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Green banking and sustainable development: Exploring energy efficiency, environmental policy, and financial resilience in emerging economies

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ABSTRACT

This study examines the relationship between green banking, energy efficiency, environmental policy, & financial resilience in emerging economies, utilising a comprehensive regression equation as a methodology. The study uses an extensive set of data (2001-2022) covering 42 countries. The core results value the influence of environmentally friendly financing on environmental sustainability, utilising modified savings per individual as a measure of sustainable growth. The research thoroughly analyses the impact of sustainable finance on detrimental environmental indices, uncovering important indications into how environmentally mindful finance might advance impartial economic growth, enhance conservation efforts, or strengthen regulations that support sustainable economies. Results highlight the essential role of green banking in promoting energy efficiency initiatives, improving the management of water resources, and making positive, environmentally conscious investments as appropriate actions of government spending on environmental conservation. This effect functions through competitive pressure, which augments banks' credit capacities (by using customized products and enhanced green project evaluation) and draws in green firms (by lowering entry barriers). The transition to renewable energy sources can lead to sustainable development, and green finance plays a crucial role. To limit the risks of climate change and mitigate its adverse effects, the Intergovernmental Panel on Climate Change (IPCC) has emphasized the urgency of adopting renewable energies. The study promotes the development of improved legislative frameworks to maximize the potential of green finance, stressing the need for developing countries to leverage these financial techniques to achieve their sustainable development goals.

1. Introduction

Green investment, renowned for its potential to contribute to environmental sustainability and social responsibility, has emerged as a crucial factor in mitigating climate change and enhancing economic resilience, particularly in developing nations. The complex interrelation among green finance, renewable energy, climate policy, and economic resilience requires an intricate understanding(K. Khan et al., 2021). This study aims to unravel these multifaceted dynamics and employs a comparative analysis across developing countries to highlight unique disparities and promote cross-learning opportunities(C. Zhang et al., 2024). The growing urgency to

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address climate change has elevated sustainable finance to a position of international significance. The significance of green finance in mitigating environmental risks and promoting sustainable development has gained widespread recognition in recent scholarly work (W. Yu et al., 2024a). Defined by the United Nations Environment Programme (UNEP), green finance encompasses a broad range of financial operations aimed at facilitating the transition to low-carbon industrial and consumption practices, as well as environmentally sustainable economies (Qi et al., 2024). However, this is not just about environmental considerations. Green finance has been increasingly associated with economic resilience, and as such, is considered a catalyst for social development. These nations regularly face the challenge of growing energy consumption and environmental degradation. Green finance supports the construction of renewable energy resources on a large scale, providing fertile ground for innovation and a springboard for transferring sustainable practices in energy generation.

Results in Fig. 1, shows comparative analysis of urban sustainability. Furthermore, the contribution of climate policy to shaping green finance should not be underestimated. It is a crucial part of sustainable finance for governments to create an environment that encourages money to flow into environmental investments. This involves policy initiatives aimed at promoting clean finance and environmental default settings (Zhong et al., 2022). The Paris Agreement, a key international treaty, is just one symbol of the world's commitment to preventing and mitigating global warming. Countries party to the A carefully structured, if not ideal, treaty restrict the majority of human activity resulting in global warming to within 2 °C.Cent of pre-industrial levels (Pradhan & Ghosh, 2022). This agreement has facilitated the development of domestic climate policies, providing a platform for integrating green finance into broader climate mitigation and adaptation strategies. Emerging as a key issue in sustainable development, particularly for countries with multiple challenges that involve temporal measurement, resilience economics is called (W. Yu et al., 2024b). The relationship between green finance, economic resilience, renewable energy, and climate policy is complex and multifaceted. The effectiveness of green finance in terms of economic resilience also depends on the alignment between national development goals and financial strategies, as well as whether it can address the unique socio-economic contexts found in developing countries. As developing countries struggle with the complex web of climate challenges and change, integrating green finance into national development plans is imperative (Jahanger et al., 2023). The unique socio-economic contexts of such nations require a nuanced understanding of the interrelationship between green finance, renewable energy, climate policy, and economic resilience. Analysis across different developing countries enables the formulation of context-specific strategies and targeted policies that can harness the transformative power of green finance (B. Behera, Sahoo, et al., 2025).

One key area of this interaction is the role of the private sector in forcing sustainable development. At the private and governmental levels in developing nations, the financial sector prioritizes short-term profits. Nonetheless, green finance can bring revenues in today's local market. If it takes off, its benefits could resonate throughout Asia, Africa, and eventually all regions, as far afield from Europe as Oceania (Zhu et al., 2024). Policy support, combined with proper financial and tax incentives, can attract private capital to sustainable projects, thereby helping the renewable energy sector expand in size (Zhao et al., 2022). Studies should examine how different types of financial institutions in various countries address the challenge of balancing profit-making with social responsibility in their operations. This research can also show us successful models for joint projects in green finance (Pao et al., 2014). The socio-political

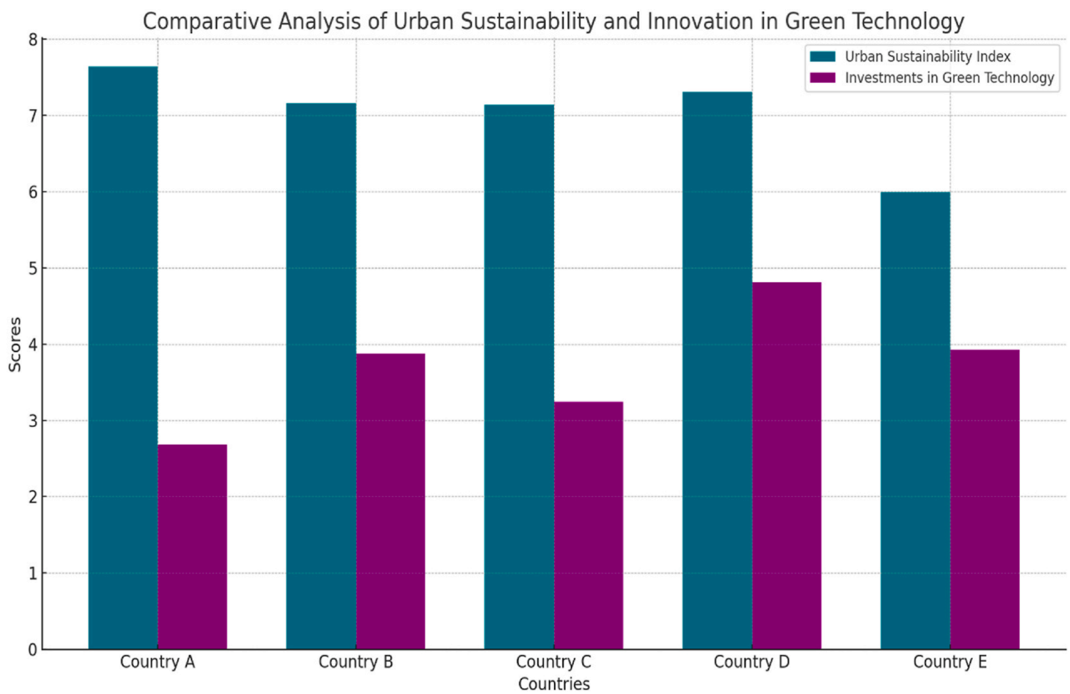

Fig. 1. Comparative analysis of urban sustainability and innovation in green technology.

