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ARTICLE

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Green Finance and Environmental Sustainability: Evidence from Developing Economies

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Abstract: The current research aims to investigate the effect of green finance on environmental sustainability in 13 establishing countries over the period of 2005-2020 through static panel estimation models. Green finance is measured via financial support for research and development on clean energy. Whereas, environmental sustainability is computed through carbon emissions. Consistent with previous empirical studies, green finance significantly reduces the carbon emission in developing economies. The findings are in line innovation growth theory. Overall, the study underscores the crucial responsibility of green finance in attaining sustainable development and calls for aligning financial mechanisms with broader environmental goals to address global challenges.

Key Words
Green Finance, Environmental Sustainability, Developing Economies

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Introduction

The international economy landscape has undergone a remarkable transformation over the past two decades, with worldwide GDP surging from $29.3 trillion in 1994 to an impressive $106 trillion in 2023-year end. However, this unprecedented economic expansion has cast a long shadow over our environment, ushering in a host of critical challenges that demand immediate attention. As highlighted in the previous studies, the world now grapples with intensifying global warming, accelerating climate change, and steadily rising average temperature, manifesting in increasingly frequent extreme weather events, devastating floods, and widespread ecosystem degradation (Yadavet al., 2025). The effect of the current environmental crises goes beyond harming nature they also create serious risks for people's health and well -being (Fiksel & Bakshi, 2023). It is very important to focus on sustainable development and take quick action to fight climate change in today's fast-changing world (Radu et al., 2013). Green finance has become an important way to support eco-friendly economic growth and reach carbon neutrality. It focuses on investing in projects and activities that are good for the biosphere (Bhatnagar et al.,2022; Fe et al., 2023).

Establishing countries are the center of this serious issue, playing a major role in the rapid rise of global oil natural gas use. These nations face many challenges in becoming environmentally sustainable. They often lack money, have poor systems for using resources, and have weak institutions that make it hard to deal with climate change (Sarkar, Debnath, & Reang, 2021). Because of these problems, green finance offers a helpful and hopeful solution. This new type of finance supports a sustainable system that carefully considers environmental, social, and governance (ESG) factors while helping build low-carbon, climate-friendly economies (Huseynov, 2024). By wisely directing money toward initiatives that are good for the environment and society, Eco-finance has become a vital tool in solving many biosphere problems, such as fighting climate change, reducing pollution, and protecting nature. The growth of Eco-finance is very important for reaching sustainable establishment goals and solving urgent environmental issues (Goel et al., 2022).

The fast growth of the world economy has caused serious environmental problems like climate change, global warming, and an increase in greenhouse gas emission. Although green finance, which encourages sustainable investments, has gained attention as a possible remedy, its influence on environmental sustainability—especially in developing countries—is minimal. High CO2 emissions, pollution, deforestation, and heightened vulnerability to climate change are some of the particular environmental issues these nations face. Prior studies on green finance have mostly

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concentrated on developed countries, especially China, leaving a knowledge gap regarding how it affects lower- and lower-middle-income countries. For inclusive, long-lasting, and effective solutions to global environmental problems, this gap must be closed.

Green finance performs an important task in promoting environmental sustainability however, its specific impact on reducing CO2 emissions remains limited. Money used for environmental projects (green finance) plays a big role in lowering pollution from carbon. Research shows that when countries spend money on eco-friendly projects, they successfully reduce their carbon pollution. For example, in China, this type of funding has shown clear positive results in directly cutting down carbon emission. Most of the world's carbon pollution (about 65%) comes from developing countries. These nations face a significant challenge: they need to grow their economies but often lack both the financial resources and proper systems manage climate change effectively. To better understand this situation, scholars are studying how green finance affects the environment across 13 developing and non-developing countries. This comprehensive method helps us better understand how green finance can support environmental sustainability in these nations.

Research Question

On the basis of literature review following research question can be derived:

1. Does Green Finance contribute to promoting environmental sustainability?

Research Objective

Following are research purposes:

To analyze the performance of eco-finance in fostering environmental sustainability.

This research encompasses a broad scope, analyzing data from 13 developing countries over a 15-year timeframe (2005–2020). The sample includes 9 establishing and 6 un-established countries, representing a diverse array of economic conditions. The study assesses environmental sustainability through two critical metrics: carbon emissions quantified in metric tons per capita, and ecological footprint expressed in global hectares per person.

