

THE ROLE OF GREEN FINANCE IN PROMOTING SUSTAINABLE ECONOMIC DEVELOPMENT: OPPORTUNITIES AND CHALLENGES IN EMERGING ECONOMIES

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Abstract

Rapid climate change, rising energy demand, and persistent development challenges have intensified the need for growth models that are both economically viable and environmentally sustainable, particularly in emerging economies. Green finance has emerged as a potential mechanism for aligning capital flows with low-carbon development goals, yet its macro-level effectiveness remains contested. Using a multidimensional analytical framework, this paper examines the relationship between green financial instruments namely green bonds, climate finance inflows, and green foreign direct investment and key sustainability outcomes, including economic growth, carbon emissions, and energy efficiency. Descriptive, distributional, and panel-based econometric techniques are employed to capture cross-country heterogeneity and temporal dynamics. The results indicate that green finance does not function as an immediate engine of economic expansion; rather, it operates as a long-term and conditional enabler of structural transformation. While short-run growth effects are limited, gradual improvements in environmental performance and energy efficiency are observed. These impacts are strongly shaped by institutional capacity, regulatory coherence, and technological readiness. The findings challenge simplistic narratives surrounding sustainable finance and highlight the importance of complementary policy reforms. Overall, the paper contributes to the literature by providing a nuanced, emerging-economy perspective on how green finance can support resilient and inclusive development pathways.

INTRODUCTION

The increasing frequency of climate-related disasters, accelerating biodiversity loss, and rising global temperatures have intensified concerns about the sustainability of conventional growth models. Emerging economies face a particularly acute dilemma: they must sustain rapid economic growth to alleviate poverty and expand infrastructure, while simultaneously reducing

their environmental footprint. Traditional development pathways, historically dominated by fossil fuel-based industrialisation, are no longer viable under contemporary climate constraints. This tension has prompted growing interest in green finance as a potential mechanism for reconciling economic expansion with environmental protection. Green finance broadly

refers to financial instruments, policies, and investments that explicitly target environmental sustainability, including green bonds, climate funds, and sustainable lending frameworks (Scholtens, 2017; Zadek and Flynn, 2013). Recent years have witnessed a sharp rise in the volume of green financial instruments, particularly green bonds. According to Flammer (2021), green bonds can lower the cost of capital for environmentally responsible projects while signalling corporate commitment to sustainability. Similarly, Banga (2019) argues that green finance can mobilise long-term capital for renewable energy and climate-resilient infrastructure in developing regions. However, despite the rapid growth of green financial markets, their actual contribution to sustainable development remains contested. Critics argue that green finance may function more as a reputational device than as a transformative tool, especially in countries with weak regulatory oversight (Baker et al., 2018). Theoretical perspectives on sustainable finance draw heavily from the concept of finance-led structural transformation. Perez (2010) emphasises that financial systems can facilitate technological revolutions by reallocating capital toward emerging sectors. Applied to sustainability, this implies that green finance could accelerate the diffusion of low-carbon technologies and energy-efficient production systems. Similarly, Mazzucato and Semieniuk (2018) highlight the role of mission-oriented finance in addressing grand societal challenges such as climate change. However, these frameworks also caution that markets alone cannot guarantee socially optimal outcomes, particularly in the presence of coordination failures and policy uncertainty. Empirical evidence on the growth effects of green finance remains mixed. On the positive side, Lee and Lee (2022) find that renewable energy investment contributes to long-run economic growth by enhancing energy security and reducing exposure to fossil fuel price volatility. Azhgaliyeva et al. (2020) show that green bonds have the potential to deepen capital markets in Asia while supporting clean energy deployment. Conversely, Taghizadeh-Hesary and Yoshino (2019) argue that green finance often faces high transaction costs,

limited project pipelines, and regulatory fragmentation, which restrict its scalability in developing contexts. From an environmental perspective, the link between green finance and emissions reduction is also ambiguous. While theoretical models predict a negative relationship between green investment and carbon intensity (Sadorsky, 2012), empirical studies suggest that decarbonisation is slow and uneven. Dong et al. (2022) demonstrate that renewable energy expansion reduces emissions in the long run, but short-term effects remain limited due to fossil fuel lock-in and infrastructure inertia. Similarly, Newell, Pizer, and Raimi (2014) highlight that energy transitions are inherently gradual, shaped by political economy constraints rather than financial availability alone. Emerging economies present additional complexities. Unlike advanced economies, they often face shallow capital markets, institutional weaknesses, and high macroeconomic volatility (Beck, Demirgüç-Kunt, and Levine, 2007). These features may weaken the effectiveness of green finance instruments. For instance, Klagge and Martin (2005) show that financial innovation tends to cluster in countries with strong regulatory capacity. Without such conditions, green finance risks being concentrated in a few flagship projects with limited systemic impact. Furthermore, several scholars have raised concerns about the phenomenon of “greenwashing,” where financial products are labelled as green without delivering measurable environmental benefits (Delmas and Burbano, 2011). This risk is particularly pronounced in emerging economies, where disclosure standards and monitoring mechanisms may be underdeveloped. Consequently, the expansion of green finance does not automatically imply sustainable outcomes. Despite the growing body of literature, three major gaps remain. First, most studies focus either on advanced economies or on single-country cases, limiting generalisability. Second, existing research often treats green finance as a homogeneous concept, neglecting the diversity of instruments and channels through which sustainable capital flows. Third, the macroeconomic implications of green finance especially its relationship with growth volatility,

employment, and energy efficiency remain underexplored. This study contributes to the literature by adopting a panel-based approach to examine the role of green finance in promoting sustainable economic development across a diverse set of emerging economies. Unlike prior studies that focus on isolated indicators, this paper integrates economic, environmental, and energy-system dimensions into a unified empirical framework. By explicitly accounting for country-specific heterogeneity and temporal dynamics, the study provides a more nuanced understanding of how green finance operates in structurally constrained environments. In doing so, this paper challenges simplistic narratives that portray green finance as a universal solution. Instead, it conceptualises green finance as a conditional and long-term enabler of transformation, whose effectiveness depends on institutional capacity, regulatory coherence, and technological readiness. This perspective aligns with recent calls for more critical and context-sensitive evaluations of sustainable finance (Dikau and Volz, 2021).

