

GREEN FINANCE AND SUSTAINABLE DEVELOPMENT GOALS IN DEVELOPED ECONOMIES: AN EMPIRICAL ANALYSIS

Madiha Naseem¹, Wajid Alim^{*2}

¹MPhil Scholar, Lahore School of Accountancy and Finance, University of Lahore

^{*2}Assistant Professor, Lahore School of Accountancy and Finance, University of Lahore

¹madihanaseem6624@gmail.com, ²wajid@uolcc.edu.pk

Corresponding Author: *

Wajid Alim

DOI: <https://doi.org/10.5281/zenodo.18310800>

Received	Accepted	Published
25 November 2025	06 January 2026	20 January 2026

ABSTRACT

This study investigates the role of green finance in promoting sustainable development across developed economies, with particular emphasis on its contribution to achieving environment- and climate-related Sustainable Development Goals (SDGs). Using a comprehensive analytical framework, the study examines how green financial instruments such as green bonds, sustainable investments, and ESG-oriented financing facilitate the allocation of capital toward environmentally beneficial projects. The findings reveal that green finance plays a significant and positive role in advancing sustainable development in developed countries, where well-established financial markets and supportive regulatory frameworks enhance its effectiveness. Empirical evidence indicates a strong association between green finance and key SDGs, notably SDG 13 (Climate Action), SDG 7 (Affordable and Clean Energy), and SDG 12 (Responsible Consumption and Production). The results suggest that green finance supports the transition toward low-carbon economies by encouraging investments in renewable energy, sustainable infrastructure, eco-friendly manufacturing, and resource-efficient technologies. Moreover, green financial mechanisms contribute to inclusive and resilient economic growth by reducing environmental risks and promoting long-term economic stability. The study also highlights the importance of governance quality, transparency, and policy support in strengthening the link between green finance and sustainable development outcomes. Effective disclosure standards and regulatory incentives are found to enhance investor confidence and improve the impact of green funding.

Keywords: Sustainable Development Goals, Green Finance, Triple Bottom Line (TBL), GMM

INTRODUCTION

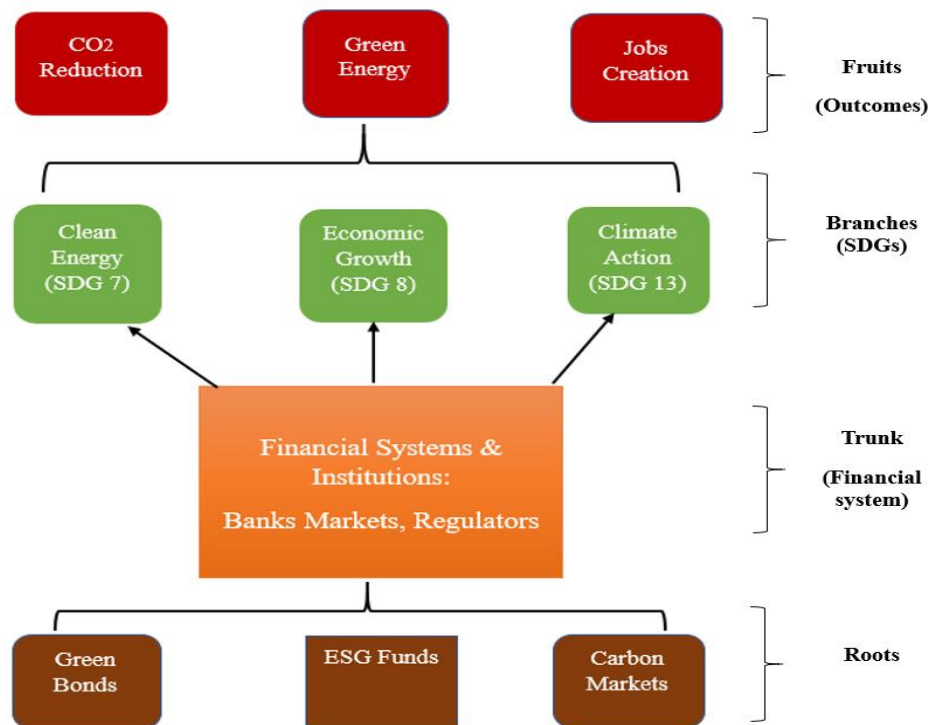
Planet Earth is facing serious sustainability challenges driven by industrial growth, environmental degradation, and rapid urbanization. The expansion of economic and industrial activities and increased dependence on fossil fuels accelerated deforestation, intensifying global warming and pollution (Shang et al., 2023). These pressures place immense strain on the ecosystem, leading to depletion of natural resources, loss of biodiversity, and a considerable rise in natural