In addition, the study incorporates various factor like green innovation and income per person (GDP per capita) that are kept constant during the analysis and Industrial activities (covering construction), trade as a percentage of economic growth, and demographic growth. This wide range of variables enables a broader perspective of the factors that shape ecosystem sustainability in developing economies. The temporal scope also includes the COVID-19 pandemic, allowing for an analysis of how global disruptions impact the interaction between Eco-finance and environmental sustainability.

Literature Review

Ecosystem sustainability indicates to the liable management and conservation of natural resources.it involves maintaining ecological balance, reducing pollution, preserving biodiversity, and promoting practices that do not deplete natural resources. In the context of Eco-finance, environmental sustainability is the ultimate goal-completing by lowering CO_2 emissions, rising energy efficiency, investing in renewable energy, and encouraging eco-friendly innovation.

Green finance, as defined by Lindenberg (2014), refers to the financing of public and private green investments, including Ecosystems goods and services and activities that mitigate environmental damage. Ozili (2021a) expands this definition to incorporate projects that generate economic gains while supporting sustainability. "Wang and Zhi (2016) elaborate eco-finance as a way to combine environmental protection with economic benefits. This concept shows how eco-finance serves as a tool to maintain balance between economic establishment and biosphere protection.

The field of green finance has gained ate worldwide as countries and nations work to combat climate change. Lindenberg (2014) points out that eco-finance involves government policies that help protect the environment. Building on this, Bahl (2012) mentions that green finance covers funding for both environmental technologies and pollution reduction efforts, making it crucial for achieving environmental goals. All of this helps us build a healthier planet.

The relationship between green finance and environmental sustainability encompasses two primary theoretical frameworks, as identified in recent research by Raazia Gul and Shahzad Hussain (2024). The debate focuses on the

innovative-growth and innovation -fragility theories, each elaborate distinct insights into how green finance affects renewable economic development (Ma,2024: Tao et al.2020).

The first view known as the advancement approach suggests that eco-finance helps the environment by directing money towards businesses that care about environmental protection. This approach, supported by multiple studies (Want et al,2023; Wan et al.2022: Zhang et al2023), support this idea that how it aids in environmental recovery and sustainable development.

The innovation-fragility perspective, however, shows the notable concerns about the practical implementation of green finance. Research by Tao et al. (2022) and He et al. (2019) indicates that green finance initiatives may impede traditional banking operations, particularly in loan distribution. Their findings suggest this limitation could reduce the effectiveness of renewable energy investments and potentially harm environmental improvement efforts.

Eco-finance can efficaciously mitigate environmental pollution and carbon emissions (Zhou et al. (2023). Jin et al. (2023), Liu et al. (2023), and Wang et al. (2023) prove that green finance can greatly help promote carbon emission reduction in different countries. Zhang et al. (2023) showed that eco-finance focuses on shifting flows away from projects and firms with heavy Green Finance for a Sustainable Economy: An Empirical Study of China 5 pollution toward more environmentally friendly projects and sectors and toward a green recovery (strict adoption) of the economy. Yu et al. (2022) also strongly supports this view with the demonstration of green finance's leverage effects on the carbon neutrality.

Sethi et al. find evidence that eco-finance has a beneficial impact on CO2 emissions which is clearer for developing countries, namely, Fu & Ng and Prakash & Mahdvi reported a higher level of emissions due to ineffective use of green projects. arcing, 2018 and Parvaz and Raghji, 2018.braces or reinforce the green initiatives. Similarly, Liang et al. reported a positive linear influence between green technology innovation and emissions, and attributed it to recover effects in the developing countries.

The effect of green finance, represented by its square term, also shown a significant positive impact on CO2 emission, as record by Fu and Ng in their analysis of green financing impacts. The innovation-fragility theory, supported by Tao et al. (2022) and He et al. (2019), claims that eco-finance effects the coverage of financial loans obstructing the capital allocation productivity in sustainable energy has a damaging impact on the environments conditions.

Destek et al. (2021) and Shan et al. (2021) that renewable vitality uses significantly decrease CO2 emissions in developing countries. Wang et al. further support that agricultural value include appears a critical negative impact on CO2 emissions through sustainable practices. Moreover, Xu et al. discover that the interaction of regulation quality with green fund shows promising results in reducing emissions when these variables are combined effectively, recommending the importance of institutional system in environmental sustainability.