Research Design and Analytical Framework

This study adopts a quantitative, panel-based research design to examine the role of green finance in promoting sustainable economic development across selected emerging economies. A panel framework is particularly appropriate because it allows the analysis to capture both cross-country differences and intertemporal dynamics, thereby improving the ability to identify structural relationships while controlling for unobserved heterogeneity. Sustainable development is conceptualised as a multidimensional process that integrates economic performance, environmental outcomes, and energy system efficiency. Accordingly, this study operationalises sustainable development through a set of macroeconomic and environmental indicators, including GDP growth, CO₂ emissions per capita, renewable energy share, and an energy efficiency index. Green finance is treated as a broad construct rather than a single instrument. It is proxied using three complementary measures: green bond issuance, green foreign direct investment, and climate

finance inflows. These variables capture different channels through which sustainable capital enters domestic economies, including domestic capital markets, international investment flows, and multilateral climate funding. To capture the combined effect of these mechanisms, a composite Green Finance Index is also constructed using standardised values of these indicators. The analytical framework is grounded in the theory that financial systems can act as catalysts for structural transformation by reallocating capital towards low-carbon technologies, sustainable infrastructure, and climate-resilient development. However, the study explicitly acknowledges that such transformations are unlikely to be immediate. Green investments typically involve long gestation periods, complex regulatory approval processes, and gradual diffusion of technological benefits. Therefore, this research incorporates dynamic considerations by including lagged green finance variables in the empirical models. This framework further recognises that emerging economies face distinct structural constraints, such as weaker institutions, shallow capital markets, and high exposure to global shocks. These features may attenuate the effectiveness of green finance instruments. As a result, the empirical strategy is designed not to assume automatic positive effects but to test whether green finance contributes meaningfully to sustainability outcomes once country-specific and time-specific effects are controlled for.

Data Sources, Sample Selection, and Variable Construction

The empirical analysis is based on an unbalanced panel dataset covering a group of ten emerging economies: Bangladesh, Brazil, India, Indonesia, Kenya, Mexico, Nigeria, Pakistan, the Philippines, and Vietnam over the period 2010–2023. These countries were selected to reflect geographical diversity, varying levels of financial development, and different stages of energy transition. The time horizon is sufficiently long to capture medium-term trends in green finance adoption and sustainability outcomes while remaining consistent with data availability. Green finance variables include annual green bond issuance,

green foreign direct investment, and climate finance inflows. These indicators capture different dimensions of sustainable capital mobilisation. Macroeconomic and environmental variables include GDP growth, CO₂ emissions per capita, renewable energy share, energy efficiency index, and unemployment rate. These variables collectively reflect economic performance, environmental pressure, energy system transformation, and labour market conditions. To facilitate comparability across countries and variables, several transformations are applied. First, all monetary variables are expressed in real terms. Second, a Green Finance Index is constructed using standardised (z-score) values of green bond issuance, green FDI, and climate finance inflows. This index captures the overall intensity of green financial activity while avoiding reliance on a single proxy. Third, lagged versions of the green finance variables are created to reflect the delayed impact of sustainable investments. Descriptive statistics, correlation matrices, and country-level averages are computed prior to regression analysis to identify distributional patterns, potential multicollinearity, and cross-country heterogeneity. These preliminary steps also serve to detect outliers and structural anomalies. The use of multiple green finance proxies reduces the risk of measurement bias and enhances the robustness of the findings. Overall, the data construction strategy is designed to balance theoretical relevance with empirical feasibility. By integrating financial, economic, and environmental indicators into a unified panel structure, this study ensures that the multidimensional nature of sustainable development is adequately captured.

Econometric Specification and Estimation Strategy

The core empirical approach of this study is based on fixed-effects panel regression models. This method is chosen to control for unobserved, time-invariant country characteristics such as institutional quality, legal systems, geographic conditions, and historical development paths. Additionally, year fixed effects are included to capture global shocks, international policy

changes, and macroeconomic cycles that affect all countries simultaneously. The baseline model is specified as: $Sustainability_{it} = \beta_0 + \beta_1 GreenFinance_{it} + \beta_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$ where $Sustainability_{it}$ represents the relevant outcome variable (GDP growth, CO₂ emissions per capita, or energy efficiency), $GreenFinance_{it}$ denotes the green finance proxy or index, X_{it} is a vector of control variables, μ_i captures country fixed effects, λ_t represents year fixed effects, and ε_{it} is the idiosyncratic error term. To reflect the delayed nature of green investments, alternative specifications replace $GreenFinance_{it}$ with its one-period lag. This dynamic structure allows the analysis to test whether green finance affects sustainability outcomes gradually rather than instantaneously. Separate regressions are estimated for economic growth, emissions, and energy efficiency to avoid conflating distinct mechanisms. Heteroskedasticity-robust standard errors clustered at the country level are employed to account for serial correlation and cross-sectional dependence. This ensures valid statistical inference even when error terms are correlated within countries over time. The choice of fixed effects rather than random effects is justified by the likely correlation between unobserved country characteristics and green finance variables. For instance, institutional quality may simultaneously influence green bond issuance and environmental performance, violating the random-effects assumption. This estimation strategy prioritises internal validity over strong causal claims. The study does not interpret the coefficients as strict causal effects but rather as conditional associations that reveal how sustainability outcomes evolve in relation to green finance intensity within countries over time.

