000)	7.929 *** (0.094)	22.151 * (0.000)	46.981 * (0.000)	−3.541 [−4.883]
GDPPC	9.114 *** (0.058)	-	6.373 (0.172)	6.601 (0.158)	9.713 ** (0.045)	26.052 * (0.000)	−2.117 [−3.129]
GDPPCK	8.941 *** (0.062)	6.372 (0173)	-	6.802 (0.146)	9.529 ** (0.049)	24.849 * (0.000)	−37.617 [−3.116]
NR	11.626 ** (0.020)	2.780 (0.595)	1.994 (0.736)	-	7.642 (0.105)	11.022 ** (0.026)	−13.053 [−2.237]
URB	3.697 (0.448)	6.605 (0.158)	7.502 (0.111)	0.883 (0.926)	-	3.940 (0.414)	4.325 ** [2.019]
BIO	0.508 (0.972)	0.950 (0.917)	0.901 (0.924)	0.572 (0.966)	1.751 (0.781)	-	0.118 [0.162]

Note: Number in "( )" brackets are probabilities. "[]" are *t*-statistics, *, ** and *** indicates significance at the 1%, 5% and 10%, respectively.

The long-term causality results presented in Table 6 show a causal relationship from EFP, economic growth, natural resource income and biocapacity to urbanization. The results obtained are in agreement with the long-term results of Baloch et al. [45] and Hassan et al. [38].

5. Conclusions

In this study, the effects of different variables such as natural resources, urbanization and biological capacity on the EFP were investigated using annual data from 1970 to 2018. In addition to these variables, the validity of the EKC hypothesis was also tested using the ARDL method. The short- and long-term effects and directions of EG, natural resources, urbanization and biological capacity on the EFP were examined using the ARDL method. Furthermore, the causal relationship between the variables in the model was analyzed using the VECM Granger causality method, which provides short- and long-term results.

According to the results of the ARDL test, EG has a significant increasing effect on the EFP in Turkey, but this effect decreases after a certain threshold in the long term. These results indicate that the EKC hypothesis is valid for Turkey. In previous studies [25,55], the relationship between EG and EFP has been examined for Turkey, and it has been found that EG creates serious pressure on environmental quality. One of the most important problems in this regard for Turkey is the increasing energy demand with EG. However, the fact that this energy demand is largely met by fossil fuels makes the solution to the problem difficult.

6. Policy Implications

Our policy recommendation for the solution of this problem is to increase and promote the use of renewable energy sources. In terms of the use of renewable energy sources, the public sector should play a guiding role and incentives should be increased. The government should inform the public about energy efficiency and clean energy for household needs. In addition, preventing uncontrolled fishing and pollution of land and seas in the fishing industry will reduce environmental pressure.

The study also presents various policy recommendations for natural resources, urbanization and biological capacity. Firstly, policymakers should establish regulations that positively affect environmental quality for mining companies, and license issuance should be conditional upon compliance with such rules. Moreover, effective monitoring mechanisms and penalties should be implemented to prevent polluting companies. Additionally, the government should provide positive discrimination, such as tax reductions and low-interest financing, to environmentally conscious institutions to ensure the efficient use of natural resources. Policymakers should take necessary precautions to protect and utilize the country's productive lands. Results from the analyses indicate that biological capacity has a positive effect on EFP, which implies that biological capacity is insufficient in mitigating environmental degradation. Therefore, construction on agricultural lands should be restricted, and measures should be taken to prevent deforestation caused by human and natural factors. Turkey, surrounded by three seas, must be extremely cautious regarding marine pollution. Effective measures should be taken to combat issues such as the discharge of industrial waste and waste from passenger and cargo ships. The difference between biological capacity and EFP is increasing in Turkey, and although fossil fuel usage seems to be the primary cause, the decline in biological capacity level is also an important factor.