Khan et al. (2022) recognized that public-private organizations (LNPPP) have a negative effect on CO2 emissions, proposing these collaborative efforts help decrease environmental degradation. Their research also established that R&D expenditure (REDE) demonstrates a significant negative relationship with CO2 emissions, showing that expanded research investment contributes to natural change. Wang et al. (2019) complemented these discoveries by showing that mechanical structure optimization has a negative impact on CO2 emissions, advance supporting the importance of structural changes in environmental protection.

Hussain & Dogan found that institutional quality and the interaction of eco-finance with sustainable technology has a weak and statistically minimal effect on CO2 emissions. Similarly, Tian et al. noted that eco-finance tech innovation shows limited short-term effects. Sun (2023) noted that in Central and South Asia, eco-finance, patents, and clean energy development have only a small effect on reducing environmental harm, especially in developing countries.

Wang and Zhang (2020) determined that financial establishment and industrial structure optimization show minor correlations in their impact on environmental outcomes. Khan et al. (2022) further established that no evidence of one-way causality was identified from public-private partnerships to CO2 emissions, suggesting a non-significant direct relationship between these variables. Their research also revealed that R&D expenditure causes renewable energy investment uni-directionally, indicating a one-way relationship rather than a bilateral one.

Litu Sethi, Biswanath Behera et al. (2023) this study aims to examine how green technology innovation, eco-finance, renewable energy consumption, institutional quality, and agricultural value added contribute to achieving environmental sustainability by reducing CO2 emissions across 25 selected developing countries between 1998 and 2019. This study employed various techniques, including the driscoll-kraay and two step SGMM estimators, to evaluate the influence of green finance on environmental sustainability. The empirical findings reveal that green finance, green technology innovation, and institutional quality induce CO2 emissions, whereas agricultural value-added and renewable energy use are observed to have detrimental effects on CO2 emissions. Advising that developing nations to implement policies that encourage investments and innovation in the clean energy sector to achieve sustainable development goals by reducing carbon emissions.

Raazia Gul & Shahzad Hussain (2024) We study the complex connection between eco-finance and ecosystem sustainability in 13 developing countries from 2000 to 2022.To do this, we use several advanced statistical methods, such as Drishcoll-Kraay standard error (D-K), feasible generalized least squared (FGLS), and the generalized linear model (GLM).

Ayesha Afzal, Ehsan Rasoulinezhad et al. (2022) A research study by Ayesha Ehsan Rasoulinezhad and others in 2022 looked at how the growth of financial systems affects environmental damage over time. The study found how money systems, government structures, and money from other countries influence green growth. They studied 40 European counties and gathered information on many factors from 1990 to 2019. They measured financial growth by looking at money lent within the country to private businesses, money lent by banks to private businesses, and money invested from foreign countries. They checked environmental damage by looking at how much energy is used, carbon dioxide released into the air, greenhouse gases produced, and how fast natural resources are being used up. They used math calculations (regression analysis) to study all this information. What they found was interesting - when financial systems grew, environmental damage actually went down. They suggested that people making rules should create eco-friendly money policies and build strong organizations to help reduce environmental damage in the future.

A 2022 study by Sohail Ali Naqvi, Avinash Kumar et al.and their team looked at how green money systems are developing in Pakistan. They wanted to understand what's working and what's not in Pakistan's approach to environment-friendly financing. The country faces challenges because it uses too many natural resources and doesn't manage environmental issues well enough, which shows why it needs to switch to a more circular economy (where resources are reused and recycled). The researchers talked to more than 20 people, including small business owners, government workers, and bank employees, and also studied existing research to understand green banking and the challenges faced by Pakistan's leather and textile businesses in becoming more environment friendly. They mentioned how this connects to the bigger picture of climate change, referring to the 2015 Paris agreement where 195 countries, including Pakistan, promised to work together to keep global temperature rise below 2 degrees Celsius compared to pre-industrial times. The researchers focused on English language sources from 2005 to 2019 for their study.

