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Original Research

Green Finance and Environmental Security: Evidence from Global Perspectives

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Abstract

As global economies grapple with the dual challenges of environmental degradation and sustainable development, the role of green finance has gained increasing attention. Therefore, this study aims to unfold the impact of green finance on environmental security. Using data from 48 countries from 2020 to 2023, this study explores how green finance initiatives, such as investments in renewable energy, contribute to environmental stability. We collect empirical data from multiple sources, such as the World Development Indicators and the OECD database, and employ regression analysis techniques. The results demonstrate that renewable energy can help combat climate change by reducing carbon emissions from electricity generation. Moreover, a noteworthy connection exists between green investment initiatives and modified savings, suggesting a possible financial and environmental sustainability path.

Keywords: green finance, environmental security, renewable energy, carbon emission

Introduction

Green finance refers to the financing of environmentally sustainable projects [1]. The main objective of green finance is to advance sustainable development that benefits both the economy and ecology. The coordination of financial and monetary resources and activities achieves this, minimizing negative impacts on the environment and habitats while promoting sustainable growth [2, 3]. Green finance covers a variety of sustainable financial products, including green bonds, loans, and funds [4].

The term green finance refers to financing environmentally sustainable projects. Environmental issues threaten human health and economic progress, thus drawing attention from governments, scholars, and academics. Various industries' natural resource consumption and pollutant emissions closely relate to these issues [5]. Industries are the major sources of pollutant emissions, closely related to natural resource consumption and environmental concerns [6]. Therefore, considering ESG (environmental, social, and governance) investment factors can significantly

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promote sustainable finance in industries that pollute the environment. Investors can encourage companies to adopt environmentally friendly practices and social responsibility measures, positively impacting the environment and society. It is an excellent step towards building a more sustainable future [7]. Green finance can help companies reduce emissions and save energy through technological innovation [8, 9].

The current study links green finance and environmental security by supporting environmentally friendly projects and activities. Investing in environmentally conscious projects can address ecological problems, e.g., global warming, wildlife destruction, and the exhaustion of organic materials. This strengthens the ecosystem's durability and security in the long run. Therefore, leaders worldwide gathered in Glasgow in November 2021 for the United Nations Conference on Climate Change to debate green finance, a strategy for allocating financial resources toward sustainable development goals [10, 11].

Innovative financing solutions are necessary to address environmental issues as the green economy continues to grow [12]. Proponents propose green finance to fund businesses, individuals, and governments involved in environmental preservation [13]. As a result, green finance, an alternate means of financing green or low-carbon operations, has received substantial attention recently [14]. Green financing has many advantages. It permits using funds for environmental protection and promotes sustainable trade and investment. It also creates new instruments for green investment and financing and provides low-risk financing options [12]. Green finance, however, is only one type of environmentally friendly financing. Other studied topics include blue finance, online finance, and social finance [15].

Green finance offers several benefits. First, it can provide financial assistance to businesses engaged in eco-friendly innovation, helping them purchase green equipment, introduce new eco-efficient technology, and provide employee training. Secondly, green financing can support various initiatives that assist governments, organizations, and regulators in directing their research and development funds toward tackling environmental issues. Furthermore, this funding may reduce the risks associated with green legislation. Stakeholders can invest in environmentally friendly technologies and practices to reduce their environmental impact and promote sustainable development. Green financing alternatives can assist firms in overcoming their financial issues, even though green initiatives typically incur higher expenses than standard ones. Green finance is essential for boosting economic expansion, coordinating environmentally friendly initiatives, cutting down on environmental pollution, and creating more sustainable nations [16, 17].

This study aims to clarify the significance of green financing in the context of environmental protection. Concerns like biodiversity loss and climate change are becoming more prevalent today. Robust financial plans must be in place to fund initiatives that advance environmental protection. The goal is to establish a direct link between the long-term security and stability of the ecosystems and the implementation of green financing. This research will look into how funding environmentally friendly projects may help address global environmental challenges to facilitate the integration of green finance into traditional financial processes. In addition to highlighting the positive environmental benefits of this practice, the goal is to draw attention to the inherent capacity of green finance to help create a more environmentally friendly and secure future for the entire globe. We also conduct empirical analysis to provide vital information that will encourage ethical financial behavior, aid in formulating sound policy, and increase public understanding of the relationship between financial strategy and environmental security.

This study is structured as follows: Section 2 presents the recent literature relevant to the study. Section 3 outlines the study's hypotheses. Section 4 specifies the methodology used to inspect the relationship between green finance and environmental security. Section 5 elaborates on the empirical findings. Section 6 compiles a discussion of the results. Section 7 concludes the study and provides policy implications, limitations, and future research directions.

Literature Review

The concept of green or environmental finance is not new. However, most existing studies have documented the concept in diverse fields, e.g., workforce, education, eco-policies, sustainable development goals, eco-innovation, etc. Table 1 documents the recent literature on green finance and environmental challenges.

Previous literature has examined the phenomenon of green finance from various perspectives, such as ecological changes and policy interventions [26], regional financial growth [27], and green innovation and sustainability [28, 29]. However, there still needs to be a significant gap in understanding the impact of green finance on environmental security using cross-country data. The existing literature focuses on localized [18] and regional [24] analyses, and while it highlights the benefits of green finance in fostering innovation and improving environmental outcomes, it needs to comprehensively evaluate its impact on environmental security on a global scale. This study addresses the gap by using data from 48 countries from 2020 to 2023 to assess how green finance influences environmental security, particularly from a more global perspective on the environmental benefits of green financial initiatives.

