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The impact of carbon finance, renewable energy, and environmental knowledge on load capacity factor

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Annotation. Load capacity factor is a comprehensive indicator which compares biocapacity and ecological footprint to track an environmental threshold. Scholars observe that, with rising environmental pollution, the load capacity factor decreases. The existing literature empirically measures environmental degradation through over-explored proxies such as ecological footprint, carbon emissions, GHG emissions, and nitrogen emissions. Because of the proxies used, the supply side of environmental problems is often neglected. This study addresses this gap by investigating renewable energy, environmental knowledge, and carbon finance, and their influence on load capacity factor in China. A nonlinear autoregressive distributed lag (NARDL) technique is used to evaluate the associations. The results show that renewable energy output and consumption, environmental knowledge, carbon finance, and population growth have positive relationships with load capacity factor in China. Therefore, the Chinese government must encourage biomass use and investment in renewable energy forms to restrict emissions.

Keywords: renewable energy, environmental knowledge, carbon finance, load capacity factor, sustainable environment.

JEL classification: Q5, Q3, K14, M19, P2.

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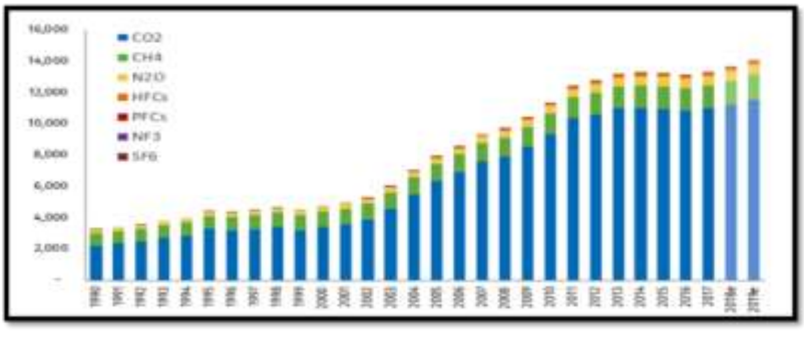
Introduction

One issue which has attracted the world's attention over the past few decades is ecological change. Due to its terrible consequences, the world is paying special attention to its solution. Keeping these consequences in mind, developed countries are encouraging the developing world to focus on activities which control the factors that result in ecological change. There are numerous causes of ecological change, such as emissions of greenhouse gases (GHG), from numerous sources such as traditional energy production from coal and other fossil fuels (Khan *et al.*, 2025; Wang *et al.*, 2019). The entire world can, in a sense, be considered a global village, and this transformation has changed energy demand. Energy is a basic need for almost for every aspect of business and community life. The rise in demand for energy and countries continuing to produce energy from traditional resources result in environmental deprivation through GHG emissions. Industrialization results in increased energy demand, and is therefore one of the factors which results in increased GHG emissions and environmental degradation (Z.-Z. Li *et al.*, 2021). China, which is both the largest producer and user of coal in world, pushed hard to restructure its energy production between 2013 and 2016, which resulted in a decline in coal usage. The three countries with the highest coal use, China, the United States, and India, all boosted coal mining in 2017 (Dong *et al.,* 2018; Ma *et al.*, 2019). China increased its use of natural gas and electricity as the government enacted many initiatives to reduce coal consumption. Looking ahead, China's industrial and construction sectors are set to make way for the service sector, and the government of China is setting ever greater targets for economic growth. China has the greatest global GHG emissions, at 27%, with the US in second with 11%, as of 2019 (X. Chen *et al.*, 2020; L. Wu *et al.*, 2021).

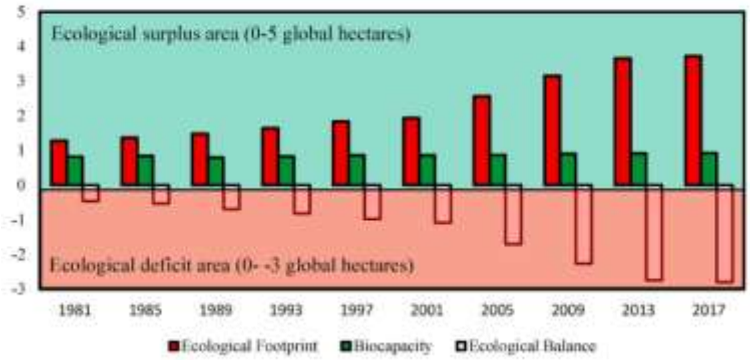
However, China is putting climate change mitigation measures into place, the majority of which aim to reduce coal and fossil fuel use for energy production. China has set objectives and made a commitment to reduce GHG emissions to their lowest level by 2030 using non-fossil fuels, which are set to account for 20% of the nation's total primary energy supply (Cai *et al.*, 2021; Wu *et al.*, 2020). If China can successfully meet the agreed objectives, the GHG emissions level in 2030 will be 12.8–14.3 GtCO2e, a reduction of 64%–70% from 2005 levels (Jiali Zheng *et al.*, 2019). China is focusing on the transition to renewable energy (RE), as the ultimate way to control GHG emissions, and has already surpassed its 2020 goals for the installation of solar and wind energy. The GHG emissions of China are shown in *Figure 1*.