Shi et al. (2024) studied how controlling corruption affects the efficiency of green finance, using data from 37 Asian countries between 2000 and 2020. Their 13 findings show that the results are reliable, based on several checks. These checks included using different ways to measure environmental sustainability and corruption control, as well as trying different estimation methods. The study highlights that controlling corruption at the national level is very important for using green finance effectively and improving environmental sustainability. Khan et al. (2022) studied the development of eco- finance in five regions South Asia, Southeast Asia, China, the middle East, and Europe over 15 years (2008_ 2022). They measured green finance progress using indicators like national income, investment in renewable energy, eco-friendly research and establishment (R&D), and public-private partnerships in green energy projects. Deng et al. (2023) looked at how strong environmental rules and green finance affect environmental sustainability in China. Their study, covering data from 30 provinces between 2004 and 2019, is important because China is the world's largest carbon emitter. They pointed out serious environmental problems and the high costs involved, stressing the urgent need for sustainable actions. Balsalobre-Lorente et al. (2023) found that eco-finance and clean energy improve environmental quality in ASEAN countries, while their decline harms it. They also showed that economic growth and urbanization have negative effects on the ecosystem.

"Madaleno et al. (2022) conducted an in-depth analysis to explore the causal links among eco-finance, clean energy, ecosystem responsibility, and green technology, using daily data spanning from July 31,2014 to October 12,2021. They applied the dynamic causality test proposed by Shi et al. (2018, 2020)."Employing the time-varying causality test developed by Shi et al. (2018, 2020), their research reveals intricate relationships between these environmental and financial variables. The findings demonstrate consistent bidirectional causal relationships among the variables, though these relationships experienced notable disruptions during the COVID-19 duration. Interestingly, while the effect of eco-finance on clean energy appears less definitive and is only significant during specific time windows, the researchers found that clean energy exhibits a stronger causal influence on green finance throughout the entire study period.

Sample Countries, Sample period and Statistical Techniques

The study examined 51 developing countries from 2000 to 2022, consisting of 33 lower-moderate income countries and 18 low-moderate income countries. The sample selection was strategic, as establishing the sharp is largely attributed to nation increases in global natural gas and petroleum usage, this shows that expansion and harm to the environment are closely connected.

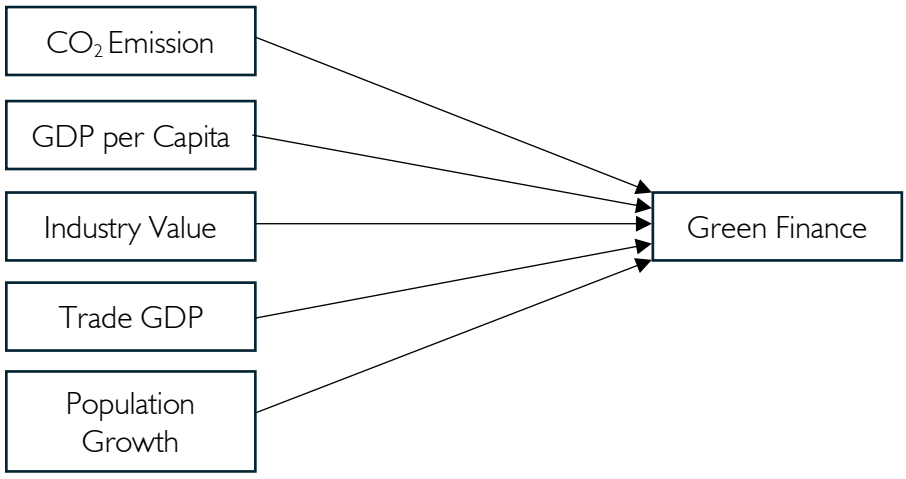
For robustness checks, they employed a unique bootstrap quantile approach. Additionally, they tested cross sectional dependency using Pesaran (2004, 2015) tests and applied cross-sectionally augmented panel unit root (CIPS) test. The Wooldridge (2002) test and Modified Wald test by Greene (2002) were used to investigate serial correlation and heteroscedasticity assumptions.