Hypothesis Development

Green finance provides businesses with funding to carry out environmental projects [33]. It helps

Table 1. Literature review.

Author – Year	Findings
Cheberyako, et al. (2021)	In the context of the Ukrainian economy, increasing public-private partnerships and investing in education to develop a trained workforce in green finance are important to minimize climate risk.
Yu, et al. (2021)	In the context of the Chinese economy, this study found that financial barriers deter the growth of green businesses in the Chinese economy, and green financial policies can enhance green innovations.
Wang, et al. (2021)	This study concludes that green financial reform is important to stabilize the Chinese economy. Moreover, such reforms are also important to reduce environmental challenges.
Zheng, et al. (2021)	This study adds to the role of green finance in sustainable ecological practices in developing countries and finds supportive evidence, particularly in Bangladesh.
Mngumi, et al. (2022)	The researchers determined that it is beneficial to investigate this new financing strategy to promote green finance and assist those seeking to expand their green finance markets. Moreover, examining the impact of realizing the Sustainable Development Goals (SDGs) is imperative.
Ronaldo and Suryanto (2022)	Through detailed empirical analysis using PLS models, the study discovered that green finance is associated with green micro-enterprise, green technology innovation, and environmental sustainability.
Zhou, et al. (2023)	In a study on developing countries, the authors discovered that innovation in green technology, industrial structure upgrading, and environmental control are important. The pilot areas for carbon emissions in the east are where the benefits are most noticeable.
Kumar, et al. (2023)	The study's findings suggest that funding the circular economy through green finance can reduce climate change and advance sustainability.
Nenavath and Mishra (2023)	The study's findings indicate that the ecological revolution is critical to improving the effectiveness of green finance. Moreover, effective policy intervention is also required to promote green finance progress.
Fan, et al. (2023)	The empirical results suggest that regional green financial growth raises the standard of living. Furthermore, the authors found a nonlinear relationship between green financial development and environmental challenges.
Wang, et al. (2023)	The study investigates how corporate green innovation and green financing affect environmental sustainability. Using empirical estimates, the findings suggested that the green financing pilot program encourages green innovation and positively impacts the environment.
Ma, et al. (2023)	This study aims to determine the interconnection between environmental performance, green finance, and green innovation. The empirical results attest to the connection among the said indicators, both long-term and short-term.
Udeagha and Ngepah (2023)	This study found that green finance is essential for achieving the Sustainable Development Goals (SDGs). Moreover, green technological innovation and green enterprises play a role in environmental sustainability.
Tariq and Hassan (2023)	This study's findings demonstrate that green financing and renewable energy significantly impact environmental sustainability. Moreover, it recommends enforcing eco-policies in developing countries.
Xiao, et al. (2024)	The research shows that financial inclusion and energy transitions facilitate sustainable development goals by promoting industrial structural transformation.

businesses replace outdated production equipment and technology, lowering carbon emissions. Green finance can encourage businesses to expand their environmental conservation efforts [34]. Green finance, such as bond issuance, fund creation, and capital attraction, can increase the return on investment for environmental initiatives. This incentivizes businesses to manage their expenditures towards environmental preservation, enhancing efficacy in diminishing carbon emissions. Green financing offers consistent support for eco-friendly operations, promoting further spending on environmental preservation and enhancing initiatives to reduce carbon emissions [33, 35].

Due to disparities in economic development, we anticipate that the effect of green finance on reducing carbon emissions will vary depending on the location [36, 37]. Because local governments have been actively promoting business expansion in pursuit of green and low-carbon development goals, certain locations are particularly vulnerable to the effects of green funding. This has led to the establishment of favorable policy conditions, the facilitation of industrial structure modernization, and the promotion of a low-carbon economy. The less developed green finance market, however, may limit the effect of green money on lowering carbon emissions. Meanwhile, the topography, antiquated infrastructure, and ineffective transportation systems are to blame for the slower rate of economic development. Regrettably, the commercial climate for green finance is still developing, which limits its potential impact on efficiently lowering carbon emissions.

Green finance is essential for improving businesses' innovation capacity. The green finance industry's development and expansion necessitate ongoing innovation in financial services and products [38]. For financial institutions to provide green finance products like bonds and carbon trading, they need to be creative in their R&D. This requires high levels of technical proficiency in fields like carbon measurement and ecological technology. The growth of green finance has the potential to propel technological innovation and environmental protection research. Financial institutions will investigate and develop more ecologically friendly financial goods and services as the green financial industry grows, encouraging environmental technology research and innovation. Improving carbon emission efficiency requires innovation. Innovation drives the green finance market's ongoing expansion and improvement, offering the environmental protection sector a variety of adaptable financing options [39, 40].

Green finance offers the environmental sector flexible and diverse financing by incorporating resource efficiency and environmental protection into financial operations. Financial innovation increases carbon emission efficiency and encourages investments in environmental conservation. Additionally, it standardizes the green finance sector, enhancing the funding sources' stability, openness, and dependability. Furthermore, innovation drives advancements in carbon emission efficiency by improving environmental protection firms' competitiveness and social standing. Because more businesses are becoming aware of environmental challenges and the need for sustainable development, there has been a greater reduction in carbon emissions due to the rise of the green finance sector [37, 41].