Source: Statista.

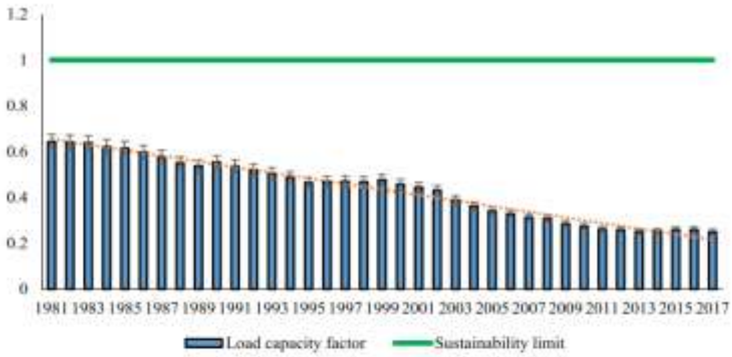
Figure 1. **GHG Emissions in China**

The main problem associated with comprehensive environmental assessment is that carbon emissions and ecological footprint (EF) both reveal only human uses of natural resources. However, bio capacity can be considered an environmental measure. Siche *et al.* (2010) introduce load capacity factor (LCF), measured via EF or biocapacity. LCF, as an approach, offers a comprehensive assessment, as it includes ecological aspects from both supply and demand perspectives (Pata, 2021). The value of LCF can be 1, less than 1, or greater than 1. LCF equal to 1 indicates a sustainability limit. If it exceeds this value, it means the environmental system is sustainable, but LCF less than one means the ecological system is unmanageable.



Source: Global Footprint Network, 2021.

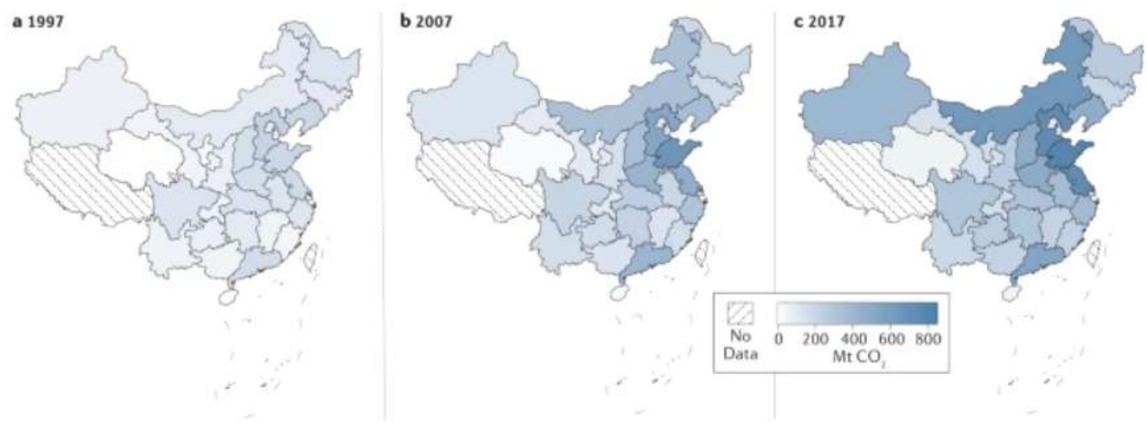
Figure 2. **Ecological Balance in China (gha)**



Source: Global Footprint Network, 2021.

Figure 3. **Load Capacity Factor of China**

There seem to be a few shortcomings in the literature linking carbon finance, environmental knowledge, renewable energy, and the environment. For example, previous studies, such as Zhang *et al.* (2023) and Chen *et al.* (2019), examine renewable energy and its role in carbon emissions. Similarly, Ali *et al.* (2021) evaluate environmental performance through GHG emissions, while Wenlong *et al.* (2022) and Baloch *et al.* (2021) investigate GHG emissions in terms of environmental quality. Studies of carbon emissions, GHG, and EF analyse the pressure on the environment only from the demand side, neglecting the ability of natural resources to cope with anthropogenic pressure. To address the issue, the present study emphasizes LCF, which covers both biocapacity and EF. This enables environmental measurement on both demand and supply sides. Thus, the study empirically evaluates the connection between carbon finance, environmental knowledge, renewable energy, and load capacity factors.



Source: CEADs.