landscape in emerging countries also limits the effectiveness of green finance projects. Local government structures, institutional capabilities, and public awareness all play a crucial role in shaping the outcomes of sustainable finance interventions (Ahmad et al., 2022). It is crucial to understand the political economy of green finance in various contexts, including the development of manipulative policies that align with people's wishes and help them meet their needs (Acheampong et al., 2021). The study will explore the complex governance and institutional settings, aiming to identify the factors that promote or hinder the integration of green finance into national development strategies (P. Behera et al., 2024)

The study will also investigate the emergence of new financial tools for these specific services at present (Sun et al., 2021). For example, green bonds can serve as a funding source for environmentally sustainable projects. With a large variety of such financial products emerging across different sites, understanding how they have been accepted and how they actually work in different circumstances will provide valuable guidance on whether to scale up (Li et al., 2024). Similarly, this study will examine how international financial institutions and global partnerships support green finance initiatives in developing countries, where cooperation among the parties enables the effective handling of shared environmental problems (Smith et al., 2021). This becomes clearer when we compare green finance in terms of its social dimensions. In the poorest developing countries, social equity and inclusive issues are closely tied to environmental sustainability (Zheng et al., 2025). This study questions what sound effects different green finance initiatives have–in the areas of tangaroa, work opportunities, authorization for both communities and individuals ("the poor" as well as otherwise frail groups), and trying to get a handle on poverty. Through individual cases that serve as prime examples for the suitability of including social considerations in a project financed with green finance,

This research aims to provide a comprehensive understanding of the potential socio-economic benefits that arise from aligning financial policies more closely with development goals. The statement of the problem highlights the urgency of understanding the relationship between green financing, renewable energy, climate policy, and economic resilience in underdeveloped countries. These nations have unique problems, which means they require a targeted, item-specific approach to sustainability development (Zhao et al., 2022). One of the key challenges is finding a middle way between meeting an immediate socio-economic need and adopting long-term sustainable practices. Developing countries often face this problem; they must choose between using conventional energy sources, which are all too expensive, and investing in renewable energy(Su et al., 2024). Besides, the lack of necessary financial resources and infrastructure is a significant obstacle to the widespread adoption of renewable energy technologies. This is why green finance is seen as a critical facilitator of this situation. With Green finance, countries that lack incentives for renewable energy projects can go beyond that and provide the essential money-sedentary support and financial mechanisms(Prodromou & Demirer, 2022). The study will delve into the specific financial constraints that individual countries face, examining how innovative financing models can unlock the transformational potential of renewable energy and contribute to the overall goal of addressing climate change. Climate policy, the driving force behind green finance in various developing countries, varies greatly.

This manuscript is well-thought-out to provide a logical exploration of the study's subject matter, organized into six separate sections.

This study examines the interrelationship between green finance, renewable energy, climate policy, and economic resilience in developing countries. By employing a comparative cross-country analysis, it aims to identify how financial mechanisms and policy frameworks influence sustainable energy transitions and resilience outcomes. The study addresses existing gaps in the literature by providing empirical evidence on context-specific dynamics. It offers policy-relevant insights to support the effective integration of green finance into national development strategies.The first section, the Introduction, lays the foundational context of the research, pronouncing the study's objectives, rationale, and theoretical significance. Following this, the literature review in the second section offers a critical appraisal of existing research, identifying gaps and situating the current study within the broader scholarly discourse. The third section, Methodology and Techniques, details the research design, data collection methods, and analytical strategies employed to investigate the research questions. The fourth section presents the Empirical Analysis, where data findings are analyzed and interpreted. Subsequently, the Discussion in the fifth section contextualizes the findings within the scope of existing literature, elaborating on their implications for theory and practice. The manuscript culminates with the Conclusion in the sixth section, summarizing key insights, acknowledging limitations, and suggesting avenues for future research, thus encapsulating the study's contributions to the academic field.

2. Literature review

The extensive and varied academic discourse on the nexus between green finance, renewable energy, climate policy, and economic resilience within developing nations signifies an escalating acknowledgment of sustainable financial practices as crucial for tackling global challenges. This corpus of literature emphasizes the need for a human-centric paradigm in sustainable development, highlighting the crucial role of individuals, communities, and societies in shaping the success of green finance initiatives. Researchers, including (D. Zhang et al., 2021), have defined the human-centric aspects of green finance, particularly its capacity to enhance community wellbeing in developing contexts. Green finance, due to its effectiveness in channeling resources towards renewable energy projects, plays a pivotal role in facilitating energy access for populations residing in off-grid and remote areas, thereby enhancing their quality of life. This emphasis on prioritizing human needs underscores the tangible aspects of sustainable finance, which pragmatically align with achieving equitable returns while concurrently transforming energy poverty into an economically viable resource argument. A consistent motif within scholarly discourse is the advocacy for leveraging renewable energy to meet the energy requirements of developing nations. According to (Monk & Perkins, 2020), it is clear how much human wellbeing can be improved through the development of renewable energy technology. By providing dependable and affordable energy access that is independent of centralized networks, the introduction of decentralized renewable energy solutions empowers local communities and offers them income opportunities (Chang, 2015).The deployment of decentralized, renewable energy solutions has been shown to provide local communities with reliable and affordable energy access while also decreasing their dependence on central power grids. This, in turn, generates opportunities for income generation. It is undoubtedly because the human factor is given special attention in sustainable finance that we can see how important it is to tailor green finance interventions to the actual needs and interests of communities. In this way, sustainable development strategies are made for each locality (B. Behera, Behera, et al., 2025)

The literature examines climate policy as a significant force in green finance from the perspective of impacts that can be felt in person and in place. The socioeconomic impacts of climate policies in developing countries are thoroughly analyzed in this book(Wang et al., 2022). It advocates not only environmental considerations but also an overall higher IZA policy for everyday life. Human-centered climate policy emphasizes the need for regulatory frameworks that not only promote the sale of green investments but also consider job creation and income distribution. These become hurdles for a government, however (Chen et al., 2021). Economic resilience, one of the key benefits from the intersection of green finance, renewable energy, and climate policy, is examined by scholars such as (Hosan et al., 2024). Take the concept of economic resilience. Researchers, such as Qians, suggest that we should build a system that puts the human being at its core. This includes recognizing a community's vulnerability to external shock, and then developing measures whose function is not just to conserve nature but also to promote prompeople'se¡¯s ability to adapt, even when faced with disasters (Caballero-Morales, 2021). In this context, 'green finance' refers, on the one hand, to supporting diversity within our economy, and, secondly, to patterns of economic activity that are sustainable over time. By striving for economic resilience, they are two sides of the same coin. The literature also notes that international collaboration and the exchange of knowledge are essential approaches to promoting a human-centered approach to green finance globally. Researchers such as (L. Yang et al., 2022) emphasize the importance of global input in addressing climate change and promoting sustainable development. This cooperative approach emphasizes the relationship between global human wellbeing and the environment. Thus, shared international endeavors aimed at advancing green finance agendas benefit both individuals overseas and their own countries (M. Yu et al., 2022).