Yi and Zhang (2024) inspected the curved relationship between eco-finance and CO2 emissions in China, giving prove that supports the presence of a curved relation between green subsidizing and CO2 emissions. Building on this, Ma (2024) considered the complex relationship between eco-finance and ecosystem sustainability in China from 2012 to 2022, confirming that the connection is not clear. Similarly, Lan et al. (2023) looked at 30 Chinese regions from 2001 to 2020 and supported the idea of environmental Kuznets Curve (EKC), which appears a non-linear interface between green finance and ecosystem sustainability. Wang et al. (2023) and Zhang et al. (2023) supported the idea that eco-finance helps economic growth by moving funds towards businesses and activities that are good for the environment, helping with green recovery. On the other hand, Tao et al. (2022) and He et al., (2019) offered a different view, saying that green finance might limit bank loans, reduce capital efficiency in clean energy and possibly harm the environment.

This research shows the many ways green finance helps protect the environment. It clearly has positive effects, like lowering carbon emissions and supporting investments in renewable energy. However, challenges remain, particularly in developing economies where institutional quality and financial mechanisms require strengthening. The EKC hypothesis offers a valuable approach to interpreting nonlinear dynamics of eco-finance and environmental outcomes, emphasizing the need for context-specific policies and robust institutional support.

H1: Green Finance is negatively associated with carbon emission.

Framework



Research Methodology

In this chapter we will inform the structure and methods used in the research.

Data and Methods

Data and Sample

This study focuses on understanding how green finance affects the environment in underdeveloped countries. To figure out this we collected information from 13 different countries over 15 years starting from 2005 and ending in 2020.

We chose these countries very deliberately to have a good balance of different economic levels. Most of the countries we have chosen to look at, including Pakistan, India and Egypt, are in the low-middle income category. We've also added some stronger economies, such as those of Brazil and China, which are upper-middle income nations. Mexico, now a high-income country, was also included in our analysis. This diversity helps us gain an understanding of how green finance operates in various economic firmaments.

To ensure the quality and accuracy of our study, we gathered data from two trusted international organizations. We got our environmental data, like how much carbon dioxide emissions each country produces, drawn from the (WDI) dataset. To understand the financial side of our research for figuring out how much money countries spend on environmental friendly projects and clean energy research, we used information obtained from (OECD) databases. These reliable sources helped us create a solid base for our analysis. We chose this time period because it gives us enough years to see how countries have changed their actions and policies on green finance and environmental issues. Looking at this 15-year period helps us understand the long-term impact.

Research Equation and Variables of the Study

In this research, we create the following equation to see how Green Finance affects Environmental Sustainability.

$$GFit = \beta_0 + \beta_1 CO_2 it + \beta_2 TRDit + \beta_3 POPGit + \beta_4 INDit + \beta_5 GDPit + \varepsilon it$$

This equation shows how Green Finance (GF) affects carbon emissions (CO2). It also includes other factors like trade (TRADE), Population growth (POPG), industrial value (IND), and economic performance (GDP per capita).

The dependent variable, Carbon Emission (CO2), is calculated in metric tons per capita. This measurement provides a way to assess environmental impact across different countries.

Green finance (GF): Represents money spent on clean energy research and renewable energy development. This measure helps quantify each country's commitment to environmental initiatives.

Industry Value (IND): It shows how much of a country's economy comes from industrial and construction activities; it measured as a percentage of gross domestic product GDP.

Population growth (POPG): -It shows the yearly change in population numbers as a percentage helping us track population changes.

GDP per capita: Is measured in constant 2010 US dollars to make consistency across the study time. It shows the average economic wealth per person in each country.

Trade (TRD): Measures international trading activity as a percentage of GDP, helping us understanding each country's global business involvement.

The statistical techniques that current study applied three statistical approaches including descriptive analysis, regression and correlation. These models were chosen to guarantee robustness and accuracy when estimating the link between eco-finance and CO_2 emissions.