Figure 4. **Geographic Variability in Carbon Intensity in China**

1. Literature Review

Recently, environmental sustainability has caught global attention, because of the extensive degradation of the environment which demands the focus of researchers and policymakers. There are numerous reasons for environmental degradation increasing over time, including gas emissions from energy production using coal and other fossil fuels. There is an urgent need to both control energy demand and increase energy production from renewable resources to mitigate GHG emissions. Chen *et al.* (2019) investigate GHG emissions, economic growth, foreign direct investment and RE output in China, and show that increasing GDP and non-RE use increase GHG emissions but growing RE use and overseas trade reduce GHG emissions. There are causal relationships that flow in both directions, from non-RE sources to GHG emissions and international commerce to sources of RE. Using RE is a crucial strategy for lowering GHG emissions over time. Sinha and Shahbaz (2018) investigate GHG emissions and RE in India, showing that the elasticity of energy consumption in the long term is larger than elasticity in the short term, even though RE is demonstrated to have a significant negative effect on emissions of GHG. Additionally, commerce and carbon emissions are shown to have a negative relationship. Considering the findings, the study offers appropriate policy recommendations in its conclusion. Mendonça *et al.* (2020), investigate whether GDP, population, and RE output affect GHG emissions, and show that the generation of RE is a means of reducing GHG emissions and there are beneficial effects of GDP and population on GHG emissions. In the analysis, China and Denmark are outliers, as the former has increased the percentage of RE in its electrical grids over twenty times and has shown a propensity to minimize GHG emissions, while the latter has become the planet's greatest emitter of GHG.

The ultimate way to control GHG emission is switching to green resources and RE production. Countries need to invest in carbon financing-based projects so that environmental degradation can be controlled by mitigating GHG emissions. Sharif *et al.* (2022) investigate green technology innovation, carbon financing and GHG emissions in the G7 countries. The results reveal that both carbon financing and green technological innovation have a significant negative effect on GHG emissions. While social globalization moderates the association between GDP and GHG emissions it adversely affects the relationships between each of carbon financing and green innovation and GHG emissions across the G7 countries. Meanwhile, economic growth has had a large positive influence on GHG emissions in the G7 countries. China's carbon finance sector is growing quickly, and improvements in the carbon finance development index along with rising non-fossil energy consumption help lower carbon intensity (Chien *et al.,* 2023; Ren et al., 2020; Bachnik, Nowacki 2024). Additionally, a rise in carbon intensity restricts the use of non-fossil fuels, the flow of capital to green projects, and the growth of carbon finance. Moreover, carbon finance and carbon intensity have a significant impact on China"s non-fossil energy use, an outcome clearly driven by policy. The effects of carbon financing initiatives are consistently insufficient. A major source of GHG emissions is the production of energy from fossil fuel, and the world must switch to green energy by investing in carbon financing projects, which mitigate GHG emissions (Ionescu, 2021; Zhou *et al.* 2020; Lestari, Soewarno 2024).

Globalization has increased energy demand, as energy is needed in every aspect of life. This increasing demand forces countries to increase energy production from fossil fuels, which results in GHG emissions. To control emissions we need to control energy consumption. Sarkodie and Strezov (2019) investigate foreign direct investment, economic development, RE consumption and GHG emission in Indonesia and China, and show that the environmental Kuznets curve hypothesis stand true with turning points of US$ 2999 and US$ 6014, respectively. In South Africa and India, they also show a U-shaped relationship, with turning points of US$ 7573 and US$ 1476, respectively. Rising foreign direct investment flows, clean technology transfer, improvements for labour, and environmental management standards all help developing nations achieve their sustainable development goals. Enhancing energy efficiency using cutting-edge energy sources such as nuclear power and biomass energy generating techniques that utilize carbon capture and storage are essential for GHG emission reduction. Vasylieva *et al.* (2019) investigate the links between GDP, economic development, corruption, RE consumption and GHG emission, using data collected in the EU and Ukraine, and support the environmental Kuznets curve concept, with all indicators statistically significant at the 1% and 5% levels. A 1% rise in RE is shown to cause a 0.166103–0.220551 decrease in GHG emissions, while a 1% increase in the control of corruption index causes a 0.88% decrease. Sterpu *et al.* (2018) investigate the links between economic development, RE consumption, and GHG emissions, and reveal a significant association between economic growth, RE consumption and GHG emissions. Over recent decades, there have been serious concerns about changes in the world environment. The global temperature is changing very rapidly, for numerous reasons including industrialization, excessive usage of energy, and production of energy from coal and other fossil fuels. The only way to tackle this issue is environmental knowledge applied in a proper manner. The world needs to increase environmental knowledge (Taormina *et al.,* 2018), and developed countries are ahead of developing countries in this regard. There is an association between environmental knowledge and GHG emissions (Grace *et al.,* 2019). Bruderer Enzler, Diekmann (2019) investigate the links between environmental knowledge, in terms of environmental concern, income, and GHG emissions in Switzerland, revealing an association between environmental knowledge and GHG emissions. Similarly, Zhang et al. (2019) investigate whether environmental management, guided by proper environmental knowledge, affects GHG emissions, and reveal that environmental management mitigates GHG emissions. Proper management of the environment is based on the availability and application of proper environmental knowledge. One major reason for GHG emissions is a lack of waste management, and hence the world is beginning to focus on waste management knowledge. Magazzino *et al.* (2020) investigate waste management and GHG emissions and reveal an association between them.