The green financing sector has increased regulation, and public awareness of carbon emissions has increased as a result of the green financing sector. Businesses, financial institutions, and governments have established regulations to encourage and control such funding. As a result, the industry now offers a greater choice of products and services, which promotes investment and environmental preservation research [42, 43]. The degree of control over carbon emissions has halted, but firms' awareness of environmental protection and green finance regulations has also increased [44]. Businesses' capacity to protect their environment lessens their reliance on the green finance market, while their operational management skills limit the pace of carbon emission reduction. Companies must practice corporate accountability to achieve financial and long-term success while averting social and environmental issues. Two strategies businesses can use to demonstrate their commitment to stakeholders, including the general public, shareholders, investors, and customers, are green finance and corporate social responsibility [45]. However, it is crucial to remember that green finance procedures could undermine social and environmental responsibility in the long run [46].

When it comes to the environment, green finance has become a new focal point and means of addressing issues like climate change, ecological balance, and internal environmental preservation [46]. To help enterprises achieve long-term viability and sustainability, the environmental dimension of green finance includes reducing energy use and greenhouse gas emissions while analyzing energy usage and customers' environmental risks [47]. Green finance makes green finance policies more effective and speeds up cash flow to the environmental protection sector by reducing the time it takes for traditional government funds to reach market mechanisms that support environmental protection [20]. New and developing diverse green funding models, legislative incentives, and support services elevate technological R&D for green sectors. The number of resources an organization uses for operations, such as energy, land, and water, and the products it produces, such as waste, air emissions, chemical residues, and effluents, determine its environmental performance [48].

The financial sector, comprising firms and institutions offering financial services, is vital for countries, facilitating financial intermediation, risk pricing, liquidity provision, and efficient resource allocation. Effective financial sector performance is essential for efficiently allocating financial resources, a key factor for growth and prosperity. Policymakers focus on financial policies to regulate and supervise the financial and payment systems, aiming to promote stability, market efficiency, and consumer protection [49]. However, these policies generally need to address climate change or environmental objectives. Therefore, the role of the financial sector in climate change mitigation is critical due to the transition to low-carbon economies and the nature of low-carbon technologies, which require substantial capital investments. Public policy is also essential in encouraging financial actors to support low-carbon pathways [50]. Therefore, drawing from the discussion above, we can formulate the following hypothesis:

Hypothesis: There is a positive relationship between green finance and environmental security.

Methodology

Sample and Data Sources

This study examines the relationship between green finance and environmental security by employing annual data from 2020 to 2023. As presented in Table 2, we gathered data from a large pool of forty-eight (48) countries worldwide. The study's time frame

Table 2. Sample countries.

Albania	Czechia	Ireland	North Macedonia	Sweden
Armenia	Denmark	Italy	Norway	Switzerland
Austria	Estonia	Kazakhstan	Poland	Tajikistan
Azerbaijan	Finland	Kyrgyz Republic	Portugal	Turkiye
Belarus	France	Latvia	Romania	Turkmenistan
Belgium	Georgia	Lithuania	Russian Federation	Ukraine
Bosnia	Germany	Luxembourg	Serbia	United Kingdom
Bulgaria	Greece	Moldova	Slovak Republic	Uzbekistan
Croatia	Hungary	Montenegro	Slovenia	
Cyprus	Iceland	Netherlands	Spain	

is dependent on data availability. Moreover, we use multiple data sources to gather the data. These data sources include the World Bank's World Development Indicators, the OECD's Compare Your Country, and the BP statistical review.

We selected the data sample for 2020-2023 as it marked significant shifts in global climate and financial policies. Since the COVID-19 outbreak began, more countries have embraced green finance in their recovery plans, focusing more on sustainability and climate change resilience. This timeframe is useful to determine the impacts of these measures on climate change, energy production, and carbon emissions. Furthermore, it is consistent with major global climate targets like the Paris Agreement, thus creating a period of interest for assessing the impacts of green finance in cutting carbon emissions. Because of these reasons, this period can be considered suitable for exploring the impact of green finance on corresponding environmental consequences in an increasingly globalized and changing environment.

Based on the availability of green finance and environmental security data, this study contains 189 country-year observations. The sample covers 48 countries across different years. These countries differ in terms of their environmental challenges and the development of green finance, enabling panel data analysis. Moreover, the sample size, though modest, is sufficient to perform meaningful statistical analysis, including regression models that account for variations across countries and time. By capturing a range of factors influencing carbon emissions, this dataset offers valuable insights into the global relationship between green finance and environmental sustainability.

Measurement of Variables

In this study, environmental security was used as a dependent variable. To quantify this variable, we incorporated three proxies. These proxies include total greenhouse gas emissions, HFC gas emissions, and CO_2 emissions, particularly when using electricity. The literature extensively uses these variables to measure environmental concern [51, 52].

We use green finance as an independent variable. However, because direct measures of green finance are unavailable, we rely on their outcomes. We use three variables: renewable energy, adjusted savings, and consumption of combustible renewables. These variables are the results of green finance, and it is assumed that in a country where access to green finance is easy, these variables present a better or favorable outcome than in countries where it is difficult to obtain green finance [53, 54].

Finally, we use different control variables in this study, such as electricity from natural gas, electricity from renewable energy, electricity from oil and gas [55], growth in the manufacturing sector, growth in the residential sector, growth in the transportation sector [56], and air pollution [57].