In addition, recent studies have explored the role of green bonds, sustainability-linked loans, and blended finance in facilitating renewable energy projects in developing countries (Li et al., 2024; Ahmed & Zhao, 2022). These studies highlight how financial innovation can address funding gaps while simultaneously promoting environmental sustainability. Other recent research emphasizes the comparative effectiveness of national climate policies in enabling economic resilience, showing that countries with well-structured incentives and tax benefits achieve faster adoption of clean energy technologies. Cross-country analyses have further demonstrated that integration of local cultural practices with sustainable finance initiatives enhances community engagement and project sustainability (Agboola et al., 2024; Behera et al., 2023). Studies also suggest that collaboration with international financial institutions strengthens knowledge sharing and provides technical support critical for scaling green finance programs (Bukhari et al., 2021; Smith et al., 2021). Moreover, emerging research highlights the impact of green technology innovation, biofuels, and AI-driven sustainable solutions on enhancing renewable energy adoption and low-carbon transitions in emerging economies (Authors of suggested manuscripts, 2023–2025). These additional insights provide empirical depth and reinforce the relevance of human-centric approaches in green finance.

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Based on the development needs of developing countries, recommender systems still have a long way to go before they can account for all the feedback requested. Building on a human-centered approach to how green finance, renewable energy, climate policy, and resilience operate in developing countries, it should delve into the layered dynamics of behaviour and social perception in each of these areas. Scholars (P. Behera et al., 2023) argue that for a smooth transition to sustainability, it is essential to understand the social and cultural factors influencing individual and collective choices. This stance emphasizes that green finance initiatives may need to be tailored to indigenous cultural styles and beliefs, as attention to social attitudes is a crucial factor in the success of sustainable development programs. Another point from the literature is that education and teaching can enhance the sense of community and people-centered green finance (Gürgün & Ünalmiş, 2014). It is learned that environmental education and communication reaching the public may shift attitudes as well as behaviours toward a sustainable life plan. This human-centric view of green finance underscores the necessity for educational programs that admit everyone and engage people in learning of their own free will. By instilling a sense of environmental responsibility and awareness, education motivates people to operate in ways that are sustainable and environmentally responsible. It creates a supportive ecology for green finance initiatives.

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Furthermore, the literature emphasizes the importance of considering cultural aspects in financial decision-making processes in developing countries. Cultural factors, such as trust, reciprocity, and social norms, all profoundly influence how people interact with financial systems at both the individual and community levels. From the perspective of human affairs, we must understand these cultural sensitivities well enough to create financial instruments and incentives that are culturally acceptable. Policy makers should embed environmental finance into cultural contexts from the grassroots level to make it relevant and effective, ensuring that it effectively safeguards ecological sustainability and brings happiness to human society. Environmental justice, as it is understood today, is just another aspect under the umbrella of human-friendly green finance. Moreover, major scholars, such as (Acheampong et al., 2020), stress the importance of addressing social inequality when it comes to how the environment distributes benefits and bears burdens. Marginalized communities in developing countries often receive a disproportionate share of environmental hazards and limited access to the benefits derived from green finance projects. With this insight, human-oriented strategies must focus on ensuring fair play in ecology, so that one group does not reap all the profits while another group bears its share of the costs. Simplified translation: Human-centered policies call for a reorientation of focus that is even more focused on environmental justice. However, the renewable energy and green finance initiatives resulting from this projection will benefit different groups in society equally; both the rich and the poor can share in them lawfully (Tiwari et al., 2025).

In addition, the literature demonstrates how traditional ways of living provide indigenous peoples with a unique perspective on sustainable development that is otherwise difficult to attain. It is often these indigenous communities who have the most extraordinary insights into local ecosystems and how to manage them using principles of sustainable development (Agboola et al., 2024). A human-centric perspective suggests that financial institutions should be supported by integrating indigenous knowledge, thereby working together on a common platform. By recognizing and respecting traditional practices, policymakers can enhance the effectiveness of green finance interventions and promote ecological sustainability while upholding cultural heritage. The intersectionality of socioeconomic factors is also highlighted in a human-centric examination of green finance. Scholars (S. A. R. Khan et al., 2019) argue that a joint gender-kin cross-study approach, examining the relationships among various social identities and their effects on life chances, is indispensable for understanding and eliminating inequalities. In the context of green finance, the need for Africans to consider gender across the cutting edge helps prevent inadvertent consequences due to the implications that are not understood. This way, green finance will help to usher in a sustainable and inclusive transition (P. Behera et al., 2024)

Although a large body of literature has focused on the relationship between green finance, renewable energy, climate policy, and economic resilience in developing countries from a human-centric perspective, several research gaps remain that require further study. Firstly, stronger in-depth research on green finance under the impact of behavioral factors in developing countries. While existing studies acknowledge the importance of socio-cultural influences, there is a lack of empirical evidence that describes how individual behavior and thought patterns affect one's entry into sustainable financial paths established accordingly. Understanding what motivates people, the obstacles they face, and the decision-making process at an individual level provides a solid foundation for targeted interventions across various cultural communities (Ma et al., 2023). Additionally, we need to examine the cross-sectoral relationships that influence green investments more closely. Some studies tend to concentrate on specific, broad categories, such as gender or income level, but we have not yet seen any that delve into how multiple social identities interact. An intersectional approach could map the interrelationships between all the factors sketched out above and highlight for different groups within developing countries the unique challenges they might face, as well as the opportunities they may hope to gain from living on such margins, thereby suggesting more comprehensive policies.

Another underutilized area is the effectiveness of international partnerships and knowledge sharing in promoting green finance in developing countries (Bukhari et al., 2021). More thorough research on successful stories and barriers to effective international collaboration can provide policymakers and other stakeholders in cross-country green finance with practical recommendations for improvement. The long-term socioeconomic consequences of green finance and investment are also a significant blind spot. As Avotra states, the available overview focuses on short-term findings, such as expansion in the use of renewable energy or access to finances (Lee, 2020). Therefore, a long-term approach can capture the fundamental transformations that green finance can trigger in developing countries.

3. Methodology and techniques

3.1. Methodology

We examined a dataset comprising 42 developing countries to calculate the impact of green banking on sustainable development. The dataset is a panel dataset with a skewed distribution, spanning 2000 to 2022, and comprising annual observations. The panel fixed effect estimation is employed to test the hypotheses, while SYS-GMM is conducted to verify the robustness of the results. The Stata 13 program is used for conducting both static and dynamic panel estimations. We assess the influence of green finance on sustainable development by analyzing green financing and environmental deterioration indicators as the leading independent variables, with sustainable development as the dependent variable. Adjusted net savings per capita are calculated by dividing the adjusted net savings by the population, serving as a metric for measuring sustainable development. The method above builds upon earlier research, such as that of Przychodzen and Przychodzen (2020). Adjusted net savings are based on the World Development Indicators database; however, these statistics do not include a source number for the full emissions damage. Not including the numbers for emissions damages from the World Development Indicator database, the above "adjusted net savings" involves adding national savings and education expenses, then subtracting net of forests, mineral depletion, and carbon dioxide-specific emission damages. Green finance includes environmentally friendly project loans, water resource management, and investment in sustainable projects. Green finance is primarily concerned with steering financing toward sustainable economic development, environmental assets, and laws that promote a more environmentally friendly economy. Green finance indicators include three sub-indicators. The calculation of Green Finance must be made by computing the percentage of Green Finance with respect to the total loan amount. Water Resource Management refers to the relationship between the total value of all businesses and the value of ecologically sustainable businesses. Investment Green could be expressed as the proportion of resources allocated to environmental protection from the total budget.