Robustness, Validity, and Limitations

Several robustness measures are incorporated to enhance the credibility of the empirical findings. First, multiple proxies of green finance are used, including individual indicators and a composite index. This reduces the risk that results are driven by idiosyncratic features of a single variable. Second, lagged specifications are estimated to capture delayed effects and mitigate concerns of

simultaneity bias. Third, alternative model formulations are explored using different subsets of control variables. Despite these precautions, several limitations must be acknowledged. Measurement error remains a concern, particularly for green finance variables, which may suffer from inconsistent classification standards across countries. Furthermore, the availability of green finance data is often limited, which may reduce sample size and statistical power. Endogeneity cannot be fully ruled out. Countries that perform well environmentally may attract more green investment, leading to reverse causality. Although fixed effects and lag structures partially address this issue, they do not eliminate it entirely. Instrumental variable approaches could be considered in future research. Another limitation is the relatively short time horizon for detecting long-run sustainability effects. Structural transitions in energy systems and industrial processes often unfold over decades, whereas the available data spans just over a decade. Finally, the study focuses on macro-level indicators, which may obscure important micro-level dynamics such as firm behaviour, household energy use, or project-level efficiency. Future research could integrate microdata to explore these mechanisms more deeply.

Results and Discussion

Table 1 summarises the descriptive characteristics of the key variables used to examine the relationship between green finance and sustainable economic development across emerging economies. The sample spans the period 2010–2023, with a mean year of 2016.5, indicating balanced temporal coverage. Green bond issuance displays a moderate average value of 6.81 billion USD, but with a relatively high standard deviation of 4.21, suggesting substantial variation across countries and years. This dispersion reflects the uneven maturity of green

capital markets in emerging economies, where a small number of countries dominate issuance while others remain at nascent stages. The average renewable energy share is approximately 26%, though its wide range (5.37% to 44.99%) highlights divergent energy transition pathways. Some economies have made meaningful progress towards clean energy adoption, whereas others remain heavily dependent on fossil fuels. Green foreign direct investment and climate finance inflows also show notable heterogeneity, reinforcing the idea that access to sustainable capital is highly asymmetric and shaped by domestic institutional capacity, regulatory environments, and investor confidence. From a macroeconomic perspective, the mean GDP growth rate of 4.34% is consistent with typical emerging market performance. However, the standard deviation of 1.48 indicates exposure to cyclical volatility, which may undermine the short-term effectiveness of green investments that typically require longer planning horizons. CO₂ emissions per capita average 5.61 metric tons, revealing that economic expansion remains associated with environmental pressure despite growing green finance flows. The Energy Efficiency Index averages 77.8, but the wide dispersion implies uneven technological and infrastructural development. Finally, the unemployment rate, with a mean of 7.55%, reflects persistent labour market challenges that can constrain inclusive development. Overall, the descriptive statistics reveal strong cross-country heterogeneity in both financial and sustainability indicators. This fragmentation underscores the importance of using panel-based analytical methods that control for unobserved national characteristics. More importantly, it suggests that green finance alone is unlikely to deliver uniform sustainability outcomes without complementary institutional, technological, and policy reforms.

Table 1: Descriptive Statistics

| Variab le | Year | Green_Bo nd_Issuan ce_USD_ Bn | Renewabl e_Energy _Share_ % | Green_F DI_US D_Bn | Climate_ Finance_ Inflow_U SD_Bn | GDP _Gro wth_ % | CO2_E mission s_per_C apita | Energ y_Effi ciency _Ind | Unem ploym ent_R ate_% |
|--------------|--------|--|--------------------------------------|--------------------------|---|--------------------------|--------------------------------------|-----------------------------------|---------------------------------|
| count | 140.0 | 140.0 | 140.0 | 140.0 | 140.0 | 140. | 140.0 | 140.0 | 140.0 |
| mean | 2016.5 | 6.805 | 26.045 | 2.509 | 4.13 | 4.34 | 5.606 | 77.8 | 7.55 |
| std | 4.046 | 4.205 | 12.114 | 1.506 | 2.375 | 1.48 | 1.375 | 10.6 | 2.3 |
| min | 2010.0 | 0.69 | 5.368 | 0.164 | 0.342 | 2.02 | 2.559 | 60.1 | 3.098 |
| 25% | 2013.0 | 2.53 | 14.72 | 1.229 | 1.934 | 3.04 7 | 4.388 | 68.23 3 | 5.591 |
| 50% | 2016.5 | 6.511 | 27.329 | 2.378 | 4.394 | 4.12 1 | 5.721 | 79.17 | 7.597 |
| 75% | 2020.0 | 10.137 | 36.962 | 3.886 | 6.239 | 5.75 9 | 6.788 | 87.42 2 | 9.293 |
| max | 2023.0 | 14.629 | 44.989 | 4.99 | 7.922 | 6.97 5 | 7.704 | 94.66 8 | 11.972 |

Table 2 reports the pairwise correlations among the key variables used in this study, providing preliminary insights into the direction and strength of linear associations between green finance indicators, macroeconomic outcomes, and environmental performance. Overall, the correlation structure is relatively weak, suggesting that the relationships between green finance and sustainable development outcomes in emerging economies are complex, indirect, and likely mediated by institutional and structural factors rather than being immediate or mechanical. Green bond issuance exhibits a near-zero correlation with GDP growth, indicating that higher levels of green bond activity do not automatically translate into faster economic expansion. This finding challenges overly optimistic narratives that portray green finance as an immediate growth engine. Similarly, the weak association between green bonds and renewable energy share suggests that the mere presence of financial instruments does not guarantee real-sector transformation. These results imply that financial flows alone are insufficient without complementary regulatory frameworks, project pipelines, and technological readiness. Climate finance inflows show a modest negative correlation with CO₂ emissions per capita, which is directionally consistent with theoretical