The most important issue that policymakers should focus on regarding the impact of urbanization on the environment is the healthy and planned implementation of rapid urbanization. Destructing productive agricultural and forest lands during the formation of urban areas should be prevented. At the same time, the use of environmentally friendly infrastructure and construction materials should be encouraged. The use of renewable energy sources for the lighting, climate control and other needs of buildings should be promoted, and projects considering energy efficiency should be supported with low-interest loans or interest-free financing. The increasing transportation needs due to urbanization should be met with environmentally friendly vehicles, and public transportation usage should be encouraged.

The results of the analysis show that Turkey needs to take measures to reduce the pressure on the environment while achieving its EG targets. It is crucial to protect biological capacity for sustainability, and planned urbanization improves environmental quality. Therefore, legal regulations must be implemented to protect natural resources and biological capacity without negatively affecting EG. Moreover, policymakers in Turkey need to create policies that promote sustainable lifestyles, ecological awareness, clean technological innovations and efficient production.

However, this study has some limitations, and the findings should be evaluated in the context of the relevant period and model framework for Turkey. Future studies can develop new models that include other variables that could affect the EFP. Furthermore, the N-shaped EKC curve can be tested for Turkey, and the interaction between FDI and renewable energy sources' impact on the environment can be examined.

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References

1. Galli, A.; Kitzes, J.; Niccolucci, V.; Wackernagel, M.; Wada, Y.; Marchettini, N. Assessing the global environmental consequences of economic growth through the ecological footprint: A focus on China and India. *Ecol. Indic.* **2012**, *17*, 99–107. [CrossRef]
2. United Nations Environment Programme. *Emissions Gap Report 2019*; UNEP: Nairobi, Kenya, 2019; ISBN 978-92-807-3766-0. Available online: https://www.unep.org/resources/emissions-gap-report-2019 (accessed on 26 March 2023).
3. United Nations, Department of Economic and Social Affairs, Population Division: New York, NY, USA. 2022. Available online: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf (accessed on 26 March 2023).
4. 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]
5. Al-Mulali, U.; Tang, C.F.; Ozturk, I. Estimating the environment Kuznets curve hypothesis: Evidence from Latin America and the Caribbean countries. *Renew. Sustain. Energy Rev.* **2015**, *50*, 918–924. [CrossRef]