disasters (Afzal et al., 2022). CO₂ emissions have risen sharply over recent decades. According to the World Bank, global CO₂ emissions increased from 20.6 million kt in 1990 to 37.4 billion t in 2023, an increase of about 70%. This sharp increase has significantly damaged our ecosystems worldwide (Ritchie, 2019). The atmospheric CO₂ level rose from 278 parts per million (ppm) at the start of industrial revolution to about 417 ppm today (Richard Betts et al., 2020), potentially reaching 560 ppm

by 2060, which would exacerbate severe weather events (Check, 2024). The Paris Agreement of December 2015 aims to limit global temperature rise to less than 2°C; ideally, below 1.5°C (Udeagha & Breitenbach, 2023; Udeagha & Muchapondwa, 2023a). These challenges have drawn considerable attention from the government, academics, and policymakers seeking effective strategies to mitigate potential threats (Udeagha & Ngepah, 2023). The United Nations (UN) endorsed the Sustainable Development Goals (SDGs) under the 2030 Agenda for Sustainable Development in 2015 to address global social, environmental, and economic challenges (Wang et al., 2025). These SDGs represent an innovative and emerging set of objectives, targets, and measurements designed to guide political strategies and goals for the next 15 years to combat global warming, poverty, and inequalities. The ultimate objective of these goals is to minimize pollution, environmental degradation, and scarcity of natural resources while meeting present needs without compromising the future generation to satisfy their own needs (Povitkina & Jagers, 2022). Additionally, these goals also focus on combating major global issues, like poverty, hunger, inequality, global warming, fostering inclusive economic growth, and international collaboration to achieve generalized well-being (Shahzad & Xu, 2024). In order to accomplish these goals, financial systems must be aligned with sustainability goals.

The green economy has emerged as the most recent strategy for achieving the SDGs, which has been made feasible by new technologies and advancements in the domain of green finance (Houssam et al., 2023). This strategy not only promotes economic and ecological balance but also encourages the green industry by accelerating the development of industrial structures to meet sustainable standards (Carraro et al., 2012). The United Nations Environment Programme has been collaborating with different nations, jurisdictions, financial economies, and regulators to regulate and control financial flows (banking, microcredit, insurance, and

investment) in such a way that encourages or promotes the achievement of the SDGs and integrates financial systems with the 2030 Sustainable Development Agenda (NOUREDDINE, 2022). The globalized economy depends heavily on financial markets and green investments, where investors and financial institutions distribute funds to other industries. By coordinating green finance with the SDGs, the UN aims to ensure investments that promote environmental preservation and sustainable development. The main objectives of green finance initiatives are supporting the public sector, encouraging public-private partnerships, and enhancing the microcredit capacity of community enterprises (UN Environment Programme, 2024). Financial tools such as green bonds, loans, and other financial instruments can be used to allocate funds and resources to initiatives that tackle ecological issues and climate crises. This demonstrates how green bonds encourage initiatives related to sustainability and climate change activities (Niyazbekova et al., 2021). Additionally, green finance, ESG bonds, and carbon-linked innovative instruments can assist in establishing a zero-carbon environment, social sustainability (SDG 1, 3, 4, 5, 10, 16), environmental sustainability (SDG 11, 12, 13, 15), and economic sustainability (SDG 8, 9, 17) are all strongly correlated with sustainable finance (Ziolo et al., 2021). Green finance emphasizes tackling climate change (SDG 13), clean energy (SDG 7) (Raman et al., 2025), and ensuring long-term economic growth (SDG 8) (Mohsin et al., 2021). It also addresses industrial innovation (SDG 9) and institutions for peace and justice (SDG 16) (Avik Sinha et al., 2021), good health (SDG 3), and responsible consumption (SDG 12) (Y. Liu et al., 2024). Moreover, green growth strategies foster economic development while minimizing harmful impacts on the ecosystem by improving resource efficiency, preserving biodiversity, and ensuring the continuous availability of environmental services essential for long term benefits (Hwang et al., 2024).



Green Finance Tree: Driving SDGs through Financial Instruments

Literature Reviews and Proposed Hypotheses

Green finance mobilizes capital for ecologically friendly initiatives and sustainable green projects (Chen et al., 2024), supports allocated to investments, projects, and initiatives prioritizing environmental sustainability. Green Finance aims to redirect capital flows into activities that contribute to the planet's health while delivering economic returns. Green finance primarily focuses on two major areas: the environment and finance. Its product has become well-known and has contributed to the delivery of high-quality development for several industries around the globe (Nenavath & Mishra, 2023). Numerous studies (Sinha et al., 2023; Sun et al., 2025; Walaa A. A. Ismael et al., 2024; Xiao et al., 2024) concluded that green finance is crucial for allocating funds for environmentally friendly endeavors, like renewable energy, energy transitions, sustainable infrastructure, and climate change initiatives, promoting environmental sustainability (Ibrahim et al., 2024), social inclusion, and economic growth. It facilitates green innovative technology, green micro-enterprises (Ronaldo & Suryanto, 2022), energy efficiency projects, and reduces carbon