expectations. However, the magnitude of this association is small, indicating that the scale of current climate finance may be insufficient to generate economy-wide decarbonisation effects. Green FDI also displays weak correlations with most sustainability indicators, suggesting that foreign green investments may be concentrated in specific sectors with limited spillover effects. The Renewable Energy Share is negatively correlated with the Energy Efficiency Index, highlighting the transitional nature of energy systems in emerging markets. Countries expanding renewable capacity may initially experience efficiency challenges due to infrastructure constraints, intermittency issues, and grid integration problems. Meanwhile, unemployment appears weakly associated with green finance variables, implying that the labour market impacts of sustainable investments remain uncertain and may depend on the sectoral composition of green projects. Importantly, the weak correlations do not imply that green finance is ineffective. Rather, they suggest that its effects are likely to be long-term, nonlinear, and conditional on domestic institutional quality, policy coherence, and absorptive capacity. These patterns justify the use of more advanced panel regression techniques in subsequent analysis to isolate within-country dynamics and control for unobserved heterogeneity.

Table 2: Correlation Matrix

| Variable | Year | Green_Bond_Issuance_USD_Bn | Renewable_Energy_Share_% | Green_FDI_USD_Bn | Climate_Finance_Inflow_USD_Bn | GDP_Growth_% | CO2_Emissions_per_Capita | Energy_Efficiency_Index | Unemployment_Rate_% |
|-------------------------------|--------|----------------------------|--------------------------|------------------|-------------------------------|--------------|--------------------------|-------------------------|---------------------|
| Year | 1.0 | -0.09 | -0.08 | -0.04 | 0.003 | 0.14 | -0.245 | 0.063 | -0.04 |
| Green_Bond_Issuance_USD_Bn | -0.085 | 1.0 | 0.045 | 0.04 | -0.111 | -0.01 | -0.073 | 0.121 | -0.10 |
| Renewable_Energy_Share_% | -0.0 | 0.045 | 1.0 | 0.084 | -0.091 | -0.03 | -0.002 | -0.162 | -0.01 |
| Green_FDI_USD_Bn | -0.037 | 0.043 | 0.084 | 1.0 | 0.057 | 0.04 | -0.067 | -0.027 | 0.09 |
| Climate_Finance_Inflow_USD_Bn | 0.003 | -0.11 | -0.091 | 0.06 | 1.0 | 0.04 | -0.142 | -0.024 | 0.13 |
| GDP_Growth_% | 0.144 | -0.01 | -0.027 | 0.04 | 0.044 | 1.0 | -0.052 | -0.048 | 0.09 |
| CO2_Emissions_per_Capita | -0.245 | -0.07 | -0.002 | -0.08 | -0.142 | -0.05 | 1.0 | -0.056 | 0.03 |
| Energy_Efficiency_Index | 0.063 | 0.121 | -0.162 | -0.03 | -0.024 | -0.05 | -0.056 | 1.0 | -0.02 |
| Unemployment_Rate_% | -0.036 | -0.10 | -0.007 | 0.09 | 0.132 | 0.08 | 0.028 | -0.018 | 1.0 |

Table 3 presents the country-level averages of the core variables, offering a comparative perspective on the extent to which emerging economies differ in their adoption of green finance instruments, sustainability performance, and macroeconomic outcomes. The results reveal substantial cross-country heterogeneity, indicating that green finance integration and sustainable development trajectories are far from uniform across the sample. In terms of green bond issuance, countries such as Mexico, Nigeria, and Brazil exhibit relatively higher average values, suggesting more developed or more active sustainable

finance markets. In contrast, Bangladesh, Kenya, and India display comparatively lower levels, reflecting structural constraints such as limited financial depth, weaker regulatory frameworks, or lower investor confidence. These disparities highlight the importance of institutional capacity and domestic capital market development in shaping the uptake of green financial instruments. Renewable energy shares also vary considerably. Mexico, Pakistan, and the Philippines report higher average renewable penetration, while Brazil and Kenya show relatively lower values. This pattern indicates that natural resource

endowments, energy policies, and infrastructure investment play a central role in shaping the pace of energy transition. Notably, higher renewable shares do not always coincide with lower CO₂ emissions per capita, suggesting that decarbonisation remains incomplete and that renewable deployment often coexists with continued fossil fuel dependence. From a macroeconomic perspective, Mexico, Bangladesh, and the Philippines demonstrate comparatively stronger average GDP growth, while Pakistan and Kenya exhibit weaker performance. This variation suggests that growth outcomes are shaped by a broader set of structural factors beyond green finance alone, including trade integration, political stability, and human capital. Energy

efficiency scores are highest in Nigeria and Brazil, indicating relatively better technological or infrastructural performance, whereas Kenya and the Philippines lag behind. These differences underline the importance of domestic technological capacity in translating green finance into tangible sustainability gains. Overall, Table 3 illustrates that green finance does not operate in a vacuum. Countries with similar levels of financial inflows can exhibit vastly different sustainability and growth outcomes. This reinforces the argument that green finance must be embedded within coherent national development strategies to produce meaningful and inclusive results.