6. Destek, M.A.; Okumus, I. Does pollution haven hypothesis hold in newly industrialized countries? Evidence from ecological footprint. *Environ. Sci. Pollut. Res.* **2019**, *26*, 23689–23695. [CrossRef]
7. Zhang, B.; Wang, B.; Wang, Z. Role of renewable energy and non-renewable energy consumption on EKC: Evidence from Pakistan. *J. Clean. Prod.* **2017**, *156*, 855–864. [CrossRef]
8. Zoundi, Z. CO_2 emissions, renewable energy and the Environmental Kuznets Curve, a panel cointegration approach. *Renew. Sustain. Energy Rev.* **2017**, *72*, 1067–1075. [CrossRef]
9. Chen, Y.; Wang, Z.; Zhong, Z. CO_2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renew. Energy* **2019**, *131*, 208–216. [CrossRef]
10. Muhammad, B. Energy consumption, CO_2 emissions and economic growth in developed, emerging and Middle East and North Africa countries. *Energy* **2019**, *179*, 232–245. [CrossRef]
11. Gorus, M.S.; Aydin, M. The relationship between energy consumption, economic growth, and CO_2 emission in MENA countries: Causality analysis in the frequency domain. *Energy* **2019**, *168*, 815–822. [CrossRef]
12. Ulucak, R.; Apergis, N. Does convergence really matter for the environment? An application based on club convergence and on the ecological footprint concept for the EU countries. *Environ. Sci. Policy* **2018**, *80*, 21–27. [CrossRef]
13. Wachernagel, M.; Rees, W. *Our Ecological Footprint: Reducing Human Impact on the Earth*; The New Catalyst Bioregional Series; New Society Publishers: Gabriola, BC, Canada, 1998.
14. Ulucak, R.; Erdem, E. Ekonomik Büyüme Modellerinde Çevre: Ekolojik Ayak İzini Esas Alan Bir Uygulama. *Hacet. Univ. J. Econ. Adm. Sci./Hacet. Üniversitesi Iktis. Ve Idari Bilim. Fakültesi Derg.* **2017**, *35*, 115–147. [CrossRef]
15. Hassan, S.T.; Xia, E.; Khan, N.H.; Shah, S.M.A. Economic growth, natural resources, and ecological footprints: Evidence from Pakistan. *Environ. Sci. Pollut. Res.* **2018**, *26*, 2929–2938. [CrossRef]
16. Rashid, A.; Irum, A.; Malik, I.A.; Ashraf, A.; Rongqiong, L.; Liu, G.; Ullah, H.; Ali, M.U.; Yousaf, B. Ecological footprint of Rawalpindi; Pakistan's first footprint analysis from urbanization perspective. *J. Clean. Prod.* **2018**, *170*, 362–368. [CrossRef]
17. Destek, M.A.; Sarkodie, S.A. Investigation of environmental Kuznets curve for ecological footprint: The role of energy and financial development. *Sci. Total Environ.* **2019**, *650*, 2483–2489. [CrossRef]
18. Yasin, I.; Ahmad, N.; Chaudhary, M.A. Catechizing the Environmental-Impression of Urbanization, Financial Development, and Political Institutions: A Circumstance of Ecological Footprints in 110 Developed and Less-Developed Countries. *Soc. Indic. Res.* **2020**, *147*, 621–649. [CrossRef]
19. Altay Topcu, B.; Doğan, M. The effect of solar energy production on financial development and economic growth: Evidence from 11 selected countries. *Energy Sources Part B Econ. Plan. Policy* **2022**, *17*, 2141377. [CrossRef]
20. Shahbaz, M.; Topcu, B.A.; Sarıgül, S.S.; Doğan, M. Energy imports as inhibitor of economic growth: The role of impact of renewable and non-renewable energy consumption. *J. Int. Trade Econ. Dev.* **2023**, 1–26. [CrossRef]
21. Doğan, M.; Raikhan, S.; Zhanar, N.; Gulbagda, B. Analysis of Dynamic Connectedness Relationships among Clean Energy, Carbon Emission Allowance, and BIST Indexes. *Sustainability* **2023**, *15*, 6025. [CrossRef]
22. Al-Mulali, U.; Ozturk, I. The effect of energy consumption, urbanization, trade openness, industrial output, and the political stability on the environmental degradation in the MENA (Middle East and North African) region. *Energy* **2015**, *84*, 382–389. [CrossRef]
23. Alam, M.M.; Murad, M.W.; Noman, A.H.M.; Ozturk, I. Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. *Ecol. Indic.* **2016**, *70*, 466–479. [CrossRef]
24. Uddin, G.A.; Alam, K.; Gow, J. Does ecological footprint impede economic growth? An empirical analysis based on the environmental Kuznets curve hypothesis. *Aust. Econ. Pap.* **2016**, *55*, 301–316. [CrossRef]
25. Acar, S.; Aşıcı, A.A. Nature and economic growth in Turkey: What does ecological footprint imply? *Middle East Dev. J.* **2017**, *9*, 101–115. [CrossRef]
26. Destek, M.A.; Sinha, A. Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries. *J. Clean. Prod.* **2020**, *242*, 118537. [CrossRef]
27. Sharif, A.; Baris-Tuzemen, O.; Uzuner, G.; Ozturk, I.; Sinha, A. Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. *Sustain. Cities Soc.* **2020**, *75*, 102138. [CrossRef]
28. Shahbaz, M.; Dogan, M.; Akkus, H.T.; Gursoy, S. The effect of financial development and economic growth on ecological footprint: Evidence from top 10 emitter countries. *Environ. Sci. Pollut. Res.* **2023**, *30*, 73518–73533. [CrossRef] [PubMed]
29. Liu, H.; Kim, H. Ecological footprint, foreign direct investment, and gross domestic production: Evidence of Belt & Road Initiative countries. *Sustainability* **2018**, *10*, 3527. [CrossRef]
30. Majeed, M.T.; Mazhar, M. Financial development and ecological footprint: A global panel data analysis. *Pak. J. Commer. Soc. Sci. (PJCSS)* **2019**, *13*, 487–514.
31. Sabir, S.; Gorus, M.S. The impact of globalization on ecological footprint: Empirical evidence from the South Asian countries. *Environ. Sci. Pollut. Res.* **2019**, *26*, 33387–33398. [CrossRef]
32. Ozturk, I.; Al-Mulali, U.; Saboori, B. Investigating the environmental Kuznets curve hypothesis: The role of tourism and ecological footprint. *Environ. Sci. Pollut. Res.* **2016**, *23*, 1916–1928. [CrossRef]