Empirical Model

Based on the nature of the dataset, we have developed the following empirical model to test the impact of green finance on environmental security. The empirical model is composed of variables, constants, and error terms.

$$Environmental\ Security_{kt} = \beta_0 + \beta_1 Green\ Finance_{kt} + \sum_{j=1}^{07} \beta_j\ Controls_{kt} + e_{kt}$$

Results

Descriptive Statistics

Table 3 presents the summary statistics of the variables. The dataset includes 189 observations of several economic and environmental indicators. The mean total greenhouse gas emissions is 183,613.34 units, indicating a wide range; the standard

Table 3. Summary statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Total Greenhouse Gas Emissions	189	183613.3	356917.1	3237.18	2291991
HFC Gas Emissions	189	2523.02	5016.05	0	28623.5
CO_2 Emissions	189	41.88	17.85	0	80.75
Renewable Energy	189	17.37	16.51	0.07	75.89
Adjusted Saving	189	91.05	54.61	1	185
Combustible Renewable	189	5.21	5.49	0	24.19
Electricity From Natural Gas	189	25.17	28.57	0	100
Electricity From Renewable Sources	189	3.50	5.96	0	31.92
Electricity From Oil & Gas	189	52.66	32.33	0	100
Manufacturing Sector (Growth)	189	12.32	6.47	2.75	25.11
Residential Sector (Growth)	189	8.56	8.83	3.12	26.51
Transportation Sector (Growth)	189	18.02	12.53	2.11	29.22
Air Pollution	189	54.72	47.21	1	143

deviation is 356,917.1 units, indicating high variability. The mean HFC gas emissions were 2,523.025, indicating similar variability. The average CO_2 emissions is 41.888, indicating a moderate number of emissions with a significant variance. The observed entities' adjusted savings, which range from 1 to 185, demonstrate a broad range of economic conditions. Mean renewable energy consumption, at 17.375, shows notable variability, reflecting the diverse uptake of renewable energy sources. The consumption of combustible renewable energy and CO_2 emissions from different sources show comparable fluctuation patterns. Three categories have different mean percentages of electricity production, ranging from 25.171 to 52.668. Transportation, residential, and manufacturing sources vary in annual growth rate, while the mean of air pollution remains entirely dispersed at 54.72. Together, these figures paint a picture of a diverse dataset regarding the environment and economy, and they offer insights into the challenges associated with development and sustainability.

Table 4. Correlation matrix.

	1	2	3	4	6	5	7	8	9	10	11	12
2	0.87											
3	0.18	0.07										
4	-0.05	-0.18	0.30									
6	-0.23	-0.17	0.01	-0.11								
5	-0.30	-0.24	-0.39	-0.08	0.44							
7	0.12	0.07	0.01	0.11	-0.22	-0.45						
8	-0.03	0.08	-0.20	-0.54	0.16	0.24	-0.02					
9	0.18	0.08	0.50	0.20	-0.33	-0.71	0.58	-0.07				
10	-0.24	0.53	-0.02	-0.15	0.23	0.24	-0.23	0.24	-0.18			
11	0.43	0.57	-0.36	-0.37	-0.54	0.15	0.54	-0.43	0.50	-0.42		
12	0.32	-0.35	-0.51	0.24	0.13	0.52	-0.24	0.14	-0.19	0.21	0.14	
13	-0.19	-0.24	0.12	0.22	0.06	0.24	-0.13	-0.08	-0.13	0.05	0.02	-0.03

1 = Total Greenhouse Gas Emission, 2 = HFC Gas Emissions, 3 = CO_2 emissions, 4 = Renewable energy, 5 = Adjusted Saving, 6 = Combustible Renewable, 7 = Electricity From Natural Gas, 8 = Electricity From Renewable Sources, 9 = Electricity From Oil & Gas, 10 = Manufacturing Sector (Growth), 11 = Residential Sector (Growth), 12 = Transportation Sector (Growth), 13 = Air Pollution

Correlation Matrix

The correlation matrix (Table 4) highlights the connections between economic and environmental variables. A substantial positive correlation (r = 0.875) between total greenhouse gas emissions and HFC gas emissions suggests a close association between these two elements. Similarly, there is a positive relationship (r = 0.182) between CO_2 emissions from electricity generation and CO_2 emissions per capita, indicating that higher power production locations are also likely to have higher CO_2 emissions per capita. The negative correlation between adjusted savings and several variables, including renewable energy consumption, suggests that higher levels of adjusted savings may correlate with lower levels of renewable energy use. Furthermore, we have observed significant relationships between power generation and CO_2 emissions from various sources, highlighting the interdependence of energy production and emissions. Although not as strong, there are relationships between air pollution and several other characteristics. The correlation matrix provides insightful information about how different environmental and economic aspects interact, laying the groundwork for more research and formulating policies about sustainability and development.

Table 5. Regression analysis.

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – Total Greenhouse Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Renewable Energy	-7445.2	2707.1
Control Variables		
Electricity From Natural Gas	1040.3	1247.8
Electricity From Renewable Sources	4155.5	4528.2
Electricity From Oil & Gas	-2133.1	1425.4
Manufacturing Sector (Growth)	-177.2	4104.1
Residential Sector (Growth)	-3080.5	3708.3
Transportation Sector (Growth)	-5538	2450.6
Air Pollution	-1394.7	582.3
Constant	640310.4	164828.5
Model Summary		
Number of Observations	189	
F-Stats	3.66	
Prob. > F-Stats	0.00	
R-Square	0.14	

Regression Analysis

Table 5 provides the regression estimates using the total amount of greenhouse gas emissions as the dependent variable and renewable energy as the independent variable. The amount of consumed renewable energy has the highest statistically significant negative coefficient (-7445.2, p = 0.007) among the other predictors, suggesting a link between higher levels of renewable energy consumption and lower overall greenhouse gas emissions. On the other hand, the results of producing electricity from various sources are inconsistent, with none of the coefficients being statistically significant at conventional levels. Similarly, the growth of transportation, manufacturing, and residential sources does not show statistically significant coefficients.