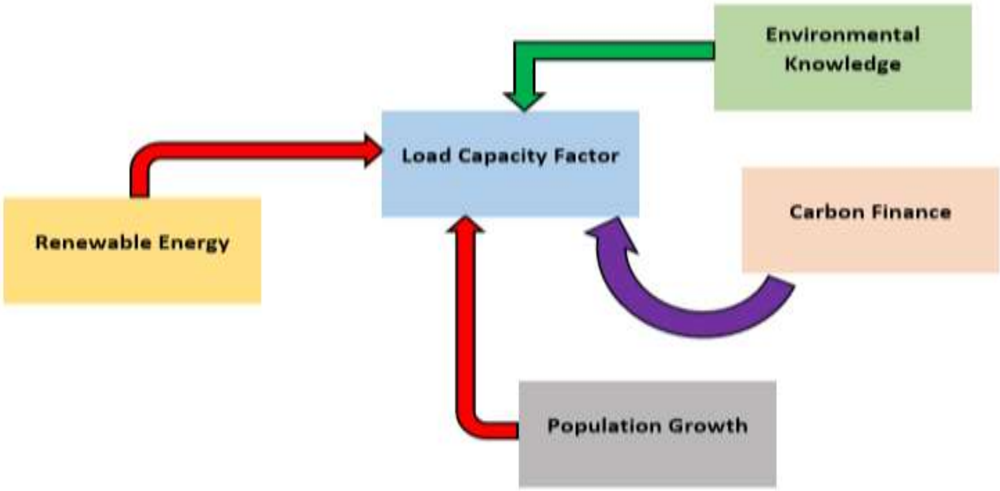
There are numerous other factors that affect environmental degradation, among them load capacity. Due to the high demand for energy, it is difficult for some countries to manage the load, and, many times, mismanagement of load results in complications for industrial production. De Oliveira-De Jesus (2019) investigates generation capacity and GHG emissions in Latin America and the Caribbean, revealing the structural factors, particularly in Brazil, are to blame for the region's rising carbon emission intensity. Thermal efficiency and the fossil fuel mix are components of intensity that have significantly improved, particularly in Mexico, but not enough to stop the regional carbon emission intensity increase. Another significant finding is that the capacity factors of fossil fuel-based generation, particularly in Venezuela, Mexico, and Brazil, play an important role in the rise in carbon emission intensity. As the area's major producer, despite a relatively low-capacity factor compared to other Latin America and Caribbean economies, Brazil deploys fuel-fired power plants to meet its base load, which may, in the future, increase the carbon emission intensity of the region, endangering the achievement of climate targets. Jiajia Zheng *et al.* (2020) study load mitigation between data centres and its effect on GHG emission in the PJM region (part of the United States), and reveal a significant association between the mitigation of load and a reduction in GHG emissions. J. Li *et al.* (2020) explore the coal-fired power industry and show that it is associated with GHG emissions in terms of load, particularly in China.

Over time, the demand for energy is rising and one prominent reason is the increase in population, which naturally results in more demand and accelerates the pressure for production. To fulfil this demand countries may produce energy from traditional resources resulting in emissions. There is an association between population growth and GHG emissions in terms of energy usage. Rehman *et al.* (2021) explore the links between climate change, population growth, forestry, livestock, crop production, and GHG emissions in Pakistan, revealing that, although temperature, rainfall, and animal output all have positive effects on carbon dioxide emissions, crop production, energy usage, and population increase have negative effects. The results of the short-term study show that, while energy use negatively affects carbon dioxide emissions in Pakistan, forestry output, agricultural production, animal production, population growth, rainfall, and temperature positively affect carbon dioxide emissions. Weber and Sciubba (2019) investigate population growth and GHG emissions in terms of the environment, revealing a significant correlation between regional population growth and increases in urban land use and GHG emissions in Western Europe. In contrast, other elements seem to be more significant in the nations of the East. Sulaiman and Abdul-Rahim (2018) investigate population growth and GHG emissions in Nigeria, and confirm that the population does not influence GHG emissions over the long term. However, economic development is the sole variable that determines long-term GHG emissions. Furthermore, population increase is only shown to influence GHG emissions in the medium term. Therefore, population control methods could be an efficient way to reduce emissions in the near term.