33. Katircioglu, S.; Gokmenoglu, K.K.; Eren, B.M. Testing the role of tourism development in ecological footprint quality: Evidence from top 10 tourist destinations. *Environ. Sci. Pollut. Res.* **2018**, *25*, 33611–33619. [CrossRef]
34. Lee, C.C.; Chen, M.P. Ecological footprint, tourism development, and country risk: International evidence. *J. Clean. Prod.* **2020**, *279*, 123671. [CrossRef]
35. Hubacek, K.; Guan, D.; Barrett, J.; Wiedmann, T. Environmental implications of urbanization and lifestyle change in China: Ecological and water footprints. *J. Clean. Prod.* **2009**, *17*, 1241–1248. [CrossRef]
36. Long, X.; Ji, X.; Ulgiati, S. Is urbanization eco-friendly? An energy and land use cross-country analysis. *Energy Policy* **2017**, *100*, 387–396. [CrossRef]
37. Nathaniel, S.; Anyanwu, O.; Shah, M. Renewable energy, urbanization, and ecological footprint in the Middle East and North Africa region. *Environ. Sci. Pollut. Res.* **2020**, *27*, 14601–14613. [CrossRef] [PubMed]
38. Hassan, S.T.; Baloch, M.A.; Mahmood, N.; Zhang, J. Linking economic growth and ecological footprint through human capital and biocapacity. *Sustain. Cities Soc.* **2019**, *47*, 101516.
39. Panayotou, T. Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development (No. 992927783402676). International Labour Organization. 1993. Available online: https://ideas.repec.org/p/ilo/ilowps/992927783402676.html (accessed on 22 August 2020).
40. World Bank 2023, The World Bank in Turkey Overview, World Bank 2020a, The World Bank in Turkey Overview. Available online: https://www.worldbank.org/tr/country/turkey/overview (accessed on 26 March 2023).
41. World Bank 2020, Europe and Central Asia Economic Update, Spring 2020: Fighting COVID-19, Washington DC, USA. Available online: https://elibrary.worldbank.org/doi/abs/10.1596/978-1-4648-1564-5 (accessed on 22 August 2020).
42. Turkish Ministry of Environment and Urbanization. *Turkey Habitat III: National Report*; Turkish Ministry of Environment and Urbanization: Ankara, Turkey, 2014.
43. Our World in Data 2020. Statistics and Research. Oxford Martin School, The University of Oxford, Global Change Data Lab. Available online: https://ourworldindata.org/ (accessed on 22 August 2020).
44. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Lafortune, G.; Fuller, G.; Woelm, F. The Sustainable Development Goals and COVID-19. In *Sustainable Development Report 2020*; Cambridge University Press: Cambridge, UK, 2020; Available online: https://sdgindex.org (accessed on 22 August 2020).
45. 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.
46. 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]
47. Grossman, G.M.; Krueger, A.B. Economic growth and the environment. *Q. J. Econ.* **1995**, *110*, 353–377. [CrossRef]
48. Coondoo, D.; Dinda, S. Causality between income and emission: A country group-specific econometric analysis. *Ecol. Econ.* **2002**, *40*, 351–367. [CrossRef]
49. Akbostancı, E.; Türüt-Aşık, S.; Tunç, G.İ. The relationship between income and environment in Turkey: Is there an environmental Kuznets curve? *Energy Policy* **2009**, *37*, 861–867. [CrossRef]
50. Nasir, M.; Rehman, F.U. Environmental Kuznets curve for carbon emissions in Pakistan: An empirical investigation. *Energy Policy* **2011**, *39*, 1857–1864. [CrossRef]
51. Shahbaz, M.; Lean, H.H.; Shabbir, M.S. Environmental Kuznets curve hypothesis in Pakistan: Cointegration and Granger causality. *Renew. Sustain. Energy Rev.* **2012**, *16*, 2947–2953. [CrossRef]
52. Shahbaz, M.; Khraief, N.; Uddin, G.S.; Ozturk, I. Environmental Kuznets curve in an open economy: A bounds testing and causality analysis for Tunisia. *Renew. Sustain. Energy Rev.* **2014**, *34*, 325–336. [CrossRef]
53. Begum, R.A.; Sohag, K.; Abdullah, S.M.; Jaafar, M. CO_2 emissions, energy consumption, economic and population growth in Malaysia. *Renew. Sustain. Energy Rev.* **2015**, *41*, 594–601. [CrossRef]
54. Godil, D.I.; Sharif, A.; Rafique, S.; Jermsittiparsert, K. The asymmetric effect of tourism, financial development, and globalization on ecological footprint in Turkey. *Environ. Sci. Pollut. Res.* **2020**, *27*, 40109–40120. [CrossRef]
55. Etokakpan, M.U.; Osundina, O.A.; Bekun, F.V.; Sarkodie, S.A. Rethinking electricity consumption and economic growth nexus in Turkey: Environmental pros and cons. *Environ. Sci. Pollut. Res.* **2020**, *27*, 39222–39240. [CrossRef]
56. 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]
57. Sun, Y.; Li, M.; Zhang, M.; Khan HS, U.D.; Li, J.; Li, Z.; Sun, H.; Zhu, Y.; Anaba, O.A. A study on China's economic growth, green energy technology, and carbon emissions based on the Kuznets curve (EKC). *Environ. Sci. Pollut. Res.* **2021**, *28*, 7200–7211. [CrossRef] [PubMed]
58. Jahanger, A.; Yang, B.; Huang, W.C.; Murshed, M.; Usman, M.; Radulescu, M. Dynamic linkages between globalization, human capital, and carbon dioxide emissions: Empirical evidence from developing economies. *Environ. Dev. Sustain.* **2023**. [CrossRef]
59. Hossain, M.R.; Rej, S.; Awan, A.; Bandyopadhyay, A.; Islam, M.S.; Das, N.; Hossain, M.E. Natural resource dependency and environmental sustainability under N-shaped EKC: The curious case of India. *Resour. Policy* **2023**, *80*, 103150. [CrossRef]
60. Gao, J.; Hassan, M.S.; Kalim, R.; Sharif, A.; Alkhateeb, T.T.Y.; Mahmood, H. The role of clean and unclean energy resources in inspecting N-shaped impact of industrial production on environmental quality: A case of high polluting economies. *Resour. Policy* **2023**, *80*, 103217. [CrossRef]