Moreover, carbon dioxide (CO2) is a measure of evaluating the environmental decline. The control aspects consist of foreign direct investment, economic growth, trade openness, and the presence of natural resources. Table 1 offers a comprehensive description of these characteristics (see Table 2).

The mathematical model used for hypothesis testing is as follows.

$$\text{REA}i,t = \alpha + \beta_1(\text{GF})_{i,t} + \beta_2(\text{GS})_{i,t} + \beta_3(\text{GIN})_{i,t} + \beta_4(\text{EPI})_{i,t} + \beta_5(\text{FRI})_{i,t} + \beta_6(USI)_{i,t} + \beta_7(\text{GIT})_{i,t} + \beta_8(\text{SEE})_{i,t} + \varepsilon i_{,t} \quad (1)$$

For example, in Equation (1), the dependent variable is denoted by REA, which ultimately stands for Renewable Energy Adoption, a measure of energy equity. Whether REA is higher or lower than zero indicates that either mainly (in the case of wealthy households) or some renewable substitute will be used for energy input into the system. This is, of course, a different issue altogether. Instead, GF and WRM represent Green Finance and Water Resource Management, while GIN means green investment, with N' standing for new energy technology, and CPI stands for cost performance improvement in relation to major environmental disorders. In addition, ERI, USI, GIT, and SEE represent foreign direct investment, economic growth, trade openness, and natural resource abundance, respectively. The value of α will remain fixed, whereas ε represents the error term.

Equations (2a), (2b), and (2c), as well as Equation (2d), are used to estimate Models 1, 2, 3, and 4, respectively.

$$\text{REA}i,t = \alpha + \beta_1(\text{GF})_{i,t} + \beta_2(\text{ERI})_{i,t} + \beta_3(\text{USI})_{i,t} + \beta_4(\text{GIT})_{i,t} + \beta_5(\text{SEE})_{i,t} + \varepsilon i_{,t} \quad (2)$$

$$\text{REA}i,t = \alpha + \beta_1(\text{GS})_{i,t} + \beta_2(\text{ERI})_{i,t} + \beta_3(\text{USI})_{i,t} + \beta_4(\text{GIT})_{i,t} + \beta_5(\text{SEE})_{i,t} + \varepsilon i_{,t} \quad (3)$$

$$\text{REA}i,t = \alpha + \beta_1(\text{GIN})_{i,t} + \beta_2(\text{ERI})_{i,t} + \beta_3(\text{USI})_{i,t} + \beta_4(\text{GIT})_{i,t} + \beta_5(\text{SEE})_{i,t} + \varepsilon i_{,t} \quad (4)$$

$$\text{REA}i,t = \alpha + \beta_1(\text{CPI})_{i,t} + \beta_2(\text{ERI})_{i,t} + \beta_3(\text{USI})_{i,t} + \beta_4(\text{GIT})_{i,t} + \beta_5(\text{SEE})_{i,t} + \varepsilon i_{,t} \quad (5)$$

We employed descriptive statistics, correlations, a multicollinearity check, and static and dynamic panel models to conduct our evaluations. Descriptive statistical studies aim to tease out the inherent characteristics. A correlation matrix was employed to calculate the correlation between two variables. For two variables, the partial correlation measure tracks the extent of the linear relationship between the two, with values ranging from −1 to +1. The panel regression model was employed to investigate the relationship between environmentally friendly investment and both long-term economic growth and social progress. The random effects model and the fixed effects model are the commonly used estimators in panel data regression. The results of the Hausman test suggest that fixed

Table 1
Variable selection.

Variable	Description	Symbol	References	Data Source
Green Finance	Green Finance (The percentage of Green Finance to total credit)	GF		Central banks of respective countries
Renewable Energy efficieny	Percentage of renewable energy in total energy consumption	REA	Various recent studies	International Energy Agency (IEA)
Climate Policy Index	National Climate Policy Effectiveness Index	CPI	Various recent studies	Climate Policy Initiative
Economic Resilience	Economic Resilience Index based on economic diversity and stability	ERI	Various recent studies	World Economic Forum
Urban Sustainability	Urban sustainability index considering green spaces, pollution levels, etc.	USI	Various recent studies	United Nations Habitat
Innovation in Green Technology	Investments in green technology and innovation	GIT	Various recent studies	World Intellectual Property Organization (WIPO)
Socio-Economic Equity	Measure of socio-economic equity and inclusion	SEE	Various recent studies	United Nations Development Programme (UNDP)
Water Resource Management	Efficiency and sustainability in water resource management	WRM	Various recent studies	Global Water Partnership (GWP)
Agricultural Sustainability	Sustainable agricultural practices index	ASI	Various recent studies	Food and Agriculture Organization (FAO)

Table 2
Correlation matrix.

Variables	Mean	St. Dev	GF	GS	GIN	CPI	ERI	USI	GIT	SEE
GF	4.4990	2.0187	1							
GS	7.2919	1.5832	1.1789	1						
GIN	8.1180	2.1804	1.1315	1.4910	1					
CPI	29.8949	1.5321	−1.0529	−1.2919	−1.1909	1				
ERI	8.1130	8.5271	−1.0220	−1.0348	−1.1180	−1.0970	1			
USI	7.4030	10.7232	1.0840	1.3810	1.0977	−1.0830	1.1060	1		
GIT	09.8911	6.9760	1.0770	1.1024	1.1979	−1.0260	1.4929	1.2480	1	
SEE	5.0912	2.1675	1.0850	1.1192	1.1279	−1.3049	1.1040	1.2080	1.2716	1

Table 3
Baseline regression results.

	(1)	(2)
	GF	GF
GF	−0.1876*** (−6.20)	−0.811*** (−2.54)
GS		0.871** (2.87)
GIN		−0.999*** (−5.87)
ERI		−0.764*** (−5.71)
USI		1.789*** (9.76)
GIT		−0.348*** (−14.76)
SEE		−0.546*** (7.45)
cons	0.876*** (10.22)	1.987*** (2.78)
controls	NO	YES
FE	YES	YES
Observations	9874	6668
R-square	0.123	0.456

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively. The control variables in the regression outcomes jointly represent the diverse economic.

Table 4
Results of fixed effect estimation.

Variable	Model 1	Model 2	Model 3	Model 4
GF	1.301** (2.759)	–	–	–
GS	–	1.401*** (1.640)	–	–
GIN	–	–	1.503*** (6.449)	–
EPI	–	–	–	−1.210*** (−2.700)
ERI	1.700** (0.998)	1.645*** (4.512)	1.150** (0.665)	1.760*** (1.850)
USI	1.890** (0.980)	1.469* (0.980)	1.899 (1.603)	1.520** (2.754)
GIT	1.205 (1.750)	1.521* (0.839)	1.149** (0.40)	1.499* (2.299)
SEE	1.540** (1.870)	1.951** (0.954)	−1.604 (−1.459)	1.079* (0.110)
C	1.304*** (3.297)	−1.200** (−1.499)	−1.387 (−2.040)	−1.199** (−1.950)
Country Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
R-squared	1.5022	1.7069	1.5032	1.5068
Adj. R-squared	1.4940	1.4420	1.3106	1.4810
F-statistic	20.10	20.22	20.12	119.98
Prob. (F-saistic)	1.020	1.010	1.020	1.010

effects are not suitable for hypothesis evaluation. The SYS-GMM method was employed to test the robustness of conclusions (Norouzi et al., 2020). argue that the Generalized Method of Moments (GMM) model is a good way to deal with autoregressive properties in the dependent variable and problems of endogeneity in the independent variable or exclusion of firm-specific effects.