2. Research Methods

This study determines the effects of environmental knowledge, RE output and consumption, carbon finance, and population growth on the sustainability of the environment in China. Secondary data sources are used, taken from the OECD central bank database, WDI, and Global Footprint Network database for the period 1986 to 2020. The estimation equation of the study is:

$$LCF_t = \alpha_0 + \beta_1 REO_t + \beta_2 REC_t + \beta_3 EKN_t + \beta_4 CF_t + \beta_5 PG_t + e_t \quad (1)$$



Source: created by authors.

Figure 5. **Conceptual Framework**

Table 1. Variables and measurements

S#	Variable	Measurement	Source
01	Sustainable Environment	LCF (gha)	Global Footprint Network
02	Renewable Energy	RE output (REO) (% of total energy output)	WDI
		RE consumption (REC) (% of total energy consumption)	WDI
03	Environmental Knowledge	EK (environmental awareness index)	OECD
04	Carbon Finance	CF (the ratio of carbon finance to total finance)	Central Banks
05	Load Capacity Factor	LCF (the ratio of actual energy produced to energy which would have been produced)	Global Footprint Network
06	Population Growth	PG (annual percentage population growth)	WDI

Source: created by authors.

Descriptive statistics are given for the variables, including yearly descriptive statistics which show the year-wise details. The research employs the Phillips-Perron (PP) and augmented Dickey-Fuller (ADF) tests to determine the unit roots between the variables. The equation for the test applied is:

$$d(Y_t) = \alpha_0 + \beta t + YY_{t-1} + d(Y_t(-1)) + \varepsilon_t \quad (2)$$

The research employs the autoregressive distributed lag (ARDL) bound test to provide co-integration results for the model. This co-integration is necessary to check the long-term associations among the variables. The ARDL model is suitable for this research, as the unit root analysis, using ADF and PP, indicates that the variables have no unit root at I(0) or I(1). The major condition for applying the ARDL model is that some variables have no unit root at I(0), and others have no unit root at I(1) (Qamruzzaman, Jianguo, 2018). The ARDL also has the characteristic of providing long- and short-term analyses (Sohail *et al.,* 2021). Moreover, the ARDL model is able to adjust for the effects of autocorrelation and heteroscedasticity in the estimations and provide accurate outcomes. The equation for the ARDL model is:

$$\Delta GLCF_t = \alpha_0 + \sum\delta_1\Delta LCFE_{t-1} + \sum\delta_2\Delta RE0_{t-1} + \sum\delta_3\Delta REC_{t-1} + \sum\delta_4\Delta EKN_{t-1} + \sum\delta_5\Delta PG_{t-1} + \varphi_1 LCF_{t-1} + \varphi_2 REO_{t-1} + \varphi_3 REC_{t-1} + \varphi_4 EKN_{t-1} + \varphi_5 CF_{t-1} + \varphi_6 LCF_{t-1} + \varphi_7 PG_{t-1} + \varepsilon_t \quad (3)$$

The research also employs the nonlinear ARDL (NARDL) model, because the purpose is to check the asymmetric linkages among CF, PG, and LCF. The unequal function for this purpose is:

$$LCF = f\,(REO, REC, EKN, CF^+, CF^-, PG^+, PG^-) \quad (4)$$

Therefore, the empirical model is established as:

$$LCF_t = \alpha_0 + \beta_1 REO_t + \beta_2 REC_t + \beta_3 EKN_t + \beta_4 CF_t^{\,+} + \beta_5 CF_t^{\,-} + \beta_6 PG_t^{\,+} + \beta_7 PG_t^{\,-} + e_t \quad (5)$$

The calculation of the asymmetric linkages among CF, PG, and LCF requires us to know the partial sums of the positive and negative changes of the variables, given as:

$$CF^+ = \sum_{i=1}^{t}\Delta CF_i^+ = \sum_{i=1}^{t}\max(\Delta CF_i\, 0) \quad \textbf{(6)}$$

$$CF^- = \sum_{i=1}^{t}\Delta CF_i^- = \sum_{i=1}^{t}\min(\Delta CF_i\, 0) \quad \textbf{(7)}$$

$$PG^+ = \sum_{i=1}^{t}\Delta PG_i^+ = \sum_{i=1}^{t}\max(\Delta PG_i\, 0) \quad \textbf{(8)}$$

$$PG^- = \sum_{i=1}^{t}\Delta PG_i^- = \sum_{i=1}^{t}\min(\Delta PG_i\, 0) \quad \textbf{(9)}$$