emissions, contributing to sustainability (Rasoulinezhad & Taghizadeh, 2022). The short-term expansion of the green economy is facilitated by the efficient utilization of natural resources and the emergence of green financial systems, which promote green growth and long-term sustainability (Li et al., 2024). Furthermore, fintech collaboration with green finance greatly encourages the expansion of the green economy (Zhou et al., 2022), by enhancing environmental disclosure and creating protocols that boost green finance in the private sector (Nenavath & Mishra, 2023). Green digital finance drives SDGs progress by supporting energy transition policies, fostering financial inclusion, and promoting the upgrading of industrial structure (Xiao et al., 2024). Artificial intelligence-driven robo-advisors facilitate automated ESG-based investment solutions for financial institutions and investors, contributing to a more efficient and sustainable financing system (Fu et al., 2023). Policymakers should encourage a green economy by facilitating financial technologies, green loans, and green resources (K. Liu et al., 2024), implement carbon taxes to achieve sustainable development goals

(Feng & Li, 2024). Additionally, Green credit policies significantly influenced energy-intensive firms' capital investment, enhancing resource utilization efficiency and promoting low-carbon development (Cheng et al., 2021), accelerating corporate funding, and imposing credit limits on polluting firms (N. Ahmed et al., 2022). For long-term economic and environmental sustainability, it promotes the growth of micro-businesses, green technologies, and innovations (Ronaldo & Suryanto, 2022). The global commitment to carbon neutrality in 2060 involves international collaboration on green transitions, financial incentives, and boosting the government's sustainability role (Amin et al., 2025). Conversely, Green financing strategies may have long-term detrimental effects on environmental and social responsibilities (A. Sinha et al., 2021), due to a lack of a climate action plan and a financial gap (Hu et al., 2023), a weak private market, and inadequate financial infrastructure (Fatima et al., 2021; Hamid et al., 2022). Additionally, the European Investment Bank issued green bonds from 2015 to 2018 for eco-friendly initiatives but wasted them due to inappropriate fund allocation (Guo et al., 2023).

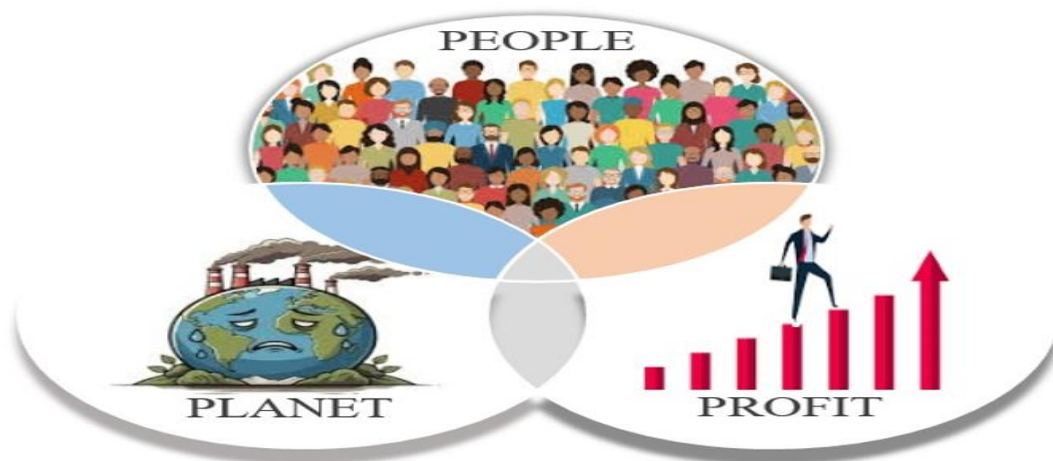
H1: Green Finance has a significant statistical impact on Sustainable Development Goals (SDGs)

Methodology:

Theoretical Model:

Global challenges like poverty, hunger, inequality, and climate change are growing and worsening frequently. Policy makers and regulators anticipated that different sustainable strategies would seek to promote a balance between the economy, environment, and society (Masood et al., 2023). An approach to comprehend the sustainable strategies is the "Triple Bottom Line," which was first used by Elkington in 1997 (Elkington, 1997). A sustainability approach that evaluates performance across three interconnected dimensions: people, planet, and profit (Jonker, 2023), to promote sustainable value creation. This approach underscores the importance of green activities that encourage organizations to integrate their social and environmental consideration into financial decision-making and benefit future generations (SWEET, 2024). Additionally, it also supports the achievement of Sustainable Development Goals by fostering green transitions and a holistic and integrated approach towards sustainable development.

3p's of Triple Bottom Line



- TBL emphasizes human well-being, which aligns with SDGs that support human rights, social equalities and growth.
- TBL focuses on improving environmental quality, which aligns with SDGs on ecosystem protection and combating degradation.
- TBL encourages economic viability, which aligns SDGs with economic growth and long-term innovative development.