61. Fakher, H.A.; Ahmed, Z.; Acheampong, A.O.; Nathaniel, S.P. Renewable energy, nonrenewable energy, and environmental quality nexus: An investigation of the N-shaped Environmental Kuznets Curve based on six environmental indicators. *Energy* **2023**, *263*, 125660. [CrossRef]
62. Majeed, M.T.; Mumtaz, S. Happiness and environmental degradation: A global analysis. *Pak. J. Commer. Soc. Sci. (PJCSS)* **2017**, *11*, 753–772.
63. Zahoor, Z.; Latif, M.I.; Khan, I.; Hou, F. Abundance of natural resources and environmental sustainability: The roles of manufacturing value-added, urbanization, and permanent cropland. *Environ. Sci. Pollut. Res.* **2022**, *29*, 82365–82378. [CrossRef]
64. Bekun, F.V.; Alola, A.A.; Sarkodie, S.A. Toward a sustainable environment: Nexus between CO_2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Sci. Total Environ.* **2019**, *657*, 1023–1029. [CrossRef]
65. Khan, A.; Chenggang, Y.; Hussain, J.; Bano, S.; Nawaz, A. Natural resources, tourism development, and energy-growth-CO_2 emission nexus: A simultaneity modeling analysis of BRI countries. *Resour. Policy* **2020**, *68*, 101751. [CrossRef]
66. Zhang, Y.; Khan, I.; Zafar, M.W. Assessing environmental quality through natural resources, energy resources, and tax revenues. *Environ. Sci. Pollut. Res.* **2022**, *29*, 89029–89044. [CrossRef]
67. Dagar, V.; Khan, M.K.; Alvarado, R.; Rehman, A.; Irfan, M.; Adekoya, O.B.; Fahad, S. Impact of renewable energy consumption, financial development and natural resources on environmental degradation in OECD countries with dynamic panel data. *Environ. Sci. Pollut. Res.* **2022**, *29*, 18202–18212. [CrossRef]
68. Zallé, O. Natural resources and economic growth in Africa: The role of institutional quality and human capital. *Resour. Policy* **2019**, *62*, 616–624. [CrossRef]
69. González-Val, R.; Pueyo, F. Natural resources, economic growth and geography. *Econ. Model.* **2019**, *83*, 150–159. [CrossRef]
70. Cui, L.; Weng, S.; Kirikkaleli, D.; Bashir, M.A.; Rjoub, H.; Zhou, Y. Exploring the role of natural resources, natural gas and oil production for economic growth of China. *Resour. Policy* **2021**, *74*, 102429. [CrossRef]
71. Wu, D.; Yang, Y.; Shi, Y.; Xu, M.; Zou, W. Renewable energy resources, natural resources volatility and economic performance: Evidence from BRICS. *Resour. Policy* **2022**, *76*, 102621. [CrossRef]
72. Gao, J.; Tian, M. Analysis of over-consumption of natural resources and the ecological trade deficit in China based on ecological footprints. *Ecol. Indic.* **2016**, *61*, 899–904. [CrossRef]
73. Azam, W.; Khan, I.; Ali, S.A. Alternative energy and natural resources in determining environmental sustainability: A look at the role of government final consumption expenditures in France. *Environ. Sci. Pollut. Res.* **2023**, *30*, 1949–1965. [CrossRef]
74. Troster, V.; Shahbaz, M.; Uddin, G.S. Renewable energy, oil prices, and economic activity: A Granger-causality in quantiles analysis. *Energy Econ.* **2018**, *70*, 440–452. [CrossRef]