Using these asymmetric linkages we derive the NARDL model equation:

$$\Delta LCF_t = \alpha_0 + \sum\delta_1\Delta LCF_{t-1} + \sum\delta_2\Delta REO_{t-1} + \sum\delta_3\Delta REC_{t-1} + \sum\delta_4\Delta EKN_{t-1} + \sum\delta_6\Delta CF_{t-1}^+ + \sum\delta_7\Delta CF_{t-1}^- + \sum\delta_8\Delta PG_{t-1}^+ + \sum\delta_9\Delta PG_{t-1}^- + \varphi_1 LCF_{t-1} + \varphi_2 REO_{t-1} + \varphi_3 REC_{t-1} + \varphi_4 EKN_{t-1} + \varphi_5 CF_{t-1}^+ + \varphi_6 CF_{t-1}^- + \varphi_7 PG_{t-1}^+ + \varphi_8 PG_{t-1}^- + \varepsilon_t \quad (10)$$

3. Empirical Findings

The outcomes shown *Table 2* indicate that the REO mean value is 18.150, REC is 22.831, and EKN is 69.884. The CF average value is 69.887, LCF is 37.886, and PG is 69.884.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LCF	35	94.754	106.475	-78.844	268.353
REO	35	18.150	1.869	15.037	23.927
REC	35	22.831	9.855	7.171	38.492
EKN	35	69.884	23.661	35.480	106.070
CF	35	69.887	24.493	31.060	103.250
PG	35	0.842	0.387	0.238	1.610

Source: created by authors.

The outcomes shown in *Table 3* indicate that the largest REO value is reported in 2015, while the largest REC value is recorded in 1986, and the highest EKN value is reported in 2020. The outcomes also indicate that the maximum CF value is recorded in 2020, while the largest LCF value is recorded in 2009, and the highest PG value is reported in 1988.

Table 3. Descriptive statistics by year

	REO	REC	EKN	CF	LCF	PG
1986	16.963	38.492	35.480	31.060	29.771	1.487
1987	17.033	37.571	37.120	32.750	30.323	1.604
1988	17.102	36.649	37.200	33.460	30.875	1.610
1989	17.172	35.728	38.170	34.650	31.428	1.533
1990	20.408	34.084	40.630	37.140	32.200	1.467
1991	18.471	33.258	40.800	38.280	32.355	1.364
1992	17.585	32.931	42.730	40.550	32.777	1.226
1993	18.125	31.678	46.010	44.290	33.900	1.150
1994	18.088	31.249	46.620	46.850	34.188	1.130
1995	19.214	29.472	49.810	51.350	34.740	1.087
1996	17.552	30.537	54.110	53.840	35.200	1.048
1997	17.512	30.183	55.280	55.940	35.620	1.023
1998	18.061	29.740	56.980	59.110	36.065	0.960
1999	16.681	30.506	59.430	61.880	38.700	0.866
2000	16.639	29.630	62.830	64.640	38.207	0.788
2001	18.959	28.360	63.750	65.700	38.887	0.726
2002	17.619	27.000	66.880	68.380	42.000	0.670
2003	15.037	23.860	66.710	69.310	41.220	0.623
2004	16.223	20.170	70.750	72.870	42.032	0.594
2005	16.175	17.440	73.090	75.660	40.900	0.588
2006	15.593	16.390	74.410	77.330	43.059	0.558
2007	15.263	14.880	76.910	79.200	43.807	0.522
2008	17.737	14.140	81.800	83.800	43.000	0.512
2009	17.864	13.430	83.830	86.140	44.435	0.497
2010	18.623	12.260	86.480	88.720	43.700	0.483
2011	16.762	11.340	90.810	91.770	42.400	0.546
2012	19.966	11.530	93.160	94.370	42.200	0.678
2013	20.296	11.450	95.480	96.310	39.700	0.666
2014	22.609	11.940	97.110	98.000	39.200	0.630
2015	23.927	12.180	101.620	101.140	38.600	0.581
2016	19.058	12.560	101.270	100.860	38.500	0.573
2017	19.128	13.130	103.380	102.590	39.100	0.605
2018	19.197	13.710	104.020	103.250	38.500	0.468

Source: created by authors.

The research uses a correlation matrix to show the correlations among the constructs. The results reveal that REC, EK, CF, PG and REO have positive associations with LCF.

Table 4. Matrix of correlations

Variable	LCF	REO	REC	EKN	CF	PG
LCF	1.000					
REO	0.420	1.000				
REC	0.968	-0.326	1.000			
EKN	0.983	0.417	0.958	1.000		
CF	0.977	0.383	0.963	0.996	1.000	
PG	0.874	-0.129	0.899	-0.894	-0.921	1.000

Source: created by authors.

The research employs the ADF and PP tests to determine the unit roots between the variables. The outcomes indicate that LCF, REO, and PG show no unit root at a level, and that EKN, REC, and CF have no unit root at first difference. The analysis is provided in *Table 5*.