Table 1: 3p's of Triple Bottom Line

<i>TBL pillars</i>	<i>Relation with SDGs</i>	<i>Connection with Green Finance</i>
People (Social Sustainability)	• No Poverty (SDG 1) • Good Health and Well-being (SDG 3) • Quality Education (SDG 4) • Gender Equality (SDG 5) • Decent Work & Economic Growth (SDG 8) • Reduced Inequalities (SDG 10)	• Financial Inclusion • Green Bonds
Planet (Environmental Sustainability)	• Clean Water and Sanitation (SDG 6) • Affordable and Clean Energy (SDG 7) • Responsible Consumption and Production (SDG 12) • Climate Actions (SDG 13) • Life Below Water (SDG 14) • Life on Land (SDG 15)	• Renewable Energy Projects • Green Loans • Climate Resilience
Profit (Economic Sustainability)	• Decent Work and Economic Growth (SDG 8) • Industry, Innovation and Infrastructure (SDG 9) • Sustainable Cities and Communities (SDG 11) • Partnership for the Goals (SDG 17)	• Sustainable Policies • Reducing Climate-Related Financial Risk

Statistical Tools

1: Ordinary least-squares (OLS)

$$Y_{it} = \alpha + \beta X_{it} + \epsilon_t$$

Ordinary least-squares (OLS) regression is a generalized linear modelling technique, which is used as a preliminary estimation method to determine the baseline relationship between one dependent variable and one or more independent variables.

2: Fixed Effect Model

$$Y_{it} = \alpha_i + \beta X_{it} + \epsilon_t$$

This method ensures that the estimated coefficients accurately reflect the influence of explanatory variables by adjusting for individual-specific characteristics that are constant over time that might bias the result of regression analysis.

3: Generalized Methods of Moments (GMM)

$$E[Z'(Y - X\beta)] = 0$$

This method helps to address potential biases in the estimation process. If there are endogenous regressors present in the model, this method

generates accurate and efficient estimates by using instrumental variables.

Econometric Model

$$SDGs_{it} = \alpha_{it} + \beta_1 GF_{it} + \beta_2 HDI_{it} + \beta_3 GDP_{it} + \beta_4 POP_{it} + \mu_{it} - - - (i)$$

This study aims to uncover the nexus between green finance and sustainable development goals (SDGs) in developed countries. Equation (i) reflects the econometric model, which has to be regressed to achieve the main purpose of the study. In this study, sustainable development goals are the dependent variable, whereas green finance is treated as the independent variable. Population, human development, and gross domestic product (GDP) are taken as control variables. This study utilized the secondary panel data for analysis, which was collected for 34 developed countries spanning the years 2000 to 2023, from different sources such as Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN), World Development Indicators (WDI), and United Nations Development Programme

(UNDP). Table 1, therefore, provides an inclusive presentation of the variables, their

measurement, and sources for the data collection.

Table 1: Description of Variables

<i>Variable</i>	<i>Measurement</i>	<i>Sources</i>	<i>References</i>
Sustainable Development Goals (SDGs)	SDG index	Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN)	(Sun et al., 2025)
Green Finance	Renewable energy consumption (% of total final energy consumption)	WDI	(Kanwal et al., 2023)
Human Development	Human Development Index	UNDP	(Kouton et al., 2024)
Gross Domestic Product	GDP per capita (current US\$)	WDI	(Sun et al., 2025)
Population	Population, total	WDI	(Sun et al., 2025)

Results and Discussion:

Table 2: Summary Statistics

<i>Variables</i>	<i>Obs</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
<i>SDG</i>	816	77.00067	3.595563	65.9955	86.41798
<i>GF</i>	816	19.06262	15.75808	0	82.9
<i>HDI</i>	816	0.8833002	0.050306	0.499	0.967
<i>GDP</i>	816	36200.58	23822.9	1621.262	133711.8
<i>POP</i>	816	6.977841	0.6869282	5.449023	8.524935

Table 2 highlights statistical information on all the variables used in the current study. SDG exhibits an average value of 77.00067, with a minimum of 65.9955 and a maximum value of 86.41798. The value of the standard deviation is 3.595563, showing very low variability. GF carries a significantly large variability, having a standard deviation of 15.75808, with a mean value of 19.06262, a minimum of 0, and a maximum of 82.9 values. HDI variability is very low (0.050306 standard deviation), ranging from

a minimum of 0.499 to a maximum value of 0.967, with a mean of 0.8833002. The mean value of GDP is 36200.58, with minimum and maximum values of 1621.262 and 133711.8, respectively. The standard deviation is 23822.9, indicating there is a high degree of variation. The mean value of POP is 6.977841, with a range of 5.449023 to 8.524935. There is low variation, as the value of standard deviation is 0.6869282.