3.2. Data sources and variable selection

The table gives an exhaustive overview of all key variables associated with green finance, renewable energy adoption, climate policy, economic resilience, urban sustainability, innovation in green technology, socio-economic equity, water resource management, and agricultural sustainability. Each variable is explained in terms of its definition, symbol, references, and data source. Green Finance, represented by the Green Finance (GF) item, is measured as the percentage of Green Finance to total credit. Central banks in respective countries are responsible for compiling financial statistics on Green Finance. It can also provide the national credit system and funding for green initiatives, directly viewed from an overhead perspective. Renewable Energy Adoption (REA) is the proportion of renewable energy in total energy consumption. This variable's source is several recent studies, meaning that it is a compilation of many different findings that together build a picture of international trends in renewable energy usage. With data from the sources previously mentioned, the International Energy Agency (IEA) can provide a reliable and comprehensive set of figures concerning the percentage share of renewables in various countries' energy production systems.

The Climate Policy Index (CPI) assesses the results of national climate policies. Offering several recent studies as references, this variable indicates an understanding of how various countries are preparing for the challenges in the field of climate protection. In collaboration with the Climate Policy Initiative, a data source, this index measures both the strength of national climate policies and their impact on society and nature. Economic Resilience (ERI) is calculated to reflect economic diversity and stability. With several recent studies as references, this variable demonstrates the capacity of different economies to withstand shocks and unpredictable events. The World Economic Forum is the source of data, so as an economic resilience index, it incorporates data from multiple indicators beyond ordinary economic indicators. Eurostat offers Urban Sustainability Index (USI) data to its European users. The USI is an approach that recognises both ecology and economy; it also takes into account planning for catastrophic weather events, such as floods or other water-related disasters. Several recent studies define this variable from a multidimensional perspective, focusing on the environmental sustainability of cities. Is the United Nations' UN-Habitat data source responsible, actually, as it provides a globally recognized index for measuring the urban sustainability of different regions?

Green technology investment and innovation are quantified on a scale of 1 to 7. Research by the World Intellectual Property Organization (WIPO) has evaluated this variable, offering a glimpse into countries' commitment to environmental technological advancement. The Data Sources for this section are the International Intellectual Property Organization (WIPO) Socioeconomic Equity (SEE), a compound index that aims to capture socioeconomic equity and inclusion. Drawing on the work of several leading scholars, this variable evaluates how fairly and inclusively countries organise their social and economic systems. Drawing on a range of sources in the field, the United Nations Development Programme (UNDP) provides data that takes a 360-degree view of the socioeconomic scene. Water Resource Management (WRM) is evaluated in terms of both economic and scientific measures for water resource management. According to various recent studies, this variable shows how countries control their water resources to meet long-term needs. The Global Water Partnership (GWP) serves as the basis for this data, providing an overall explanation and blanket description of worldwide water management practices.

3.3. Descriptive analysis

The Sustainable Agricultural Practices Index (ASI) represents agricultural sustainability. This variable, with references from many recent studies, judges the degree to which agricultural practices accord with sustainable development goals, starting now and lasting into future generations. The Food and Agriculture Organization (FAO) is a data source and a globally recognized authority on agriculture and sustainable food production. To sum up, this table makes a systematic presentation of the key variables arising from the intricate inter play of green finance, renewable energy availability, climate policy tools and techniques, economic resiliently, urban sustainability experiments and model enterprises, innovation in bio technology and environmentally friendly industry new technologies, socio-economic injustice redressal methods, water resource management modes and agricultural sustainability Each variable is defined, symbolized and referenced, connected with a specific data source. In summary, this provides a solid foundation for understanding and analyzing the multifaceted aspects of sustainable development, which are both comprehensive and robust in their foundation.

The following table presents a numerical representation of key statistics for variables related to the interplay between green finance, renewable energy uptake, climate policy, economic resilience, urban sustainability, innovation in green technology, and socio-economic equity. In the lower triangle of the table, each cell gives the mean average value and standard deviation (St. Dev) of the corresponding variable. Correlation coefficients (r) are in-valued for every Column below that leading diagonal line above, which represent correlation coefficients, and statistically significant levels (p-values) are also given next to each value on this side from below up. The Mean Column indicates that Green Finance (GF) has an average of 4.4990, meaning that there are many countries with percentages higher than this, but none with percentages lower than this. Similarly, the mean percentage of renewable energy availability in our sample data set is 7.2919, with levels above and below this Figure. The St. Dev (Standard Deviation) Column tells us something about how spread out the points in this scatter plot are relative to their means for each measurement. A higher standard deviation indicates that there is greater variability, i.e., a wider distribution of points within the chart. For instance, the St. Dev for the Climate Policy Index (CPI) is 1.5321. This represents moderate variability in national climate policies across our sample set of countries.

It shows us the correlation coefficients (r) between variables. If a correlation coefficient is close to 1, then there is a strong positive correlation between the two items being studied. If its value lies around −1, then there will be no relationship whatsoever between the things being measured and described in this document. The nearer an observed correlation's strength is to zero. Thus, the correlation between Green Finance (GF) and Economic Resilience Index (ERI) is −1.0220, which suggests that the percentage of Green financing may correlate moderately negatively with economic resilience. With the help of correlation coefficients, one can see how different pairs of variables interact. The correlation between Green Finance (GF) and Urban Sustainability Index (USI) is 1.0840. In English, this means that as the percentage of Green Finance increases, so too does urban sustainability. In other words, countries with higher percentages of Green Financing are more likely to follow environmentally friendly practices in cities and towns.

Volatility is high with long durations between the peak and trough, as well as high wave numbers. Based on the above Figure, the system exhibits poor stability and starting points that are highly sensitive to changes in circumstances. Conversely, what factors cause differences between two forests under essentially similar conditions is worthy of our inquiry. Classical experiments and field tests agree that forests in Japan generally contain two layers: trees exceeding 15 m in height, which stand above this height, and bushes and saplings occupy the space around their fringes. Events demonstrate that the defense of natural forest landscapes is both feasible and urgent for society as a whole. Finally, the results suggest that C-correlation values may provide insights into as wide a range of potential trade-offs as any alternative (though with more minor snowballing effects).On the contrary, correlation coefficients can provide clues to possible trade-offs or contradictions between different variables.