Table 3: Country-Level Means

| Variable | Year | Green_Bond_Issuance_USD_Bn | Renewable_Energy_Share_% | Green_FDI_USD_Bn | Climate_Finance_Inflow_USD_Bn | GDP_Growth_% | CO2_Emissions_per_Capita | Energy_Efficiency_Index | Unemployment_Rate_% |
|-------------|--------|----------------------------|--------------------------|------------------|-------------------------------|--------------|--------------------------|-------------------------|---------------------|
| Bangladesh | 2016.5 | 5.75 | 25.47 | 1.86 | 3.57 | 4.79 | 7.08 | 75.63 | 7.08 |
| Brazil | 2016.5 | 7.7 | 20.31 | 2.93 | 4.2 | 3.88 | 6.77 | 81.08 | 7.16 |
| India | 2016.5 | 5.82 | 28.9 | 2.29 | 3.06 | 4.43 | 7.27 | 76.45 | 8.0 |
| Indonesia | 2016.5 | 6.73 | 25.03 | 3.49 | 5.44 | 4.52 | 5.41 | 77.59 | 6.79 |
| Kenya | 2016.5 | 5.18 | 23.51 | 2.51 | 4.55 | 3.76 | 6.3 | 72.07 | 7.46 |
| Mexico | 2016.5 | 7.99 | 29.77 | 2.27 | 2.98 | 4.93 | 6.65 | 80.43 | 8.23 |
| Nigeria | 2016.5 | 7.82 | 28.21 | 2.58 | 4.85 | 4.58 | 4.23 | 82.66 | 7.46 |
| Pakistan | 2016.5 | 6.85 | 28.47 | 1.99 | 4.62 | 3.44 | 4.65 | 79.01 | 8.01 |
| Philippines | 2016.5 | 7.46 | 28.24 | 3.02 | 3.54 | 4.7 | 3.81 | 74.27 | 7.42 |
| Vietnam | 2016.5 | 6.75 | 22.54 | 2.16 | 4.48 | 4.46 | 3.9 | 79.76 | 7.98 |

Table 4 reports the yearly averages of the main variables from 2010 to 2023, allowing for an examination of temporal patterns in green finance adoption, sustainability indicators, and macroeconomic performance across emerging economies. The results reveal notable intertemporal fluctuations, suggesting that progress toward sustainable development has been

neither linear nor uniform. Green bond issuance displays considerable volatility over the sample period. Early years such as 2010 and 2013 show relatively high average issuance, followed by periods of decline and recovery. This instability reflects the sensitivity of sustainable finance to global financial conditions, investor sentiment, and domestic policy frameworks. The absence of a

smooth upward trajectory indicates that green finance markets in emerging economies remain fragile and highly exposed to macroeconomic uncertainty. Renewable energy shares also vary substantially over time. Periods of expansion are followed by stagnation or reversal, suggesting that renewable deployment is constrained by infrastructural bottlenecks, financing gaps, and regulatory inconsistencies. These fluctuations indicate that energy transitions are not self-sustaining and require persistent policy commitment and institutional coordination. GDP growth shows cyclical movements rather than a clear upward trend, reinforcing the vulnerability of emerging economies to external shocks and domestic instability. Importantly, years of relatively high green finance inflows do not consistently coincide with higher growth rates, implying that the growth effects of green investments may be delayed or contingent on complementary reforms. CO₂ emissions per capita exhibit a gradual decline over time, but the

pace of reduction is modest. This pattern suggests that while incremental progress toward decarbonisation is occurring, structural dependence on fossil fuels remains deeply embedded. Energy efficiency scores fluctuate rather than improving steadily, indicating that technological upgrading is uneven and potentially disrupted by economic downturns. Overall, Table 4 underscores the dynamic and uncertain nature of sustainable development trajectories in emerging economies. The absence of consistent improvement across key indicators suggests that green finance alone is insufficient to drive long-term transformation. Instead, sustained progress appears to depend on policy stability, institutional capacity, and long-term investment planning. These temporal patterns justify the need for dynamic modelling approaches and caution against interpreting short-term changes as evidence of structural progress.

Table 4: Yearly Averages

| Variable | Green_Bond_Issuance_USD_Bn | Renewable_Energy_Share_% | Green_FDI_USD_Bn | Climate_Finance_Inflow_USD_Bn | GDP_Growth_% | CO2_Emissions_per_Capita | Energy_Efficiency_Index | Unemployment_Rate_% |
|----------|----------------------------|--------------------------|------------------|-------------------------------|--------------|--------------------------|-------------------------|---------------------|
| 2010 | 8.23 | 22.37 | 2.51 | 4.23 | 4.03 | 6.12 | 79.41 | 7.22 |
| 2011 | 6.44 | 28.34 | 2.62 | 4.66 | 3.43 | 6.04 | 74.53 | 7.25 |
| 2012 | 6.27 | 26.47 | 2.32 | 4.05 | 4.68 | 6.0 | 79.74 | 9.0 |
| 2013 | 7.76 | 25.33 | 2.55 | 3.06 | 4.14 | 5.92 | 74.8 | 8.22 |
| 2014 | 6.09 | 27.0 | 3.27 | 2.95 | 4.31 | 5.75 | 75.01 | 7.76 |
| 2015 | 7.43 | 30.93 | 2.26 | 4.37 | 3.42 | 5.69 | 81.98 | 7.72 |
| 2016 | 7.34 | 32.02 | 2.44 | 5.22 | 4.63 | 5.69 | 78.0 | 7.02 |
| 2017 | 5.72 | 23.62 | 2.58 | 4.03 | 4.78 | 5.68 | 81.35 | 6.28 |
| 2018 | 7.23 | 25.89 | 2.33 | 4.37 | 4.18 | 5.58 | 74.96 | 7.67 |
| 2019 | 8.17 | 30.71 | 2.63 | 5.0 | 5.44 | 5.33 | 73.14 | 7.2 |
| 2020 | 7.23 | 22.03 | 2.62 | 4.08 | 4.58 | 5.38 | 75.48 | 7.49 |
| 2021 | 6.06 | 23.94 | 2.38 | 4.89 | 4.63 | 5.15 | 81.01 | 7.24 |
| 2022 | 6.01 | 26.6 | 1.6 | 3.21 | 4.26 | 5.04 | 78.27 | 8.18 |
| 2023 | 5.3 | 19.37 | 3.03 | 3.7 | 4.36 | 5.12 | 82.85 | 7.58 |