75. Saud, S.; Chen, S. An empirical analysis of financial development and energy demand: Establishing the role of globalization. *Environ. Sci. Pollut. Res.* **2018**, *25*, 24326–24337. [CrossRef]
76. Wang, Z.; Rasool, Y.; Zhang, B.; Ahmed, Z.; Wang, B. Dynamic linkage among industrialisation, urbanisation, and CO_2 emissions in APEC realms: Evidence based on DSUR estimation. *Struct. Chang. Econ. Dyn.* **2020**, *52*, 382–389. [CrossRef]
77. Zhang, Y.J.; Yi, W.C.; Li, B.W. The impact of urbanization on carbon emission: Empirical evidence in Beijing. *Energy Procedia* **2015**, *75*, 2963–2968. [CrossRef]
78. Sheng, P.; He, Y.; Guo, X. The impact of urbanization on energy consumption and efficiency. *Energy Environ.* **2017**, *28*, 673–686. [CrossRef]
79. Charfeddine, L.; Khediri, K.B. Financial development and environmental quality in UAE: Cointegration with structural breaks. *Renew. Sustain. Energy Rev.* **2016**, *55*, 1322–1335. [CrossRef]
80. Charfeddine, L.; Mrabet, Z. The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries. *Renew. Sustain. Energy Rev.* **2017**, *76*, 138–154. [CrossRef]
81. Danish; Wang, Z. Investigation of the ecological footprint's driving factors: What we learn from the experience of emerging economies. *Sustain. Cities Soc.* **2019**, *49*, 101626. [CrossRef]
82. Nathaniel, S.; Nwodo, O.; Sharma, G.; Shah, M. Renewable energy, urbanization, and ecological footprint linkage in CIVETS. *Environ. Sci. Pollut. Res.* **2019**, *27*, 19616–19629. [CrossRef] [PubMed]
83. Ahmed, Z.; Zafar, M.W.; Ali, S. Linking urbanization, human capital, and the ecological footprint in G7 countries: An empirical analysis. *Sustain. Cities Soc.* **2020**, *55*, 102064. [CrossRef]
84. Nathaniel, S.; Khan, S.A.R. The nexus between urbanization, renewable energy, trade, and ecological footprint in ASEAN countries. *J. Clean. Prod.* **2020**, *272*, 122709. [CrossRef]
85. Nathaniel, S.P. Biocapacity, human capital, and ecological footprint in G7 countries: The moderating role of urbanization and necessary lessons for emerging economies. *Energy Ecol. Environ.* **2021**, *6*, 435–450. [CrossRef]
86. Yang, X.; Khan, I. Dynamics among economic growth, urbanization, and environmental sustainability in IEA countries: The role of industry value-added. *Environ. Sci. Pollut. Res.* **2022**, *29*, 4116–4127. [CrossRef]
87. Pandey, S.; Dogan, E.; Taskin, D. Production-based and consumption-based approaches for the energy-growth-environment nexus: Evidence from Asian countries. *Sustain. Prod. Consum.* **2020**, *23*, 274–281. [CrossRef]
88. Marti, L.; Puertas, R. Analysis of the efficiency of African countries through their Ecological Footprint and Biocapacity. *Sci. Total Environ.* **2020**, *722*, 137504. [CrossRef]
89. Unal, H.; Aktuğ, M. The impact of human capital and bio-capacity on the environmental quality: Evidence from G20 countries. *Environ. Sci. Pollut. Res.* **2022**, *29*, 45635–45645. [CrossRef]