Table 1

Variable Name	Symbol	Measurement	Source
Carbon Emission	CO_2	CO_2 emission (metric tons per capita)	WDI
Green Finance	GF	Financial support dedicated to eco-friendly energy research technologies.	OECD
Industry Value	IND	Value added by industry (including construction) as a % of GDP.	WDI
Trade GDP	TRD	Trade as a share of GDP (exports + imports, % of GDP).	WDI
Population Growth	POPG	Yearly percentage increase in population.	WDI
GDP per capita	GDP	Per capita GDP measured in constant 2010 US dollars.	WDI

Table 2

Data Collection

S. No	Names	Income
1	Iran	low moderate income
2	India	low moderate income
3	Malaysia	upper moderate income
4	Pakistan	low moderate income
5	Philippines	low moderate income
6	Thailand	upper moderate income
7	Egypt	low moderate income
8	Morocco	low moderate income
9	South Africa	upper moderate income
10	Argentina	upper moderate income
11	Brazil	upper moderate income
12	Chile	upper moderate income
13	Mexico	moderate income

Empirical Results

Descriptive Staistics

Green Finance refers to Financial flows directed towards Ecosystem Sustainable project such as renewable energy and climate resilient infrastructure. It plays a crucial role in promoting sustainability by reducing CO2 emission. Eco- finance has negative effect on environmental sustainability.

The descriptive statistics reveal in Table 1 presents the descriptive statistics for all variables used in this study. The dataset comprises 207 observations from 13 developing countries over the period 2005 to 2020. These summary statistics offer key findings into the relationship between environmental biosphere and green finance.

The mean value of environmental sustainability is 4.846 and standard deviation of 1.089 which measure the variation of each variable. The minimum range of 1.736 and maximum range of 6.737, indicates a relatively consistent pattern in environmental sustainability measures across different economies. The moderate standard deviation relative to the mean suggests somewhat uniform environmental conditions among the observed regions. Hussain et al. (2024), reveals greater heterogeneity in environmental sustainability (EF mean = 3.770, SD = 2.361) and population growth (mean = 2.25, SD = 1.079). Furthermore, both datasets underline notable variations in green finance initiatives. However, our dataset reports a slightly higher Green finance (GF) average measurement of 17.365, accompanied by a standard deviation of 3.151. suggesting stronger efforts in this subset. The spread, ranging from 9.21 to 21.938, illuminates notable variations in green financial initiatives. The moderate standard deviation relative to the mean suggests diverse approaches to green financing among the observed economies.

Local government development (GDP) shows substantial stability, Moreover, GDP is higher in our dataset with a mean of 8.50 and a standard deviation of 1.746 compared to Hussain et al. (2024) (mean = 7.08), reflecting relatively more developed economies. This range, spanning from 6.854 to 9.561, suggests relatively homogeneous development patterns across the observed economies. The lower standard deviation relative to its mean indicates more consistent governmental development levels. Moreover, GDP is higher in our dataset (mean = 8.50) compared to Hussain et al. (2024) (mean = 7.08), reflecting relatively more developed economies.

The population growth and trade statistics further enrich this picture, with trade showing a mean of 63.729 and a substantial standard deviation of 37.033, indicating high heterogeneity in trading patterns. Population growth maintains a relatively consistent pattern with a mean of 1.334 and a modest standard deviation of 0.462, ranging from 0.235 to 2.344. Additionally, trade openness demonstrates significant variability in both datasets, although Hussain et al. (2024) captures a wider range. Overall, these findings emphasize the diversity of environmental and financial efforts across countries, underscoring the importance of tailored strategies for sustainable development.

With 207 observations for most variables (except gf with 193), these statistics paint a comprehensive picture of environmental, financial, and economic interactions, highlighting areas of both consistency and variation across the studied economies.

Table 3

Variable	Obs	Mean	Std. Dev.	Minimum	Maximum
CO2	207	4.846	1.089	1.736	6.737
GF	193	17.365	3.151	9.211	21.938
GDP	207	8.501	0.746	6.854	9.561
POPG	207	1.334	0.462	0.235	2.344
TRD	207	63.729	37.033	22.106	203.855

Note: GF: Green Finance, GDP: Gross Domestic Product, POPG: Population Growth, TRD: Trade.

Correlation Matrix

The Correlation matrix reveals in table 2. The Correlation coefficient of eco- finance is -0.414 (Moderate Negative) Green Finance has a moderate negative effect on CO2 emissions, suggesting that increased investments in environmentally friendly projects help reduce emissions.

GDP has 0.436 Correlation coefficient which is (Moderate Positive) CO2 emissions moderately increase with GDP growth, reflecting the environmental costs of economic activities like industrialization and energy consumption. The Correlation coefficient 0.043 (Negligible Negative) Population growth has a negligible effect on CO2 emissions in this dataset, indicating minimal direct influence.