Table 3: Pairwise Correlation

	<i>SDG</i>	<i>GF</i>	<i>HDI</i>	<i>POP</i>	<i>GDP</i>
<i>SDG</i>	1.0000				
<i>GF</i>	0.4330*	1.0000			
<i>HDI</i>	0.4991*	0.2538*	1.0000		
<i>POP</i>	0.1206*	-0.3940*	0.0887*	1.0000	
<i>GDP</i>	0.2391*	0.2038*	0.7392*	-0.0698*	1.0000

Table 3 represents the correlation between variables used to detect multicollinearity. The outcomes reveal that there is no multicollinearity since none of the correlations between variables are near 1.

Table 4: Variance Inflation Factor

<i>Variables</i>	<i>VIF</i>	<i>1/VIF</i>
<i>GF</i>	1.32	0.756992
<i>HDI</i>	2.48	0.403592
<i>GDP</i>	2.31	0.432889
<i>POP</i>	1.30	0.770515
<i>Mean VIF</i>	1.85	

Table 4 illustrates the outcomes of the variance inflation factor, indicating independent variables are sufficiently independent. All variables exhibit VIF values below the critical threshold of 5, with values ranging from 1.30 to 2.48, hence confirming the absence of multicollinearity in the model.

Table 5: Unit root tests

Levin-Lin-Chu (LLC) Test

	<i>t-statistic</i>	<i>p-value</i>
<i>SDG</i>	-6.8859	0.0000***
<i>GF</i>	-23.7336	0.0000***
<i>POP</i>	-18.6741	0.0000***
<i>HDI</i>	-13.7639	0.0000***
<i>GDP</i>	-17.4332	0.0000***

The Levin-Lin-Chu (LLC) test is used to determine a unit root in the data set. As the p-value is less than 0.05 and the value of t-statistics is extremely negative, the findings show that all variables are stationary. This means that the data set does not include a unit root, is stable in long-term behavior, and cannot drift randomly.

Table 6: Ordinary Least Squares (OLS)

<i>SDG</i>	<i>Coef.</i>	<i>Std. Err.</i>	<i>t</i>	<i>P> t/</i>	<i>[95% Conf.</i>	<i>Interval]</i>
<i>GF</i>	0.098639	0.006957	14.18	0.000***	0.0849831	0.112294
<i>HDI</i>	38.77097	2.98456	12.99	0.000***	32.9126	44.62935
<i>GDP</i>	-0.0000353	6.09e-06	-5.81	0.000***	-0.0000473	-0.000023
<i>POP</i>	1.185549	0.1581865	7.49	0.000***	0.8750462	1.496053
<i>_cons</i>	33.88069	2.389469	14.18	0.000***	29.19042	38.57096

Note: ***, **, * is for significant at 1%, 5% and 10%.

Table 7: Fixed Effect Model

<i>SDG</i>	<i>Coef.</i>	<i>Std. Err.</i>	<i>t</i>	<i>P> t/</i>	<i>[95% Conf.</i>	<i>Interval]</i>
<i>GF</i>	0.0871168	0.0066485	13.10	0.000***	0.0740659	0.1001677
<i>HDI</i>	28.99334	2.997091	9.67	0.000***	23.11011	34.87656
<i>GDP</i>	-0.0000328	5.86e-06	-5.60	0.000***	-0.0000443	-0.000021
<i>POP</i>	1.121416	0.1493957	7.51	0.000***	0.8281555	1.414677
<i>_cons</i>	43.09229	2.433785	17.71	0.000***	38.31482	47.86976

Note: ***, **, * is for significant at 1%, 5% and 10%.

The findings of the OLS and fixed effect model in tables 6 and 7 indicate that green finance (GF) has a positive and statistically significant impact on Sustainable Development Goals (SDGs). The estimated coefficient for green finance is 0.098639 in the OLS model and 0.0871168 in the fixed effect model, both significant at 1% level ($p=0.000***$). The OLS results show that a 1%

increase in green finance is associated with 9.8% increase in SDGs performance, while the outcomes of the fixed effect model indicate that 1% growth in green finance leads to 8.7% improvement in SDGs. These results highlight the substantial contribution of green finance towards the achievement of SDGs.

Table 8: Result of the Generalized Method of Moments (GMM)

<i>SDG</i>	<i>Coef.</i>	<i>Std. Err.</i>	<i>t</i>	<i>P> t/</i>	<i>[95% Conf.</i>	<i>Interval]</i>
<i>L1.</i>	0.0584189	0.0225744	2.59	0.010***	0.014174	0.1026639
<i>GF</i>	0.0473334	0.004741	9.98	0.000***	0.0380412	0.0566256
<i>HDI</i>	48.03029	2.394236	20.06	0.000***	43.33767	52.7229
<i>GDP</i>	-0.0000569	4.64e-06	-12.27	0.000***	-0.000066	-0.000047
<i>POP</i>	-1.00e-08	1.27e-09	-7.92	0.000***	-1.25e-08	-7.56e-09
<i>_cons</i>	31.64443	2.394468	13.22	0.000***	26.95136	36.3375

Note: ***, **, * is for significant at 1%, 5% and 10%.