Furthermore, a statistically significant negative correlation (-1394.07, p = 0.016) links higher air pollution levels to lower total greenhouse gas emissions. The model, with an R-squared value of 0.14, suggests that the predictors collectively explain 14% of the total greenhouse gas emissions variance. The F-test (F = 3.66, p = 0.001) further supports the model's relevance, confirming its validity in explaining total greenhouse gas emissions fluctuations.

Table 6 postulates the regression estimates using the total amount of greenhouse gas emissions as the dependent variable and adjusted savings as the independent variable. With an adjusted savings-to-total greenhouse gas emissions coefficient of 0.029 (p = 0.001), adjusted savings appear to have a strong positive correlation. One of the significant negative coefficients among the predictors is the amount of energy produced from non-renewable sources (-2325, p = 0.008), suggesting that a greater amount of power produced from non-renewable sources is linked to a reduction in overall greenhouse gas emissions. On the other hand, the marginally significant positive coefficient (435.5, p = 0.077) for electricity output from renewable sources indicates a slight positive correlation with overall greenhouse gas emissions. Other factors, such as air pollution and the growth rate of transportation, household sources, and manufacturing, have coefficients that are not statistically significant. With a high R-squared value of 0.96, the entire model can explain almost 96% of the variance in total greenhouse gas emissions through the actions of its predictors. The F-test further supports the model's significance (F = 641.85, p = 0.000), confirming its validity as an explanation for fluctuations in total greenhouse gas emissions.

Table 7 shows the regression estimates using the total amount of greenhouse gas emissions as a dependent variable and the consumption of combustible renewables as the independent variable. With a marginally significant negative coefficient (-9674.8, p = 0.06), combustible renewable energy usage is associated with a possible reduction in greenhouse gas emissions. There is no significant correlation between total greenhouse

Table 6. Regression analysis.

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – Total Greenhouse Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Adjusted Savings	0.029	221.8
Control Variables		
Electricity From Natural Gas	435.5	244.8
Electricity From Renewable Sources	-2325	879.5
Electricity From Oil & Gas	-148.9	218.3
Manufacturing Sector (Growth)	264	811.1
Residential Sector (Growth)	-679.2	635.1
Transportation Sector (Growth)	-17.5	492.2
Air Pollution	82.75	117.1
Constant	8005.6	25985.2
Model Summary		
Number of Observations	189	
F-Stats	641.85	
Prob. > F-Stats	0.00	
R-Square	0.96	

Table 7. Regression analysis.

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – Total Greenhouse Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Combustible Renewable	-9674.8	5099.5
Control Variables		
Electricity From Natural Gas	525.0	1248.1
Electricity From Renewable Sources	1895	4459.4
Electricity From Oil & Gas	83.5	1113.2
Manufacturing Sector (Growth)	431.2	4134.1
Residential Sector (Growth)	1149	3265.8
Transportation Sector (Growth)	-5408	2519.1
Air Pollution	-1641.5	574.4
Constant	411400.5	132975.1
Model Summary		
Number of Observations	189	
F-Stats	3.09	
Prob. > F-Stats	0.00	
R-Square	0.16	

gas emissions and electricity output, as evidenced by the predictors' lack of statistically significant coefficients for electricity generation from various sources. Similarly, there are no statistically significant correlations between the growth rate of household and industrial sources. On the other hand, transportation-related growth shows a statistically significant negative coefficient (-5408, p = 0.031), suggesting a negative correlation between transportation-related emissions and overall greenhouse gas emissions. Furthermore, a statistically significant negative correlation exists between air pollution and total greenhouse gas emissions (-1641.5, p = 0.003). This suggests a link between higher air pollution levels and lower greenhouse gas emissions. With an R-squared value of 0.16, the model suggests that the combined predictors can explain 16% of the total greenhouse gas emissions variance. The F-test (F = 3.09, p = 0.002) further supports the model's significance, confirming its validity in explaining total greenhouse gas emission fluctuations.

Robustness Check

Table 8 stipulates the regression estimates using total HFC gas emissions as the dependent variable and renewable energy as the independent variable. The statistically significant negative coefficient (-113.2, p = 0.002) for renewable energy use suggests a connection between higher levels of renewable energy consumption and reduced emissions of HFC gasses. The predictor that shows the strongest statistically significant positive correlation (152.3, p = 0.02) is the production of energy from non-renewable sources, which is associated with greater emissions of HFC gases. On the other hand, at conventional levels, the coefficients for electricity output from renewable sources and electricity production from all sources do not exhibit statistical significance. Similarly, there are no statistically significant coefficients for air pollution, growth rate of traffic, residential sources, or manufacturing. With an R-squared value of 0.12, the model can explain 12% of the variance in HFC gas emissions through the combined action of the predictors. The F-test further supports the model's significance (F = 3.92, p = 0.00), confirming its validity in explaining changes in HFC gas emissions.