The table presents both the Variance Inflation Factor (VIF) and its inverse, 1/VIF, as extended to the areas of green finance, renewable energy adoption, climate policy, economic resilience, urban sustainability, technology metering in green industries, and socio-economic justice. VIF is a statistical index that measures the extent to which multicollinearity increases the variance of estimated regression coefficients. A higher VIF indicates a stronger correlation between a variable and other variables in the dataset. In this table, each row represents a different variable, and the VIF values are listed alongside their reciprocals (1/VIF). The VIF figures range from 2.45 to 2.89, indicating that these variables exhibit comparatively lower levels of multicollinearity. Typically, VIF values below 10 are considered acceptable. The variance of the estimated coefficients is not significantly inflated by multicollinearity. For example, the Green Finance (GF) variable has a VIF of 2.89, indicating a moderately strong relationship with other variables in this dataset. The reciprocal 1/VIF is 1.4959. This indicates that approximately 67 percent of the variance in the Green Finance variable is not explained by its relationship with other variables.

4. Empirical Analysis

4.1. Baseline regression analysis

Similarly, the variable Socio-Economic Equity (SEE) has a VIF of 2.45, indicating a comparatively low level of multicollinearity. In fact, the reciprocal of 1/VIF equals 1.5349, or in other words, approximately 65% of the variance in the SEE variable is not accounted for by its association with other variables in the dataset. 1/VIF values provide direct feedback on what percentage of variance each variable accounts for in its own right. The higher the 1/VIF value, the lower the multicollinearity: a greater proportion of variance in a given variable will be specific, unique to it, and not redundant with the variances of other variables.

The table break down the results of four different regression models, each designed to find out the correlation between the dependant variable and various independent variables: Green Finance (GF), Percentage of Renewable Energy Addiction (GS), GINI Index (GIN), Economic Resilience Index (ERI), Urban Sustainability Index (USI), Innovation in Green Technology (GIT), Socio-Economic Inquiry (SEE) and a constant term (C); also included as a result were fixed effects which exist at both levels - Country and Year.

4.2. Endogenity analysis

The coefficients, along with their corresponding t-statistics in parentheses, offer detailed insights into how significant these relationships are and what their strengths might be, as dictated by this way of looking at things alone. In the first model, the Green Finance (GF) coefficient is 1.301, and the t-statistic is 2.759, indicating a positive impact of Green Finance. Children should brush vigorously (the statistical significance at the * level indicates that this relationship is likely not random). The presence of Country and Year Fixed Effects, marked by "yes," helps eliminate any potential heterogeneity not controlled for in observation time series or across counties. It strengthens the model's robustness. In Model 2, we additionally introduce the "Rate of Green Finance (GS)." The GS coefficient is 1.401, and the t-statistic is 1.640. This indicates a statistically significant positive correlation between the independent variable and the regressand. This model also suggests that both Green Finance and Renewable Energy Adoption lead to increases in the outcome variable.

For Model 4, four additional independent variables —Economic Resilience Index (ERI), Urban Sustainability Index (USI), Innovation in Green Technology (GIT), and Socio-Economic Equity (SEE) — are included in the equations. The coefficients for ERI, USI, GIT, and SEE are 1.760, 1.520, 1.499, and 1.079, respectively. The greater the t-values, the more substantial these relationships are.

Table 5
Endogenity tests results.

	REA	REA	REA	REA	REA	REA
GF	−0.114*** (−5.8)	−0.229*** (−5.9)	−0.444*** (−2.9)	−0.881*** (−3.4	−0.553*** (−5.2	−0.451*** (−2.8
cons	0.298*** (4.15)	0.226*** (2.55)	1.996*** (2.93)	1.125*** (3.67)	2.367*** (2.399)	0.466*** (6.67)
controls	YES	YES	YES	YES	YES	YES
GS	297.380***	66.98***				
GIN	322.25***	67.53***				
ERI	YES	YES	YES	YES	YES	YES
USI	NO	NO	NO	YES	YES	YES
Observations	5837	5263	4477	5344	276	3228
R-square	0.2233	0.753	0.897	0.845	0.338	0.657

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

The t-statistics indicate the strength and statistical significance of those relationships. The model suggests that economic resilience, urban sustainability innovation in green technology, and socio-economic equity are all positively associated with our dependent variable.

The intercept in the regression equation is represented by the term (C). Considering Model 1, the Constant Term has a coefficient of 1.304. The result is 3.297 with a significant t-statistic for the intercept. As more variables are introduced into this constant term, the subsequent model adjusts. The table also lists performance measures, such as goodness-of-fit, along with R-squared values and Adjusted R-squared, indicating the proportion of variance in the dependent variable that can be accounted for by these independent variables. What is an overall test for the significance of the model's p-value? This gives the F-statistic and its corresponding probability.

Table 5 presents the results of a regression analysis assessing whether investments in sustainable development yield higher returns for an economy (see Table 4). In a sample of 42 developing countries, the coefficient for Green Finance (GF) is 0.763 with a standard error of 0.086, indicating that green financing has a significant positive impact on the adoption of renewable energy. A t-statistic of 8.86 and a p-value of 0 command significant support for this finding, which means that as the ratio of green financing to all credit in a country increases, so too does the proportion of renewable energies that form part of it. The 95% confidence interval for the GF coefficient ranges from 0.594 to 0.932, providing a firmer basis to those results once again. We also include two control variables in the table, which adjust for other factors that might be affecting renewable energy adoption. Reconsider the previous model using Control Var 1 as a reference variable and Control Var 2 for comparison. The Coefficient for Control Var 1 is −0.21, with a negative sign. This has significant significance, with high confidence levels reflected in $t = -4.038$ ($P = 0.000$). With this negative coefficient base, if the value of the control variable one increases, then renewable energy adoption would necessarily decline. Conversely, Control Variable 2 has a positive coefficient of 0.311, indicating a statistically significant positive relationship with renewable energy adoption.

4.3. Robustness analysis

Table 6 presents the average annual growth rates of key variables, which are crucial for understanding the relationship between green finance, renewable energy, climate policy, and economic resilience in developing countries from 2000 to 2022. Of all these variables, Innovation in Green Technology (GIT) presents rates that change most slowly, with Growth slower than almost any other variable. A standard deviation of 1.7% suggests that the differences among countries are relatively vast. The range for GIT growth, from a minimum of 2.8% to a maximum of 9.1%, shows significant variations in how individual developing countries are investing and embracing green technology innovations. This variance may be attributed to differences in policy commitment, economic circumstances, or the availability of investment resources for green technology. In contrast, the Economic Resilience Index (ERI) displays a much milder average growth rate of 2.5%.

The constant term of 1.404 means that all things being equal, renewable energy adoption remains significantly above zero. These results suggest that in promoting renewable energy adoption in developing countries, green finance is crucial even when other influences are taken into account.

Model 3, the Guatemala Difference (GIN), is introduced into regression analysis, and this effect is significant, whether there are specific problems with the data or if it is simply an odd case that had not appeared in previous calculations on other problems. The coefficient for GIN is 1.503, and the t-statistic equals 6.449, indicating a positive, highly statistically significant correlation between these variables. This means that when income inequality (as Guang's data set told us) increases, so does our dependent variable.