Table 5. Unit root tests

	ADF		PP	
Series	Level	First difference	Level	First difference
LCF	-2.091***	----	-3.093***	----
REO	-3.099***	----	-2.175***	----
REC	----	-4.907***	----	-6.907***
EKN	----	-5.092***	----	-5.342***
CF	----	-5.091***	----	-5.876***
PG	-3.675***	----	-4.215***	----

Source: created by authors.

The ARDL bound test provides outcomes for co-integration in the model. The outcomes indicate that the calculated f-statistics are larger than the critical values. Therefore co-integration exists, and the analysis is provided in *Table 6*.

Table 6. Bound test of NARDL

	F-statistic	Lower Bound	Upper Bound	Decision
Linear ARDL	0.730	1.592	21.902	No Co-integration
Asymmetric ARDL	4.894	2.012	2.771	Co-integration

Source: created by authors.

Table 7. NARDL results

Variable	Coefficient	Std. Err.	t-statistic
C	0.728	0.182	4.000
GHGE (-1)	0.562	0.123	-4.569
REO (-1)	-1.663	0.367	-4.531
REC (-1)	-1.785	0.453	-3.940
EKN (-1)	-0.783	0.111	-7.054
CF-P (-1)	-4.376	1.282	-3.413
CF-N (-1)	-0.664	0.103	-6.447
PG-P (-1)	-4.673	1.901	-2.458
PG-N (-1)	-3.762	1.420	-2.649
Adj. R Square	0.565		
F-statistic	47.243		
Prob.(F-statistic)	0.001		

Source: created by authors.

The study uses the NARDL model to check the associations among the variables. The outcomes reveal that REO, REC, EK, CF, and PG have positive relationships with LCF. The research outcomes also show that asymmetric linkages exist among CF, PG, and LCF. These analyses are given in *Table 7*.

4. Discussion

The results show that RE output is positively associated with a sustainable environment. This result is in line with Nathaniel, *et al.* (2021), who suggest that, in countries where the government itself invests in and manages RE production and generates higher RE output, the supply of clean energy increases. When people have a greater supply of clean energy, they reduce their use of fossil fuels to maintain their daily operations, causing fewer GHGs to be emitted into the atmosphere, hence a pollution-free environment which is sustainable. These results are supported by Usman *et al.* (2020), who emphasize RE output and imply that when small or large units are installed for the production of RE, the use of clean energy results in higher environmental sustainability. These results agree with Alola *et al.* (2019), who find that, when units give higher RE output, more businesses apply an energy transition and reduce GHG emissions from their production and operation, making the environment more sustainable.

The study result show that RE consumption is positively associated with a sustainable environment, which is in line with Kirikkaleli and Adebayo (2021), who indicate that, when energy from sustainable resources is used to perform operational functions in various economic industries, the burden on organizations to use fossil fuels is reduced, decreasing the creation of GHG, leaving the environment more sustainable. These results are also supported by Sarkodie *et al.* (2020), who claim that, when RE consumption is introduced to a country, and the majority of the public is willing and has the capability to use RE sources, they stop relying on fossil fuels. The lower use of coal, oil, and gas reduces carbon, sulphur, and methane emissions, and environmental quality becomes more sustainable. These results agree with S.A.R. Khan *et al.* (2020), who state that the introduction of energy-efficient technologies and RE consumption in these technologies discourages the use of energy from nuclear or fossil fuels, reduces GHG emissions and makes the environment sustainable.

The results show that environmental knowledge is positively associated with a sustainable environment, in line with Ardoin *et al.* (2020), who posit that, when the people of a country are provided with adequate knowledge about environmental protection, they are better able to judge clean energy sources. The reduction of GHG-emitting energy develops sustainability in environmental productivity. These results are supported by Kopnina (2020), who claims that increasing environmental knowledge enables communities to carry out activities which do not cause the emission of hazardous gases. So when people have environmental knowledge, they can sustain their environmental quality. These results agree with Teruel-Serrano and Vinals (2020), who reveal that, if environmental knowledge prevails in an economy, people use novel technologies that release fewer GHG emissions.

The results show that carbon finance is positively associated with a sustainable environment, which is in line with Cui *et al.* (2020), who find that, with carbon financing, organizations can improve their financial strength, not only by paying attention to economic goals but by addressing environmental issues in economic processes, hence minimizing GHG emissions and preserving the environment. These results are supported by Akomea-Frimpong *et al.* (2022), who suggest that carbon finance enables organizations to implement strategies for technological innovation. These organizations use renewable energy resources in energy-efficient technologies and emit relatively few GHG emissions, making the environment more sustainable. These results agree with Falcone and Sica (2019), who also highlight carbon finance, suggesting that it encourages the application of innovative energy technologies which emit low carbon, and thus the environment is safer.