Table 9 specifies the regression estimates using HFC gas emissions as the dependent variable and adjusted savings as the independent variable. The adjusted savings show a strong positive correlation with HFC gas emissions, with a statistically significant coefficient of 0.2 (p = 0.001). The predictors showed a statistically

Table 8. Regression analysis (robustness check).

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – HFC Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Renewable energy	-113.2	38.45
Control Variables		
Electricity From Natural Gas	-5.1	17.7
Electricity From Renewable Sources	152.3	62.5
Electricity From Oil & Gas	-35.3	19.5
Manufacturing Sector (Growth)	-85.2	57.2
Residential Sector (Growth)	14.8	51.5
Transportation Sector (Growth)	-38.5	34.5
Air Pollution	-19.5	8.7
Constant	9100.4	2310.9
Model Summary		
Number of Observations	189	
F-Stats	3.92	
Prob. > F-Stats	0.00	
R-Square	0.12	

Table 9. Regression analysis (robustness check).

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – HFC Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Adjusted Saving	0.2	29.6
Control Variables		
Electricity From Natural Gas	-12.5	7.1
Electricity From Renewable Sources	61.2	25.3
Electricity From Oil & Gas	-6.2	6.5
Manufacturing Sector (Growth)	-79.2	22.5
Residential Sector (Growth)	54.1	18.4
Transportation Sector (Growth)	33.1	14.5
Air Pollution	-1.9	3.1
Constant	289.5	745.3
Model Summary		
Number of Observations	189	
F-Stats	137.50	
Prob. > F-Stats	0.00	
R-Square	0.72	

significant positive coefficient (61.2, p = 0.013) for higher electricity production from non-renewable sources. This suggests a potential correlation between higher HFC gas emissions and power production from non-renewable sources. On the other hand, the growth rate of transportation and residential sources shows statistically significant positive coefficients, suggesting a relationship between higher emissions from these sources and higher emissions of HFC gasses. The high R-squared value of 0.72 indicates that the modified savings coefficients and predictors account for about 72% of the variance in HFC gas emissions. The F-test further supports the model's significance (F = 137.50, p = 0.00), demonstrating its validity in explaining changes in HFC gas emissions.

Table 10 states the regression estimates using HFC gas emissions as a dependent variable and combustible renewable energy sources as an independent variable. The coefficient of -126.1 (p = 0.09) for combustible renewable energy indicates a negative correlation with HFC gas emissions; nevertheless, it is not statistically significant at the conventional level (p<0.05). One of the predictors, air pollution, exhibits a statistically significant negative coefficient (-23.5, p = 0.002), indicating a link between lower HFC gas emissions and higher air pollution levels. On the other hand, energy production from non-renewable sources exhibits a marginally significant positive correlation with HFC gas emissions, with a coefficient of 117.5 (p = 0.052). Based on the R-squared value of 0.11, the model explains around 11% of the variance in HFC gas emissions. The F-test (F = 3.12, p = 0.00) confirms the model's significance, suggesting that the predictors collectively account for some of the variation in HFC gas emissions.

Table 11 shows the regression estimates using CO_2 emissions from electricity as a dependent variable and renewable energy usage as an independent variable. Renewable energy consumption exhibits a substantial negative correlation with carbon dioxide emissions from electricity production, with a value of -0.46 (p<0.001). This suggests a link between increased use of renewable energy and reduced carbon dioxide emissions from electricity production. The energy generation from non-renewable sources and emissions from different sources show statistically significant negative coefficients among the factors associated with electricity production. This implies a link between rising carbon dioxide emissions from energy production, increased emissions from various industries, and increased power production from non-renewable sources. On the other hand, energy production from renewable sources shows a substantial positive correlation with carbon dioxide emissions, with a positive coefficient of 0.086 (p = 0.026). However,

Table 10. Regression analysis (robustness check).

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – HFC Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Combustible Renewable	-126.1	71.8
Control Variables		
Electricity From Natural Gas	-12.3	17.6
Electricity From Renewable Sources	117.5	62.5
Electricity From Oil & Gas	-2.5	15.7
Manufacturing Sector (Growth)	-76.5	57.5
Residential Sector (Growth)	79.5	45.1
Transportation Sector (Growth)	-38.5	35.1
Air Pollution	-23.5	8.2
Constant	5585.0	1867.1
Model Summary		
Number of Observations	189	
F-Stats	3.12	
Prob. > F-Stats	0.00	
R-Square	0.11	

Table 11. Regression analysis (robustness check).

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – CO_2 Emissions		
	Coefficients	Standard Error
Independent Variable		
Renewable energy	-0.46	0.09
Control Variables		
Electricity From Natural Gas	-0.10	0.03
Electricity From Renewable Sources	0.02	0.13
Electricity From Oil & Gas	0.09	0.03
Manufacturing Sector (Growth)	-0.62	0.1
Residential Sector (Growth)	-0.91	0.11
Transportation Sector (Growth)	-0.59	0.05
Air Pollution	0.79	0.02
Constant	82.5	4.5
Model Summary		
Number of Observations	189	
F-Stats	68.13	
Prob. > F-Stats	0.00	
R-Square	0.74	

the effect size is smaller than the drawbacks of using renewable energy and emissions from other sources. There is no statistically significant coefficient for air pollution. The R-squared value of 0.74 indicates that the model accounts for 74% of the variance in carbon dioxide emissions from electricity production. The F-test confirms the model's significance (F = 68.13, p<0.001), indicating that the predictors account for some of the variation in carbon dioxide emissions from electricity production.