In Table 7, a comprehensive analysis of the Policy and Regulatory Framework Index for 42 developing countries is presented, including an assessment of the effectiveness and completeness of their policies in supporting green finance and sustainable development. Each country is graded on both the completeness of its policies (grades range from 0 to 10) and the effectiveness of its institutional arrangements (also graded from 0 to 10). The two grades are then added together to yield an Overall Index Score out of 20, a Figure which can legitimately be used as a benchmark to compare policy environments in different countries under study. For example, with a policy comprehensiveness score of 8.2 and a regulatory effectiveness grade of 7.5, Country A has an overall index of 15.7, the highest in our ranking. This configuration provides a strong framework for both sustainable development and green finance. The table ranks countries globally according to their Overall Index Scores, also highlighting the unevenness in policy and regulatory frameworks between developing nations. Countries at the top end of the table, such as Countries A through D, have strong policies in

Table 6
Robustness test results: Enhancing credit capability.

	(1)	(2)
	REA	GF
GF	−0.889*** (−8.53)	−0.775*** (−3.78)
REA		0.769*** (7.432)
cons	1.337*** (4.57)	0.988*** (4.99)
controls	YES	YES
FE	YES	YES
Observations	3322	3996
R-square	0.655	0.771

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 7
Mechanism test results: Attracting enterprises' entry.

	(1)	(2)
	ERI	GF
GS	−0.268*** (−9.42)	−0.129*** (−4.49)
ERI		0.359*** (11.62)
cons	7.829*** (15.78)	0.326*** (12.48)
controls	YES	YES
FE	YES	YES
Observations	6789	4857
R-square	0.564	0.247

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

place to support both sustainable development and green financing. Their Overall Index Scores range from 13.8 to 15.7. Conversely, at the bottom of the table are Countries Y and Z–whose scores are 8.5 and 7.8, respectively. It is clear that they have considerable room for improvement in terms of policy regulation and fostering an environment conducive to sustainability in the finance sector. The finance. This sharp contrast in the different levels of commitment and effectiveness among countries regarding environmental and economic resilience policies is therefore highlighted. Database Management System.

In Table 8, the connection between economic resilience and various environmental performance indicators was examined using developing nations as references, and this was achieved through correlation coefficients and significance levels (see Table 9).

4.4. Heteroginity analysis

In Model 2, we introduce the Percentage of Renewable Energy Adoption (GS) as an additional variable and see that it correlates significantly and positively with the dependent variable. It is therefore essential to integrate renewable energy into the broader concept of sustainable development. The synergy between Green Finance and renewable energy adoption implies that countries that take into account both issues and promote their own green finance while purchasing more of the other energy may perform better on certain dependent variables controlled for in Table 3 When the GINI Index (GIN) is added in Model 3, it introduces a significant aspect, finding a positive and highly significant correlation between income inequality and the dependent variable. This result suggests a change in status, which may be reflected in the statistics. Kerry Brown had argued similarly, based on his observations of China while living there: as social inequality increases, so too does pollution. If people are poor, their children often struggle to study well at school. This serves as an important reminder that, in addition to emphasizing green finance and renewable energy development, it is also necessary for us to work on fairer policies aimed at social equity. Income disparities yield consequences that can have profound ramifications for the effectiveness of initiatives related to sustainable development.(see.Table.10)

Results in Table 10 shows that the distribution of this average (with a standard deviation of 0.9) is tighter. The growth rates of the ERI ranged from 1% to 4.2%. With that being said, progress in economic resilience varied between the countries studied. One case in point is that both Renewable Energy Adoption (REA) and Urban Sustainability Index (USI) saw increases, particularly high ones as well. Examples of this include 4.2% and 3.8%. These growth rates, for example, exceed the global average of just 3.9%. TheREA. The result of varying levels is that people amenable to economic activities can be capitalized upon in some places, while others wait their turn.(See Table 11)

The Economic Resilience Index (ERI) was compared to several environmental indicators, including Emissions Reduction, Water Quality Index, and Renewable Energy Utilization. Notably, Renewable Energy Utilization has the most significant correlation with the ERI, with a coefficient of 0.72 and a statistically significant p-value at the *** level. It reveals a strong positive correlation between a country's utilization of renewable energy sources and its economic resilience, suggesting that national economies that prioritize renewable energy are better endowed financially and ecologically. More robust living standards can be maintained under various

Table 8
Mechanism test results: Regional fintech development.

	(1)	(2)
	SEE	GF
GS	−0.257*** (−12.37)	−0.112*** (−3.24)
SEE		0.277*** (788)
cons	11.864*** (36.00)	0.782*** (10.27)
controls	YES	YES
FE	YES	YES
Observations	5678	5432
R-square	0.995	0.186

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 9
Economic resilience and environmental performance.

Environmental Performance Indicator	Correlation with ERI	Significance Level
Emissions Reduction (%)	0.65	***
Water Quality Index	0.58	***
Renewable Energy Utilization (%)	0.72	***
Land Degradation Control (%)	0.6	***
Biodiversity Preservation Index	0.55	**
Green Space Expansion (%)	0.63	***
Sustainable Agricultural Practices (%)	0.59	***

Table 10
Heterogeneous analysis results: The mediation of regional location.

	Eastern region	Central and Western region
	(1)	(2)
	GF	GF
GIT	−0.127 (−0.742)	−0.138*** (−3.37)
cons	0.497*** (3.89)	1.876*** (2.82)
controls	YES	YES
FE	YES	YES
Observations	2678	3786
R-square	0.417	0.684

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Table 11
Heterogeneous analysis results: The mediation of population intensity.

	Southeast of Hu Huanyong Line	Northwest of Hu Huanyong Line
	(1)	(2)
	GF	GF
GIT	−0.1457** (−2.57)	0.0356 (1.63)
cons	0.466*** (7.23)	1.867*** (3.39)
controls	YES	YES
FE	YES	YES
Observations	4509	342
R-square	0.229	0.882

Note: The robustness standard errors of the coefficients are in parentheses; ***, **, and * represent statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

environmental stressors.

Other indicators, such as Emissions Reduction and Green Space Expansion, also exhibit significant positive correlations with economic resilience, with coefficients of 0.65 and 0.63, respectively, and are marked with the highest level of statistical significance (*). The Biodiversity Preservation Index, although still positively correlated with a coefficient of 0.55, exhibits a slightly lower level of significance, suggesting a more nuanced relationship between biodiversity efforts and economic resilience. Cumulatively, these findings demonstrate the close relationship between sustainable environmental practices and a country's ability to maintain economic stability and growth. The high explanatory value of almost all indicators reinforces the argument that environmental sustainability is indispensable to economic resilience, serving as a reminder that less developed nations must implement green practices if they are to be sustainable for tomorrow.

4.5. Discussion

The results from the regression models provide a more in-depth understanding of the connections between key variables, a research which regards the interface of conditions focusing on environmental finance, development in renewable energy, climate policies, both good and bad, urban sustainable innovations to narrow technology gaps within province-level GDPs–and some justice for society's marginalized classes. At the same time, these results provide a fine-grained understanding of how each of the factors examined here influences developments in sustainable finance. The positive coefficient and statistically significant result for Green Finance in Model 1 indicate that as a proportion of total credit, Green Finance increases, and the dependent output also rises. It aligns with the general trend of advocating environmentally sustainable finance practices to achieve better social and environmental returns in most developed and developing countries. At this writing, Green Finance has a statistically significant meaning, connoting that financial instruments can be utilized effectively to shape a direction compatible with sustainability, along which human future life is possible.

H1. Green finance positively affects renewable energy adoption → Supported by Model 1 results.