The Correlation coefficient 0.304 (Moderate Positive) Trade moderately contributes to CO2 emissions, likely due to energy-intensive production and transportation associated with traded goods. The Correlation coefficient -0.278 (Low Negative) eco-finance has a low negative relationship with GDP, eco-Finance has a small negative impact on GDP, likely due to the costs of transitioning to sustainable practices.

The Correlation coefficient -0.101 (Low Negative) population growth has a small negative effect on Green Finance, possibly due to higher demands for conventional infrastructure. The Correlation coefficient -0.468 (Moderate Negative) Green Finance moderately reduces trade, likely by limiting environmentally harmful trading activities.

The Correlation coefficient -0.460 (Moderate Negative) Higher population growth moderately reduces GDP, which could reflect resource limitations or economic strain in growing populations. The Correlation coefficient 0.198 (Low Positive) Trade has a low positive impact on GDP, indicating a minor contribution of trade activities to overall economic growth in this dataset. The Correlation coefficient -0.086 (Negligible Negative) Population growth has a negligible negative effect on trade, showing no significant direct relationship between the two.

Table 4

Matrix of Correlations

Variables	(1)	(2)	(3)	(4)	(5)
CO2	1.000				
GF	-0.414	1.000			
GDP	0.436	-0.278	1.000		
POPG	-0.043	-0.101	-0.460	1.000	
TRD	0.304	-0.468	0.198	22.106	1.000

Regression Analysis

The OLS, Random and fixed effect model reveals in table 3. The coefficient for Green Finance is -0.0763, meaningful at the 0.01 level ($p < 0.01$), suggesting that eco-finance is highly associated with a decrease in ecosystem Sustainability,

based on OLS model. The coefficient for Green Finance is -0.0743, highly significant (1% level), again showing a negative relationship in random effect model. The coefficient for Green Finance is -0.102, also passing 1 % significant test, indicating a similar negative association with Environmental Sustainability in fixed effect model.

The coefficient for GDP is 0.569, significant at the 1-percent confidence level, suggesting that higher GDP is positively associated with Environmental Sustainability. The coefficient is -2.815 highly significant (1% level), showing a strong negative effect of GDP on Environmental Sustainability when fixed effects are considered. The coefficient of GDP is 0.143, not statistically significant ($p > 0.1$) for Environmental Sustainability.

The indicator for Population Growth is 0.304, passing the 1% significant test, ($p < 0.1$), indicating a positive but weak relationship with Environmental Sustainability. The coefficient is 0.829, also significant at the 1% level, indicating a robust positive effect of popg on Environmental Sustainability. The multiplier is 0.930 significant at the 1% level, suggesting a strong beneficial relationship.

The constant for Trade is 0.00384, highly significant level (1%) ($p < 0.1$), showing a weak positive relationship. The coefficient of trade is 0.00726, not statistically significant ($p > 0.1$) for Environmental Sustainability. The indicator is 0.0107, passing at the 1% significant level, indicating a stronger favorable association with Environmental Sustainability Significant.

In the Random Effects model, it is 3.415 significant at the 10% level ($p < 0.1$). In the Fixed Effects model, the constant is 28.39 significant at the 1% level ($p < 0.01$).

R-squared: The findings are consistent with (ma,2024; Tao et al.2022) and are in line with the innovative-growth and innovation-fragility theories on green finance's impact. The R-squared value for the OLS model is 0.306, suggesting that about 30.6% of the change in Environmental Sustainability can be explained by the included variables. The R-squared for Random Effects is not reported, and for Fixed Effects, it is 0.433, indicating that the Fixed Effects model explains 43.3% of the difference in the dependent variable, which is a relatively good fit.

Table 5

Impact of Green Finance on Environmental Sustainability

Variables	OLS	Random	Fixed
GF	-0.0763***	-0.102***	-0.0743***
	(0.0248)	(0.0235)	(0.0219)
GDP	0.569***	0.143	-2.815***
	(0.102)	(0.214)	(0.488)
POPG	0.304*	0.930***	0.829***
	(0.164)	(0.217)	(0.219)
TRD	0.00384*	0.0107***	0.00726
	(0.00208)	(0.00368)	(0.00536)
Constant	0.622	3.415*	28.39***
	(1.247)	(2.028)	(4.307)
Observation	193	193	193
R-Squared	0.306		0.433

Number of id: 13

Standard error in parentheses,*** p<0.01, ** p<0.05, * p<0.1

Conclusion

This study investigates the effect of eco-Finance measured as financial support for clean energy R&D on Environmental Sustainability captured by carbon emission, in 13 developing countries from 2005 to 2020 using static panel estimation models. The finding reveal that eco-Finance serve a significant role in reducing carbon emission, aligning with the

innovative growth theory. These results support the importance of integrating financial instruments into environmental strategies to promote sustainability.