The results of generalized methods of moments (GMM) are shown in Table 8, indicating that past

SDGs performance and green finance have significant positive effects on current SDGs

outcomes. The coefficient for lagged SDGs is 0.0584189 ($p = 0.000^{***}$), indicating that a one-unit increase in past SDGs performance results in a 5.8% rise in current SDGs performance. Green finance has a coefficient value 0.0473334 ($p = 0.000^{***}$), showing that a 1% rise in green finance is associated with a 4.7% increase in SDG performance.

Result of the study highlight that green finance makes a substantial and positive contribution to the achievement of SDGs across developed countries. Allocating funds for eco-friendly projects, like renewable energy, energy transitions, sustainable infrastructure, and climate change initiatives, is essential for fostering a sustainable environment (Ibrahim et al., 2024), social inclusion, and economic growth (Kwilinski et al., 2023; Sinha et al., 2023; Sun et al., 2025; Walaa A. A. Ismael et al., 2024; Xiao et al., 2024). Policymakers can further promote a green economy by facilitating financial technologies, green loans, and green resources (K. Liu et al., 2024). Implement carbon taxes to achieve sustainable development goals (Feng & Li, 2024). Additionally, Green credit policies have been shown to influence energy-intensive firms' capital investment, enhancing resource utilization efficiency and promoting low-carbon development (Cheng et al., 2021), accelerating corporate funding, and imposing credit limits on polluting firms (N. Ahmed et al., 2022). For long-term economic and environmental sustainability, it promotes the growth of micro-businesses, green technologies, and innovations (Ronaldo & Suryanto, 2022). However, green finance may also have a detrimental impact on the accomplishment of SDGs, due to a lack of a climate action plan and financial gap (Hu et al., 2023), a weak private market, and insufficient financial infrastructure (Fatima et al., 2021; Hamid et al., 2022). Green financing strategies could negatively impact environmental and social responsibilities in the long run (A. Sinha et al., 2021).

Conclusion

The study examines the influential role of green finance on sustainable development across developed nations. The result of the study disclosed that green finance plays an influential role in developed countries. The SDGs pertaining to environment and climate-related strategies

showed a high positive connection with green funding. Green bonds and sustainable investments are the tools that allocate funds and resources for ecologically advantageous projects like climate action, green energy initiatives, and eco-friendly manufacturing, as well as utilization. It also encourages renewable energy, sustainable infrastructure, and inclusive growth. Green finance is directly linked with SDG 13 (Climate Action), SDG 7 (Affordable and Clean Energy), and SDG 12 (Responsible Production and Consumption).

Building on these findings, the study highlights the broader policy and practical implications of strengthening green finance frameworks in developed economies. Effective regulatory environments, transparent disclosure standards, and well-developed financial markets enhance the efficiency with which green financial instruments channel capital toward sustainable projects. The results suggest that when governments and financial institutions actively support green bonds, sustainability-linked loans, and ESG-based investments, the impact on sustainable development outcomes becomes more pronounced. This alignment between financial systems and environmental objectives not only accelerates progress toward climate targets but also improves resource efficiency and long-term economic resilience. Furthermore, the study underscores the importance of integrating green finance into national development strategies to ensure sustained progress toward the SDGs. By fostering innovation, encouraging private sector participation, and promoting cross-border green investments, developed countries can serve as benchmarks for emerging and developing economies. The expansion of green finance can reduce environmental risks, enhance energy security, and support a transition toward low-carbon and circular economies. Overall, the findings reaffirm that green finance is not merely a financial mechanism but a strategic tool for achieving sustainable development, environmental stewardship, and inclusive long-term growth.

Recommendations

Governments should establish enabling regulations for small-scale renewable energy projects, provide concessional loans for SMEs, and mobilize climate finance through international mechanisms such as the Green Climate Fund

(GCF). Policy frameworks should also include tax incentives and subsidies to attract private sector participation. Strengthening public-private partnerships can accelerate investments in clean energy and sustainable infrastructure. Clear green finance taxonomies and disclosure standards are essential to ensure transparency and investor confidence. Capacity-building initiatives can improve SMEs' access to green financing. Continuous monitoring and evaluation are necessary to ensure alignment with sustainable development goals.