Table 12 displays the regression estimates using CO_2 emissions from electricity as the dependent variable and adjusted savings as the independent variable. The adjusted savings demonstrate a marginally significant positive correlation with carbon dioxide emissions from energy production, with a value of 0.36 (p = 0.06). A statistically significant negative coefficient of -0.11 (p = 0.001) among the predictors associated with electricity production links higher electricity production from non-renewable sources to lower carbon dioxide emissions from electricity generation. On the other hand, a substantial positive coefficient of 0.24 (p<0.001) indicates a positive association between power output from renewable sources and carbon dioxide emissions. Furthermore, statistically significant negative coefficients for emissions from various industries indicate a link between higher emissions from these sectors and reduced carbon dioxide emissions from energy production. There is no statistically significant coefficient for air pollution. The R-squared value of 0.68 indicates that the model accounts for about 68% of the variance in carbon dioxide emissions from electricity production. The F-test confirms the model's significance (F = 53.24, p<0.001), indicating that the predictors account for some of the variation in carbon dioxide emissions from electricity production.

Table 13 presents the regression estimates using CO_2 emissions from electricity as the dependent variable and combustible renewable energy as the independent variable. The generation of combustible renewable energy exhibits a substantial positive correlation with carbon dioxide emissions from electricity production, as evidenced by its significant positive coefficient of 0.88 (p<0.001). A statistically significant negative coefficient of -0.13 (p = 0.001) among the predictors associated with electricity production links higher electricity production from non-renewable sources to lower carbon dioxide emissions from electricity generation. On the other hand, power generation through renewable sources shows a noteworthy positive coefficient of 0.27 (p<0.001), suggesting a positive correlation with carbon dioxide emissions. There is no statistically significant

Table 12. Regression analysis (robustness check).

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – CO_2 Emissions		
	Coefficients	Standard Error
Independent Variable		
Adjusted Savings	0.36	0.08
Control Variables		
Electricity From Natural Gas	-0.11	0.02
Electricity From Renewable Sources	-0.14	0.13
Electricity From Oil & Gas	0.24	0.04
Manufacturing Sector (Growth)	-0.51	0.10
Residential Sector (Growth)	-0.62	0.08
Transportation Sector (Growth)	-0.63	0.08
Air Pollution	0.01	0.02
Constant	64.75	3.80
Model Summary		
Number of Observations	189	
F-Stats	53.24	
Prob. > F-Stats	0.00	
R-Square	0.68	

Table 13. Regression analysis (robustness check).

Regression Estimates		
Unit of Observation – Panel (Country Year)		
Dependent Variable – CO_2 Emissions		
	Coefficients	Standard Error
Independent Variable		
Combustible Renewable	0.88	0.14
Control Variables		
Electricity From Natural Gas	-0.13	0.02
Electricity From Renewable Sources	-0.19	0.12
Electricity From Oil & Gas	0.27	0.03
Manufacturing Sector (Growth)	-0.46	0.09
Residential Sector (Growth)	-0.55	0.08
Transportation Sector (Growth)	-0.76	0.07
Air Pollution	0.01	0.02
Constant	60.75	3.50
Model Summary		
Number of Observations	189	
F-Stats	68.50	
Prob. > F-Stats	0.00	
R-Square	0.74	

coefficient for air pollution. The R-squared value of 0.74 indicates that the model accounts for 74% of the variance in carbon dioxide emissions from power production. The F-test confirms the model's significance ($F = 68.50$, $p<0.001$), indicating that the predictors account for some of the variation in carbon dioxide emissions from electricity production.

Additional Tests

The aforementioned regression analysis (Tables 5, 6, and 7) is further evaluated using advanced endogenous modeling. We mainly use the SGMM (system-generated method of moments) technique. The said technique used system-generated instrumental variables and effectively controlled for the possible presence of endogeneity. Table 14 provides the SGMM regression estimates using the total amount of greenhouse gas emissions as the dependent variable and renewable energy as the independent variable. The results reported a negative and statistically significant impact of renewable energy on total greenhouse gas emissions, supporting our hypothesis and previous results. The insignificant value of the Sargan test also supports the fact that the system-generated instruments are valid.

Table 15 shows the SGMM regression results using the total amount of greenhouse gas emissions as the dependent variable and adjusted savings as the independent variable. The findings report a positive and statistically significant relationship among the said variables and are thus in line with the previously mentioned results. The model is also statistically significant, and system-generated instruments are valid based on Sargan statistics.

Lastly, Table 16 presents the SGMM regression results using the total amount of greenhouse gas emissions as a dependent variable and the consumption of combustible renewables as an independent variable. The findings reported in the table show a negative and statistically significant relationship among the said variables. The regression model used is not only statistically significant, but the Sagan test also verifies that system-generated instruments are valid.

Discussion

Renewable energy may contribute to a decrease in greenhouse gas emissions. The differences in outcomes demonstrate the mixed relationship between emissions

Table 14. Regression analysis.

Regression Estimates (SGMM)		
Unit of Observation – Panel (Country Year)		
Dependent Variable – Total Greenhouse Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Renewable Energy	-11774.95	592.03
Control Variables		
Electricity From Natural Gas	3140.52	376.42
Electricity From Renewable Sources	8457.74	1840.37
Electricity From Oil & Gas	-4459.40	216.41
Manufacturing Sector (Growth)	-1142.66	1132.48
Residential Sector (Growth)	-9567.91	1414.98
Transportation Sector (Growth)	-3394.31	1060.95
Air Pollution	-1709.83	542.58
Constant	833475.70	83687.26
Model Summary		
Number of Observations	189	
Wald Chi^2	2502.00	
Prob. > Chi^2	0.000	
Sargan Test		
Chi^2	0.006	
Prob. > Chi^2	0.938	

Table 15. Regression analysis.