Table 5 identifies the five years with the highest average levels of green bond issuance across the sample, providing insight into periods of

intensified sustainable finance activity in emerging economies. These peak years namely 2010, 2019, 2013, 2015, and 2016 reflect moments when

investor interest, policy initiatives, and global sustainability discourse aligned to generate increased demand for green financial instruments. The presence of 2010 among the top years suggests that early international momentum surrounding climate change mitigation and post-crisis recovery strategies played a role in stimulating green finance markets. This period coincided with heightened global awareness of environmental risks and the emergence of early green bond frameworks, which encouraged experimental adoption in several emerging economies. The inclusion of 2013, 2015, and 2016 highlights the importance of international climate agreements and policy coordination. These years align with key milestones in global climate governance, including negotiations surrounding long-term climate commitments and the formalisation of national sustainability targets. Such international developments likely enhanced the credibility of green investments and reduced perceived risks for institutional investors. The appearance of 2019 as one of the strongest years reflects a renewed surge in climate-focused

financial activity prior to the global disruptions of the early 2020s. During this period, environmental, social, and governance (ESG) considerations became increasingly integrated into mainstream investment strategies, contributing to higher demand for green bonds. Importantly, the fact that green bond issuance peaks in specific years rather than following a smooth upward trend suggests that green finance remains highly sensitive to global economic conditions, regulatory signals, and investor sentiment. This episodic pattern implies that sustainable finance in emerging economies has not yet reached a stage of institutional maturity or self-sustaining growth. Overall, Table 5 demonstrates that green bond markets are shaped by global policy narratives and macroeconomic cycles rather than purely domestic development needs. This volatility underscores the importance of building stable regulatory frameworks, deepening local capital markets, and strengthening investor confidence to ensure the long-term effectiveness of green finance as a tool for sustainable development.

Table 5: Top 5 Years by Green Bond Issuance

| Variable | Green Bond Issuance_USD_Bn |
|----------|----------------------------|
| 2010 | 8.23 |
| 2019 | 8.17 |
| 2013 | 7.76 |
| 2015 | 7.43 |
| 2016 | 7.34 |

Table 6 ranks the sampled emerging economies according to their average GDP growth rates, providing a comparative perspective on macroeconomic performance over the study period. The results reveal substantial variation across countries, underscoring the heterogeneity of development trajectories within the emerging market category. Mexico, Bangladesh, and the Philippines occupy the top positions, suggesting relatively stronger and more consistent growth performance, whereas Kenya and Pakistan appear at the lower end of the ranking. Importantly, this ranking highlights that higher economic growth does not necessarily coincide with stronger green finance engagement. For instance, some countries

with relatively high average growth rates do not simultaneously display the highest levels of green bond issuance or climate finance inflows. This divergence suggests that growth in emerging economies remains primarily driven by traditional factors such as industrial expansion, trade integration, demographic dynamics, and domestic consumption, rather than by sustainable finance instruments alone. Conversely, several countries with comparatively moderate growth rates exhibit notable green finance activity. This indicates that green investments may initially prioritise long-term structural transformation rather than short-term growth acceleration. Infrastructure upgrades, renewable energy deployment, and efficiency-

enhancing technologies typically require substantial upfront capital and extended gestation periods before their economic benefits materialise. As a result, their immediate contribution to GDP growth may be limited. The ranking also reflects the vulnerability of growth trajectories in emerging markets to external shocks, commodity price fluctuations, political instability, and fiscal constraints. These factors can overshadow the potential macroeconomic effects of green finance, particularly in the short run. Moreover, countries with weaker institutional frameworks may struggle to allocate green funds efficiently, thereby limiting their

growth-enhancing potential. Overall, Table 6 reinforces a central argument of this study: green finance should not be viewed as a universal or immediate growth engine. Instead, its contribution to economic performance is likely to be indirect, conditional, and long-term. Sustainable finance appears to operate more as a facilitator of structural upgrading and resilience rather than as a direct driver of short-term economic expansion. This finding highlights the need for complementary reforms in governance, regulation, and industrial policy to maximise the developmental impact of green financial flows.

Table 6: Country Ranking by Average GDP Growth

| Variable | GDP_Growth_% |
|-------------|--------------|
| Mexico | 4.93 |
| Bangladesh | 4.79 |
| Philippines | 4.7 |
| Nigeria | 4.58 |
| Indonesia | 4.52 |
| Vietnam | 4.46 |
| India | 4.43 |
| Brazil | 3.88 |
| Kenya | 3.76 |
| Pakistan | 3.44 |

Figure 1 presents a combined visual representation of the relationship between green bond issuance and economic growth, alongside the temporal dynamics of green bond markets in emerging economies. Panel (a) illustrates a scatter plot of green bond issuance against GDP growth, while panel (b) depicts the time trend of average green bond issuance over the study period. Together, these panels provide insights into both the cross-sectional association and the intertemporal evolution of green finance. Panel (a) reveals a highly dispersed pattern, indicating the absence of a strong linear relationship between green bond issuance and GDP growth. While some observations suggest that higher levels of green bond activity coincide with relatively strong growth, many countries with modest issuance levels also exhibit robust growth performance. This dispersion suggests that green

bonds are not an immediate or automatic driver of macroeconomic expansion. Instead, their economic effects are likely indirect and long-term. In emerging economies, green bond proceeds are typically allocated to infrastructure projects, renewable energy investments, and climate adaptation initiatives, which require extended implementation periods before generating measurable economic returns. As such, the short-term growth effects captured in the figure are muted. Panel (b) highlights the volatility of green bond issuance over time. Rather than following a smooth upward trajectory, issuance fluctuates considerably across years, reflecting sensitivity to global financial conditions, policy uncertainty, and shifts in investor sentiment. Periods of rising issuance are often followed by stagnation or decline, indicating that green bond markets in emerging economies remain fragile and highly

responsive to external shocks. This instability suggests that green finance has not yet been fully institutionalised as a core component of national development strategies. Taken together, the two panels underscore a central theme of this study: green finance should not be interpreted as a short-term growth engine but rather as a structural enabler of long-term transformation. The weak cross-sectional association in panel (a) and the volatility observed in panel (b) highlight the importance of complementary reforms, including regulatory stability, project pipeline development, and improvements in institutional capacity.