References

- Afzal, A., Rasoulinezhad, E., & Malik, Z. (2022). Green finance and sustainable development in Europe. *Economic research-Ekonomska istraživanja*, 35(1), 5150-5163.
- Ahmed, N., Areche, F. O., Sheikh, A. A., & Lahiani, A. (2022). Green finance and green energy nexus in ASEAN countries: A bootstrap panel causality test. *Energies*, 15(14), 5068.
- Amin, N., Sharif, A., Shabbir, M. S., & Pan, Y. (2025). Evaluating the Impact of Natural Resource Rents, R&D Expenditures, Green Finance and Energy Efficiency on Carbon Emissions in BRICS Economies: Greening the path to carbon neutrality in the post-COP 27 era. *Technology in Society*, 102826.
- Carraro, C., Favero, A., & Massetti, E. (2012). Investments and public finance in a green, low-carbon economy. *Energy Economics*, 34, S15-S28.
- Chen, J. M., Umair, M., & Hu, J. (2024). Green finance and renewable energy growth in developing nations: a GMM analysis. *Heliyon*, 10(13).
- Cheng, D., Shi, X., & Yu, J. (2021). The impact of green energy infrastructure on firm productivity: Evidence from the Three Gorges Project in China. *International Review of Economics & Finance*, 71, 385-406.
- Fatima, N., Li, Y., Ahmad, M., Jabeen, G., & Li, X. (2021). Factors influencing renewable energy generation development: a way to environmental sustainability. *Environmental Science and Pollution Research*, 28(37), 51714-51732.
- Feng, H., & Li, Y. (2024). The role of fintech, natural resources, environmental taxes, and urbanization on environmental sustainability: Evidence from the novel panel data approaches. *Resources Policy*, 92, 104970.
- Fu, C., Lu, L., & Pirabi, M. (2023). Advancing green finance: a review of sustainable development. *Digital Economy and Sustainable Development*, 1(1), 20.
- Elkington, J. (1997). The triple bottom line. *Environmental management: Readings and cases*, 2, 49-66.
- Guo, B., Wang, Y., Zhang, H., Liang, C., Feng, Y., & Hu, F. (2023). Impact of the digital economy on high-quality urban economic development: Evidence from Chinese cities. *Economic Modelling*, 120, 106194.
- Hamid, I., Alam, M. S., Kanwal, A., Jena, P. K., Murshed, M., & Alam, R. (2022). Decarbonization pathways: the roles of foreign direct investments, governance, democracy, economic growth, and renewable energy transition. *Environmental Science and Pollution Research*, 29(33), 49816-49831.
- Houssam, N., Ibrahim, D. M., Sucharita, S., El-Aasar, K. M., Esily, R. R., & Sethi, N. (2023). Assessing the role of the green economy on sustainable development in developing countries. *Heliyon*, 9(6).
- Hwang, Y. K., & Díez, Á. S. (2024). Renewable energy transition and green growth nexus in Latin America. *Renewable and Sustainable Energy Reviews*, 198, 114431.
- Hu, F., Qiu, L., Xiang, Y., Wei, S., Sun, H., Hu, H., & Zeng, M. (2023). Spatial network and driving factors of low-carbon patent applications in China from a public health perspective. *Frontiers in Public Health*, 11, 1121860.
- Ibrahim, A., Almasria, N. A., Almaqtari, F. A., Al-Kasasbeh, O., Alhatabat, Z., & Ershaid, D. (2024). The Impact of Green Finance, FinTech, and Digital Economy on Environmental Sustainability: Evidence from Advanced Panel Techniques. *International Journal of Energy Economics and Policy*, 14(6), 621-627.