The results show that population growth is positively associated with a sustainable environment, in line with I. Khan *et al.* (2021), who state that the rate of population growth affects a region's development policies. In highly populated places, environmentally friendly development techniques are used. These procedures eliminate the causes of GHG emissions while maintaining environmental quality. These results are supported by Kulkarni (2020), who looks at the effects of population expansion on achieving a sustainable environment. A large population encourages development, which improves environmental quality and shields it from commercial pollutants. Hence, a sustainable environment is possible. These results agree with Mohsin *et al.* (2019), who claim that human capital is primarily accessible in locations with rapid population expansion, and a decreased reliance on machinery lowers GHG emissions.

5. Implications

This study provides guidelines for the authors of future research through its many novel contributions. The main subject of the study is a sustainable environment, as it explores the influences of RE output, RE consumption, environmental knowledge, carbon finance, and population growth. The authors use load capacity factor as a proxy for environmental sustainability. The study contributes to the literature by examining the impacts of RE output, RE consumption, environmental knowledge, carbon finance, load capacity factor, and population growth on a sustainable environment in China.

The study has considerable significance for GHG-emitting economies such as China, because its focus is to eradicate GHG emissions to attain a sustainable environment. The study suggests ways for economic and environmental regulators to attain environmental sustainability. It suggests that a greater number of units be installed, or subsidies given to promote RE output, to mitigate GHG emissions for a sustainable environment. Individuals and commercial interests must be motivated to apply RE consumption to contribute to environmental sustainability. It also provides a guideline that there must be an improvement in environmental knowledge to minimize the emission of GHGs so that a sustainable environment can be achieved. The article guides policymakers developing policies regarding a sustainable environment to use RE, environmental knowledge, and carbon finance. It also suggests that banks and financial institutions provide carbon finance so that environmental sustainability can be achieved. The study suggests that policymakers must encourage an increase in load capacity factor in order to attain a sustainable environment. It also implies that the population growth of a country must be properly managed for environmental sustainability.

Conclusions

The authors examine the impacts of RE output, RE consumption, environmental knowledge, carbon finance, and population growth on a sustainable environment. The results show that, when energy production units give higher RE output, people employ energy transition in businesses and reduce GHG emissions from business processes. Hence, the environment is sustainable. Likewise, when there is an increasing trend of RE consumption, people stop relying on fossil fuels which are sources of GHGs. The results reveal that, if the environmental knowledge of the public increases, they start to use novel eco-friendly technologies and the environment becomes more sustainable. The results also indicate that carbon finance, such as green securities, green credit, and green investment, encourages the eco-friendly application of innovative energy technologies which emit less carbon, and thus the environment is kept safe with sustainable productivity. The results reveal that an increase in load capacity factors boosts the economy, without GHG emissions, leading to sustainable development. In countries with large populations, there is greater environmental sustainability.

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ANGLIES FINANSAVIMO, ATSINAUJINANČIOS ENERGIJOS IR APLINKOS ŽINIŲ POVEIKIS APKROVOS KOEFICIENTUI

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Santrauka. Apkrovos koeficientas yra kompleksinis rodiklis, leidžiantis palyginti biologinį pajėgumą su ekologiniu pėdsaku ir stebėti aplinkos slenksčio būklę. Mokslininkų teigimu, didėjant aplinkos taršai, apkrovos koeficientas mažėja. Esamoje literatūroje aplinkos degradacija dažniausiai matuojama empiriškai, remiantis gerai ištirtais rodikliais, tokiais kaip ekologinis pėdsakas, anglies emisija, šiltnamio efektą sukeliančių dujų išmetimas ir azoto išskyrimas. Dėl naudojamų tarpinių serverių dažnai nepaisoma aplinkos problemų tiekimo pusės. Šis tyrimas užpildo esamą spragą, kadangi nagrinėtas atsinaujinančios energijos naudojimas, įtrauktos aplinkosaugos žinios ir informacija apie anglies dioksido finansavimą bei jų poveikį apkrovos koeficientui Kinijoje. Asociacijoms įvertinti taikytas netiesinis autoregresyvus paskirstytasis atsilikimo (NARDL) metodas. Rezultatai atskleidė, kad atsinaujinančios energijos gamyba ir vartojimas, žinios apie aplinką, anglies dioksido finansavimas ir gyventojų skaičiaus augimas teigiamai koreliuoja su apkrovos koeficientu Kinijoje. Todėl Kinijos vyriausybė turi skatinti biomasės naudojimą ir investicijas į atsinaujinančios energijos formas, kad apribotų emisijas.

Reikšminiai žodžiai: atsinaujinanti energija; aplinkosaugos žinios; anglies dioksido finansavimas; apkrovos koeficientas; tvari aplinka.