90. Pesaran, M.H.; Shin, Y. An autoregressive distributed-lag modelling approach to cointegration analysis. *Econom. Soc. Monogr.* **1998**, *31*, 371–413.
91. GFN. Global Footprint Network. 2023. Available online: https://www.footprintnetwork.org/ (accessed on 26 March 2023).
92. The World Bank, World Development Indicators. Available online: https://databank.worldbank.org/source/world-development-indicators (accessed on 26 March 2023).
93. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econ.* **2001**, *16*, 289–326. [CrossRef]
94. Engle, R.F.; Granger, C.W. Co-integration and error correction: Representation, estimation, and testing. *Econom. J. Econom. Soc.* **1987**, *55*, 251–276. [CrossRef]
95. Yildirim, M.; Destek, M.A.; Özsoy, F.N. Direct Foreign Investments and P Pollution Haven Hypothesis. *Cumhur. Univ. J. Econ. Adm. Sci.* **2017**, *18*, 99–111.
96. Dickey, D.A.; Fuller, W.A. Distribution of the estimators for autoregressive time series with a unit root. *J. Am. Stat. Assoc.* **1979**, *74*, 427–431. [CrossRef]
97. Dickey, D.A.; Fuller, W.A. Likelihood ratio statistics for autoregressive time series with a unit root. *Econom. J. Econom. Soc.* **1981**, *49*, 1057–1072. [CrossRef]
98. Elliott, G.; Rothenberg, T.J.; Stock, J.H. Efcient Tests for an Autoregressive Unit Root. *Econometrica* **1996**, *64*, 813. [CrossRef]
99. Phillips, P.C.B.; Perron, P. Testing for a Unit Root in Time Series Regression. *Biometrika* **1988**, *75*, 335–346. [CrossRef]
100. Kwiatkowski, D.; Phillips, P.C.; Schmidt, P.; Shin, Y. Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *J. Econom.* **1992**, *54*, 159–178. [CrossRef]
101. 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]
102. Nathaniel, S.P. Ecological footprint, energy use, trade, and urbanization linkage in Indonesia. *GeoJournal* **2020**, *86*, 2057–2070. [CrossRef]
103. Ulucak, R.; Bilgili, F. A reinvestigation of EKC model by ecological footprint measurement for high, middle and low income countries. *J. Clean. Prod.* **2018**, *188*, 144–157. [CrossRef]