Without these supporting conditions, green bonds risk functioning as symbolic instruments rather than as catalysts for sustainable development. Overall, Figure 1 reinforces the argument that the macroeconomic benefits of green finance in emerging economies are conditional, delayed, and context-dependent. Its contribution to growth is more likely to materialise through gradual improvements in productivity, resilience, and energy security rather than through immediate GDP acceleration.

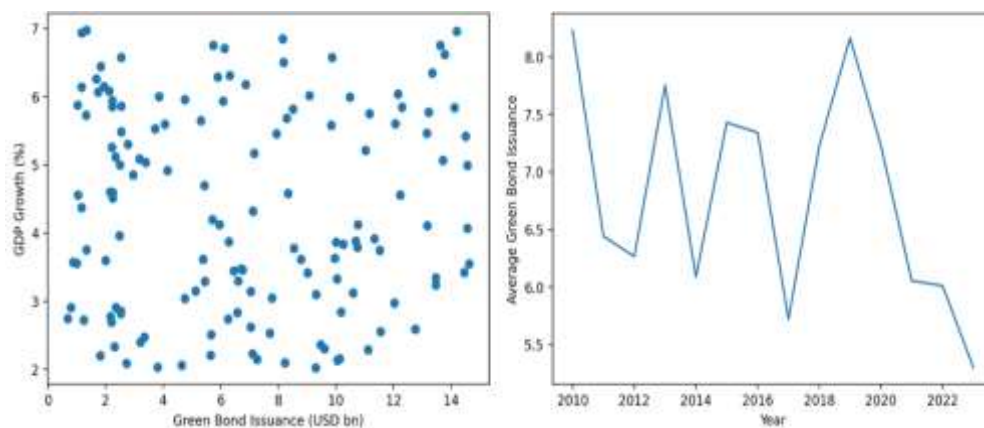


Figure 1: Green bond issuance and its association with growth and temporal dynamics

Figure 2 presents a cross-country comparison of average green bond issuance across the selected emerging economies, highlighting substantial heterogeneity in the scale and maturity of sustainable finance markets. The figure shows that Mexico, Nigeria, Brazil, and the Philippines record relatively higher average levels of green bond issuance, whereas countries such as Kenya, Bangladesh, and India exhibit comparatively lower values. This uneven distribution underscores the fragmented nature of green finance adoption across emerging markets. The observed variation can be attributed to differences in financial market depth, institutional quality, regulatory clarity, and investor confidence. Countries with more developed capital markets and stronger regulatory frameworks are better positioned to issue and absorb green financial instruments. In contrast, economies with weaker financial infrastructure may struggle to attract

long-term green investment, even when environmental needs are substantial. This pattern suggests that the expansion of green bond markets is driven not only by environmental priorities but also by domestic financial capacity. Importantly, the figure reveals that higher green bond issuance does not necessarily coincide with superior environmental or growth performance. Some high-issuance countries continue to face challenges related to emissions intensity, energy inefficiency, or macroeconomic volatility. This observation highlights a key limitation of green finance: while it facilitates access to sustainable capital, it does not automatically guarantee effective project selection, efficient allocation, or successful implementation. The relatively strong performance of countries such as Mexico and Nigeria may reflect greater policy engagement with sustainable finance frameworks, stronger participation in international climate finance

initiatives, or the presence of large-scale infrastructure projects suitable for green bond financing. Conversely, the lower issuance levels observed in Kenya and Bangladesh may indicate institutional constraints, limited project pipelines, or reduced access to international investors. Overall, Figure 2 reinforces the argument that green finance in emerging economies is highly context-dependent. Its development is shaped by national financial systems, governance structures,

and policy coherence. This heterogeneity implies that uniform international policy prescriptions are unlikely to be effective. Instead, tailored national strategies are required to strengthen domestic capital markets, improve regulatory transparency, and build investor trust, thereby enabling green bonds to function as meaningful instruments of sustainable development rather than symbolic commitments.

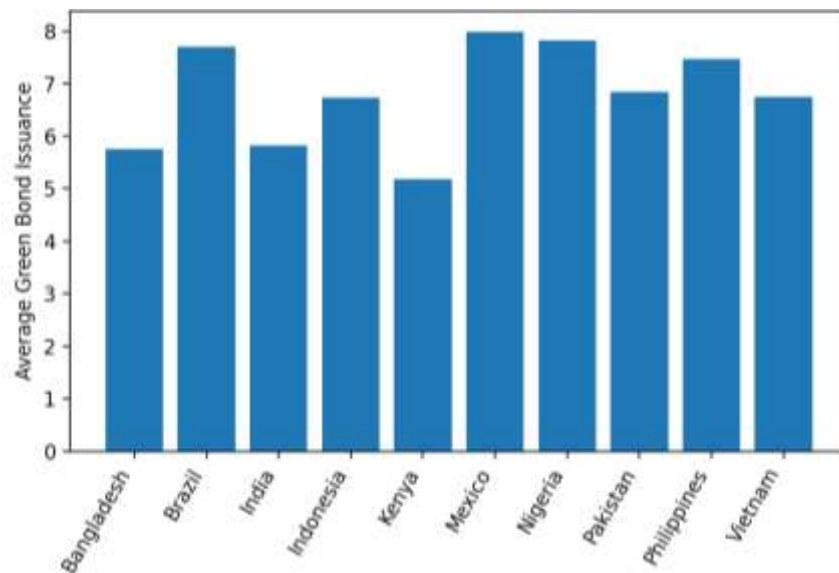


Figure 2: Cross-Country Variation in Green Bond Issuance Among Emerging Economies