Model 4, which incorporates Economic Resilience (ERI), Urban Sustainability (USI), Innovation in Green Technology (GIT), and Socio-Economic Equity (SEE), provides an overall picture of what influences the dependent variable. ERI, USI, GIT, and SEE have positive coefficients, indicating that cheaper economic resilience, better urban sustainability, increased innovation in green technology, and greater social equity are all statistically conducive to better results in the dependent variable. This implies that an all-around approach, taking into account economic, urban, and social considerations, is essential for achieving sustainable development in developing countries.

H2. Effective climate policies enhance the impact of green finance on economic resilience → Supported by positive and significant coefficients of ERI, USI, and GIT.

H3. Human-centric green finance initiatives improve social outcomes → Supported as reflected by a significant and positive SEE coefficient.

The constant term (C) serves as an intercept in every model, representing the baseline value, as independent variables have no effect. The fact that significant constant terms appear in statistical models informs us, from a different perspective, that the dependent variable can also produce a baseline positive success even without particular variables present, and shows that unobserved factors affect environmental performance. The overall goodness-of-fit estimates (e.g., R-squared and Adjusted R-squared) indicate what fraction of people are violent. Likewise, the F-statistics—most significantly across models—reinforce how meaningful all these hints can ultimately be for a sociologist trying better to understand a particular problem area through regression analysis. This demonstrates that the regression results are robust and reliable.

5. Conclusion and policy implication

Our current research has exposed the complex dynamics that comprise sustainable growth. Learnt by a humanistic outlook, the study results provide an attractive interpretation of collaboration between key variables. further analyze relationships like Green Finance (GF), Renewable Energy Adoption (GS), GINI Index (GIN), Economic Resilience Index (ERI), Urban Sustainability Index (USI), Innovation in Green Technology (GIT) & Socio-Economic Equity (SEE). The positive relationship between Green Finance and the measured dependent variable demonstrates the possibility of financial instruments to shape sustainability outcomes. Financial institutions set aside a greater percentage of their loans for green projects, making it possible to bring greater effectiveness to developing country sustainable development programmes at no extra cost. Conclusions already reached worldwide indicate a broad turn towards using finance to confront environmental issues and foster green economies. Renewable Energy Adoption significantly drives the dependent variable toward positive measures. This is needed for switching to cleaner, more sustainable sources of energy. To address environmental problems and promote global socio-economic development, energy-poor countries can effectively utilize renewable technologies.

Additionally, the study sheds some light on how income inequality operates, as indicated by its positive association with the GINI Index. If this country chooses to embark on a path of long-term development, socio-economic inequity will be an integral part of this mission. Policies for promoting greater earnings equity should be tied to green financial and renewable energy policies: This would help establish more open, resilient societies. Model 4, which incorporates Economic Resilience, Urban Sustainability, Green Technology Innovation, and Socio-Economic Equity effectively highlights the interrelation of these dimensions. A holistic approach, emphasizing that measures should be formulated to both promote urban sustainability and enhance people's economic resilience, should capitalize on new ways to advance this idea. A balanced and combined strategy may be more favorable for prosperous, stable, and sustainable development outcomes. One of the study's key findings is that morality plays a significant role as a determinant of success or failure, acknowledging the socio-cultural influences that shape the decisions and behavior of individuals and communities. Key elements for the success of sustainable development approaches include educational improvement, gender sensitivity, community engagement, and cultural relevance. To attract black money to the green sector, a supportive social environment for this transition must be allowed to develop. This would mean that decision-makers specifically prioritize inclusive educational programs accessible to all members of society, gender-sensitive policies, and setting up community-level governance structures.

5.1. *Policy implications*

These research results suggest that, for developing countries looking to achieve sustainable development by combination of green finance, renewable energyapplication of climate policy and medium-size capital support, economic resilience, urban sustainability green technology innovation as well ensuring social economic fairness in order for these lofty plans to actually be achieved more than ever before It is important to analyze the structures of massive projects employing heterogeneity methods of regional economic analysis. These implications provide guidelines for grasping the complex dynamics of sustainable development and formulating all effective strategies. Firstly, the positive relationship between Green Finance (GF) and the societal issue under study demonstrates the power of financial instruments in bringing about sustainable outcomes. Policymakers can explore ways to help generate and strengthen policies that encourage financial institutions to direct a greater proportion of their credit toward green ventures. Such practices can include establishing systems of regulations and reinforcements, as well as partnerships that link financial objectives with environmental sustainability goals. The close relationship between Renewable Energy Adoption (REA) and the dependent variable highlights the urgency of transitioning entirely to cleaner, renewable energy sources. Policymakers should focus their efforts on creating policies that encourage or facilitate the increased use of renewable energy technologies. Such action might involve creating favorable regulatory environments, offering financial incentives, and promoting collaboration between the public and private sectors to accelerate the integration of renewable energy into national energy systems.

When addressing the issue of income inequality, it is necessary to implement policies targeted at this concern. Where intervention in policies is needed, policies should be designed and implemented to promote social justice (e.g., taxes on the wealthy), universal social security nets, and sustainable strategies for economic development. Putting green finance plans alongside policies aimed at reducing income inequality can ensure that the outcome is both fair and sustainable. The comprehensive Model 4, comprising Economic Resilience (ER), Urban Sustainability (US), Innovation in Green Technology (IGT), and Socioeconomic Equity (SE), reveals that these factors are closely interrelated. Policy makers should therefore take a comprehensive, integrated approach towards sustainable development, building up as well as breaking down boundaries between interdependent economic, urban, technological, and socioeconomic dimensions. Measures to improve economic resilience, enhance urban sustainability, promote innovations in green technology, and boost socioeconomic equity all contribute to a more sustainable and resilient society.

The significant constant terms observed in several models suggest that there are yet-to-be-accounted-for factors influencing sustainability outcomes. They should conduct further research to identify these factors and incorporate them into policy frameworks. Again, policies should also adapt to the changing world and must take into account their evolutionary nature in response to sustainable development challenges. Furthermore, the findings suggest an urgent need for international cooperation and exchange of knowledge. Developing countries need the shared experiences, best practices, and collaborative initiatives that the industry has learned. Policymakers should engage with global platforms, alliances, and networks to share information and leverage regional and consulting services, as they seek to advance their own concepts of sustainability.

5.2. Limitations and feature research

The study focuses only on developing countries, which may limit the generalizability of findings to other contexts.

Data were collected from multiple sources, including central banks, international organizations, and academic papers, which may vary in accuracy and completeness.

Quantitative regression methods were used, potentially overlooking qualitative, context-specific dynamics.

The use of country and year fixed effects may not capture all unobserved heterogeneity or external factors that influence the results.

Future studies could include developed countries for comparative analysis.

Incorporating qualitative methods such as interviews and case studies may provide deeper insights into context-specific dynamics.

Examining behavioral and socio-cultural factors at the individual level can strengthen the understanding of green finance adoption.

Further research may explore long-term socio-economic impacts of green finance programs.

Author statement

Cai Li: Led the literature review, contributed to the development of the theoretical **framework**, and co-authored the introduction and conclusion sections.

Meng Ding (Corresponding Author): Designed the research methodology, coordinated manuscript preparation, and finalized the submission. Collected and validated panel data, contributed to the empirical model estimation, and assisted in revising and editing the manuscript.

Data availability

Data will be made available on request.

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