This study offers strong justification for policy makers and financial sector controllers to support the growth of Eco-finance measure as a policy option for reducing the challenges of climate change. Increased R&D investment can help to innovation, reduce carbon footprints, and allow countries to achieve their sustainability targets. The consistency of financial systems with environmental priorities can also attract green investments and encourage green economic growth.

Like any research project we faced some challenges along the way. First, our study focused on just 13 developing countries, which means our findings might not apply to all regions worldwide. Secondly, we also focused mainly on measuring environmental health by looking at carbon emissions but this alone doesn't tell us everything about a country's ecological wellbeing. Lastly, our analysis method, while reliable, couldn't fully capture how these financial and environmental factors might influence each other over long periods of time. We could see clear connections between green finance and environmental impact, but we might have missed some of the more complex ways how these factors impact on each other.

Future studies could look at a wider range of countries, including developed ones, or compare countries based on income levels. Adding more environmental indicators—like air and water quality, biodiversity, and how efficiently resources are used—would give a more complete picture. Also, using advanced panel methods or causal analytical methods like GMM and difference- in- difference could improve the strength and depth of the findings.

References

Afzal, A., Rasoulinezhad, E., & Malik, Z. (2022). Green finance and sustainable development in Europe. *Economic Research-Ekonomska Istraživanja*, *35*(1), 5150-5163. https://doi.org/10.1080/1331677x.2021.2024081

Akomea-Frimpong, I., Adeabah, D., Ofosu, D., & Tenakwah, E. J. (2021). A review of studies on green finance of banks, research gaps and future directions. *Journal of Sustainable Finance & Investment*, *12*(4), 1241-1264. https://doi.org/10.1080/20430795.2020.1870202

Fu, C., Lu, L., & Pirabi, M. (2023). Advancing green finance: A review of sustainable development. *Digital Economy and Sustainable Development*, *1*(1). https://doi.org/10.1007/s44265-023-00020-3

Gilchrist, D., Yu, J., & Zhong, R. (2021). The limits of green finance: A survey of literature in the context of green bonds and green loans. *Sustainability*, *13*(2), 478. https://doi.org/10.3390/su13020478

Gul, R., & Hussain, S. (2024). Unlocking sustainable futures: Exploring the non-linear linkages between green finance and environmental sustainability in developing countries. *Journal of Environmental Management*, *370*, 122971. https://doi.org/10.1016/j.jenvman.2024.122971

Khan, S., Akbar, A., Nasim, I., Hedvičáková, M., & Bashir, F. (2022). Green finance development and environmental sustainability: A panel data analysis. *Frontiers in Environmental Science*, *10*. https://doi.org/10.3389/fenvs.2022.1039705

Kumar, L., Nadeem, F., Sloan, M., Restle-Steinert, J., Deitch, M. J., Ali Naqvi, S., Kumar, A., & Sassanelli, C. (2022). Fostering green finance for sustainable development: A focus on textile and leather small medium enterprises in Pakistan. *Sustainability*, *14*(19), 11908. https://doi.org/10.3390/su141911908

Mohd, S., & Kaushal, V. K. (2018). Green finance: A step towards sustainable development. *MUDRA : Journal of Finance and Accounting*, *5*(01). https://doi.org/10.17492/mudra.v5i01.13036

Sethi, L., Behera, B., & Sethi, N. (2023). Do green finance, green technology innovation, and institutional quality help achieve environmental sustainability? Evidence from the developing economies. *Sustainable Development*, *32*(3), 2709-2723. https://doi.org/10.1002/sd.2811

Yang, C., & Masron, T. A. (2022). Impact of digital finance on energy efficiency in the context of green sustainable development. *Sustainability*, *14*(18), 11250. https://doi.org/10.3390/su141811250