- Jonker, A. (2023). What is the triple bottom line (TBL)?
<https://www.ibm.com/think/topics/triple-bottom-line>
- Kanwal, A., Khalid, S., & Alam, M. Z. (2023). Analyzing the Asymmetric Effects of Green Finance, Financial Development, and FDI on Environmental Sustainability: New Insights from Pakistan Based Non-Linear ARDL Approach. *iRASD Journal of Economics*, 5(3), 625-644.
- Kouton, J., Tuo, S. T., & Guilsou, E. W. (2024). Thresholds to sustainability: Globalization's impact on the institutional quality-ecological footprint nexus in Africa. *Science of the Total Environment*, 954, 176205.
- Li, J., Gu, X., Han, T., & Juan, C. (2024). Leveraging green finance and technological innovations for sustainable urban development: A comparative study of Chinese mega-cities. *Heliyon*, 10(5).
- Liu, K., Mahmoud, H. A., Liu, L., Halteh, K., Arnone, G., Shukurullaevich, N. K., & Alzoubi, H. M. (2024). RETRACTED: Exploring the Nexus between Fintech, natural resources, urbanization, and environmental sustainability in China: A QARDL study. In: Elsevier. Institute for Excellence in Education & Research
- Liu, Y., Dong, K., Wang, K., & Taghizadeh-Hesary, F. (2024). Moving towards a sustainable city: Can China's green finance policy lead to the sustainable development of cities? *Sustainable cities and society*, 102, 105242.
- Masood, T., Israr, A., Zubair, M., & Qazi, U. W. (2023). Assessing challenges to sustainability and resilience of energy supply chain in Pakistan: a developing economy from Triple Bottom Line and UN SDGs' perspective. *International Journal of Sustainable Energy*, 42(1), 268-288.
- Mohsin, M., Taghizadeh-Hesary, F., Panthamit, N., Anwar, S., Abbas, Q., & Vo, X. V. (2021). Developing low carbon finance index: evidence from developed and developing economies. *Finance Research Letters*, 43, 101520.
- Nenavath, S., & Mishra, S. (2023). Impact of green finance and fintech on sustainable economic growth: Empirical evidence from India. *Heliyon*, 9(5).
- Niyazbekova, S., Jazykbayeva, B., Mottaeva, A., Belousova, E., Suleimenova, B., & Zueva, A. (2021). The Growth of "Green" finance at the global level in the context of sustainable economic development. *E3S Web of Conferences*.
- NOUREDDINE, A. (2022). Green finance and the sustainable development goals: a review of some international experiences. In: *ASJP*. <https://www.asjp.cerist.dz/en/article/200>.
- Povitkina, M., & Jagers, S. C. (2022). Environmental commitments in different types of democracies: The role of liberal, social-liberal, and deliberative politics. *Global environmental change*, 74, 102523.
- Raman, R., Ray, S., Das, D., & Nedungadi, P. (2025). Innovations and barriers in sustainable and green finance for advancing sustainable development goals. *Frontiers in Environmental Science*, 12, 1513204.
- Rasoulinezhad, E., & Taghizadeh-Hesary, F. (2022). Role of green finance in improving energy efficiency and renewable energy development. *Energy efficiency*, 15(2), 14.
- Richard Betts, Jason Lowe, & Andrews, T. (2020). Just how sensitive is the climate to increased carbon dioxide? Scientists are narrowing in on the answer. <https://theconversation.com/just-how-sensitive-is-the-climate-to-increased-carbon-dioxide-scientists-are-narrowing-in-on-the-answer-143112>
- Ritchie, H. (2019). Who emits the most CO2 today? *Our World in Data*, 3.
- Shahzad, M. F., & Xu, S. (2024). Antecedents of international entrepreneurship and emerging technologies help to achieve sustainable development goals: Moderating role of global mindset. *Technological Forecasting and Social Change*, 209, 123831.
- Shang, M., Ma, Z., Su, Y., Shaheen, F., Khan, R., Mohd Tahir, L., Khalid Anser, M., & Zaman, K. (2023). Understanding the

- importance of sustainable ecological innovation in reducing carbon emissions: investigating the green energy demand, financial development, natural resource management, industrialisation, and urbanisation channels. *Economic research-Ekonomska istraživanja*, 36(2).
- Sinha, A., Ghosh, V., Hussain, N., Nguyen, D. K., & Das, N. (2023). Green financing of renewable energy generation: Capturing the role of exogenous moderation for ensuring sustainable development. *Energy Economics*, 126, 107021.
- Sinha, A., Mishra, S., Sharif, A., & Yarovaya, L. (2021). Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling. *Journal of Environmental Management*, 292, 112751.
- Sun, X., Meng, Z., Zhang, X., & Wu, J. (2025). The role of institutional quality in the nexus between green financing and sustainable development. *Research in International Business and Finance*, 73, 102531.
- SWEEP. (2024). https://www.sweep.net/insights/what-is-the-triple-bottom-line?utm_source=chatgpt.com
- Udeagha, M. C., & Breitenbach, M. C. (2023). Can fiscal decentralization be the route to the race to zero emissions in South Africa? Fresh policy insights from novel dynamic autoregressive distributed lag simulations approach. *Environmental Science and Pollution Research*, 30(16), 46446-46474.
- Udeagha, M. C., & Muchapondwa, E. (2023a). Achieving regional sustainability and carbon neutrality target in Brazil, Russia, India, China, and South Africa economies: Understanding the importance of fiscal decentralization, export diversification and environmental innovation. *Sustainable Development*, 31(4), 2620-2635.
- Udeagha, M. C., & Ngepah, N. (2023). The drivers of environmental sustainability in BRICS economies: do green finance and fintech matter? *World Development Sustainability*, 3, 100096.
- UN Environment Programme. (2024). <https://unep.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency/green-financing>
- Wala A. A. Ismael, Zakariya Yahya Algamal, & Abonazel, M. R. (2024). Exploring the Impact of Green Finance Initiatives on Sustainable Development Goals: A Cross-Country Analysis. *International Journal of Green Management and Business Studies*, 4.
- Wang, Y., Yu, Y., & Khan, A. (2025). Digital sustainability: Dimension exploration and scale development. *Acta Psychologica*, 256, 105028.
- Xiao, Y., Lin, M., & Wang, L. (2024). Impact of green digital finance on sustainable development: evidence from China's pilot zones. *Financial Innovation*, 10(1), 1-32.
- Zhou, G., Zhu, J., & Luo, S. (2022). The impact of fintech innovation on green growth in China: Mediating effect of green finance. *Ecological Economics*, 193, 107308.
- Ziolo, M., Bak, I., & Cheba, K. (2021). The role of sustainable finance in achieving sustainable development goals: Does it work? *Technological and Economic Development of Economy*, 27(1), 45-70.