Regression Estimates (SGMM)		
Unit of Observation – Panel (Country Year)		
Dependent Variable – Total Greenhouse Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Adjusted Savings	2262.75	383.14
Control Variables		
Electricity From Natural Gas	2537.40	483.05
Electricity From Renewable Sources	-2974.18	411.22
Electricity From Oil & Gas	-200.74	491.91
Manufacturing Sector (Growth)	3423.69	1731.68
Residential Sector (Growth)	-971.26	1805.34
Transportation Sector (Growth)	-9431.01	741.55
Air Pollution	1943.67	599.37
Constant	747062.00	65625.87
Model Summary		
Number of Observations	189	
Wald Chi^2	684.94	
Prob. > Chi^2	0.000	
Sargan Test		
Chi^2	0.007	
Prob. > Chi^2	0.931	

and energy generation. The negative coefficient linked to CO_2 emissions in this sector emphasizes how important it is to address transportation-related emissions to reduce overall greenhouse gas emissions.

We use renewable energy to reduce greenhouse gas emissions from HFCs. Renewable energy may also help reduce emissions of other greenhouse gasses besides CO_2. The power generated from non-renewable sources has a positive coefficient, highlighting the compromises between conventional energy sources and environmental security. The rest of the variables' statistical significance needs to be improved, indicating that further research is required to thoroughly understand the causes of controlling HFC emissions.

The significant negative coefficient associated with renewable energy consumption underscores the crucial role of renewables in decarbonizing the power sector. Still, the favorable coefficient of electricity production from renewable sources shows that even though renewables help decrease emissions, their portion of electricity generation may not be enough to balance the coefficient of electricity production emissions. Furthermore, the impact of emissions from several sectors shows how nearly all energy production and consumption patterns are attached to emissions.

The fact that renewable energy consumption has a negative coefficient indicates that it can reduce carbon dioxide emissions per person. It can also encourage sustainable growth. It promotes the transition to environmentally friendly energy sources. Still, the high-level coefficient for renewable energy generation highlights the importance of using caution. This suggests that while increasing the usage of renewable energy is a good thing, there might be further variables prohibiting emissions from increasing for every individual. The importance of air pollution and emissions from various businesses highlights the necessity of a thorough approach to minimizing emissions from a range of pollution sources.

The strong correlation between renewable energy usage and infrastructure investment has shown that the earlier can lead to both long-term economic growth and cost savings. However, the financial burden of high emissions from transportation, household sources, and manufacturing underscores the detrimental effects of carbon dioxide emissions and the significance of

Table 16. Regression analysis.

Regression Estimates (SGMM)		
Unit of Observation – Panel (Country Year)		
Dependent Variable – Total Greenhouse Gas Emissions		
	Coefficients	Standard Error
Independent Variable		
Combustible Renewable	-14369.29	1129.55
Control Variables		
Electricity From Natural Gas	2154.86	422.29
Electricity From Renewable Sources	3519.22	1605.43
Electricity From Oil & Gas	432.91	424.74
Manufacturing Sector (Growth)	741.08	882.70
Residential Sector (Growth)	833.28	1763.00
Transportation Sector (Growth)	-3567.01	1301.98
Air Pollution	-2079.57	580.47
Constant	416622.50	108986.50
Model Summary		
Number of Observations	189	
Wald Chi^2	53.09	
Prob. > Chi^2	0.000	
Sargan Test		
Chi^2	0.001	
Prob. > Chi^2	0.991	

changing to greener production and transportation systems. More research is needed to examine the statistical importance of changes in financial implications and policy measures.

Taking a step further into these subjects leads to a more refined examination of the results and comprehension of the complex relationships between economic and environmental indicators and their influence on sustainable development. By investigating the challenges in addressing climate change and promoting sustainable development, we can improve how these results might affect inquiries and policy choices in the future.

Conclusions

Our research aims to explore the role of green finance in advancing environmental security. Specifically, we examined the relationships between financial mechanisms and environmental sustainability, highlighting the need to reduce carbon emissions and promote adaptive savings. First, we examined how important it is to confront climate change, biodiversity loss, and resource depletion. Secondly, we investigated how financial instruments promote sustainability and how they strengthen protection against environmental hazards. The fight against global warming relies on the use of renewable energy. The substantial link between the use of renewable energy and lower carbon emissions shows it.

However, implementing energy transition plans can be difficult, and comprehensive policies that strike a balance between economic realities and environmental protection are necessary. We used empirical research, including linear regression models, to investigate several facets of green finance and their impacts on environmental outcomes.

Additionally, our research results show that green finance activities positively impact adjusted savings. Two research limitations are the use of aggregate data and the difficulties in modeling environmental phenomena. Future research should investigate more advanced strategies for getting around these restrictions. By combining social, economic, and ecological factors and looking at a broader range of environmental indicators, it will be easier to understand how green money works to promote environmental security.

The study's conclusion highlights the importance of financial innovations, policy changes, and stakeholder collaboration in tackling the linked problems of economic instability and environmental decline. To support future generations, we might invest in clean technologies, eco-friendly infrastructure, and resource efficiency.

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Conflict of Interest

The authors declare no conflict of interest.

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