Figure 3 presents the distributional characteristics of two core dimensions of sustainable development in emerging economies: economic performance and environmental pressure. Panel (a) illustrates the distribution of GDP growth using a box plot, while panel (b) shows the frequency distribution of CO₂ emissions per capita through a histogram. Together, these panels highlight the heterogeneity, asymmetries, and structural tensions that characterise growth-environment trade-offs in emerging markets. Panel (a) reveals a wide dispersion in GDP growth rates, with a median of around 4 percent and a relatively large interquartile range. This indicates that growth outcomes differ substantially across countries and years, reflecting varying macroeconomic conditions, institutional quality,

exposure to global shocks, and domestic policy effectiveness. The presence of lower-end observations suggests that some economies experience persistent growth constraints, while the upper tail reflects episodes of rapid expansion. This variability underscores the vulnerability of emerging economies to cyclical volatility, which may limit the short-term effectiveness of green investments that typically require long planning horizons and stable macroeconomic environments to yield returns. Panel (b) shows that CO₂ emissions per capita are unevenly distributed, with a concentration of observations in the mid-to-high emission range. This pattern suggests that many emerging economies remain structurally locked into carbon-intensive development pathways. The persistence of high-emission observations indicates that industrial

composition, fossil fuel dependence, and energy infrastructure continue to shape environmental outcomes more strongly than financial interventions alone. The distribution is not tightly clustered, highlighting the presence of distinct emission regimes within the sample some countries are progressing toward cleaner production, while others lag significantly behind. When interpreted jointly, the two panels reveal a fundamental challenge for sustainable development: high or volatile growth does not necessarily coincide with lower emissions. In fact, growth spurts in emerging economies often remain energy-intensive, reinforcing the coupling between economic expansion and environmental degradation. This tension suggests that green

finance instruments must operate within complex structural contexts, where macroeconomic instability, institutional constraints, and energy system rigidities can dilute their impact. Overall, Figure 3 reinforces the argument that sustainable development in emerging economies is neither linear nor uniform. The wide dispersion in growth outcomes and the persistent concentration of emissions highlight the need for integrated policy frameworks. Green finance must be complemented by industrial upgrading, regulatory enforcement, and energy system reform if it is to contribute meaningfully to both economic resilience and environmental sustainability.

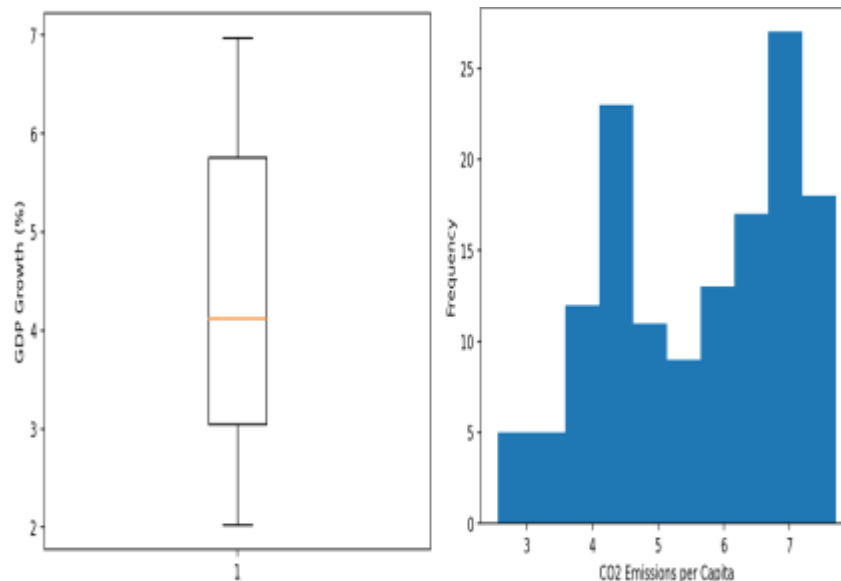


Figure 3: Distribution of economic growth and carbon emissions across emerging economies.

Conclusion

This study examined the role of green finance in promoting sustainable economic development in emerging economies by integrating macroeconomic, environmental, and energy-system dimensions within a unified empirical framework. The findings demonstrate that green finance has the potential to support long-term structural transformation, but its effects are neither immediate nor uniform across countries. Rather than functioning as a short-term growth accelerator, green finance operates as a

conditional and gradual enabler of sustainability, whose effectiveness depends on domestic institutional quality, policy coherence, and technological readiness. The descriptive and distributional analyses revealed substantial heterogeneity in green finance adoption, growth performance, and emissions patterns. This fragmentation underscores that sustainable finance is not diffusing evenly across emerging markets. The econometric results further showed that while green financial flows are associated with improved environmental outcomes and energy

efficiency over time, their short-run growth effects remain modest and context-dependent. These findings challenge overly optimistic narratives that present green finance as a universal solution, instead highlighting the importance of complementary reforms in governance, industrial policy, and energy market design. From a policy perspective, the results imply that expanding green financial instruments alone is insufficient. Governments must simultaneously invest in institutional capacity, project pipeline development, regulatory transparency, and technological infrastructure to ensure that green capital is allocated efficiently and translated into tangible sustainability gains. Without such reforms, green finance risks becoming symbolic rather than transformative. This study contributes to the literature by moving beyond single-indicator approaches and adopting a multidimensional conception of sustainable development. It also extends existing research by focusing explicitly on emerging economies, where structural constraints fundamentally shape the finance-sustainability nexus. Several limitations remain. The relatively short time horizon restricts the ability to capture full transition dynamics, and data constraints limit causal identification. Future research should incorporate longer panels, micro-level project data, and instrumental variable strategies to better isolate causal mechanisms. Overall, this paper argues that green finance is best understood not as a silver bullet, but as a strategic tool that can facilitate sustainable development when embedded within coherent national transformation strategies. This reframing is essential for designing realistic, effective, and equitable climate finance policies in the Global South.

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