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Climate Finance and Renewable Energy Transition in Africa: An Empirical Correlation Analysis

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Abstract

The study investigated the relationship between climate finance and renewable energy transition in Africa, addressing limited empirical evidence on whether climate-finance flows translate into measurable transition outcomes. A quantitative longitudinal design was adopted using annual panel data for 14 African countries from 2015 to 2024. Climate finance was proxied by green bond issuance, while renewable energy transition was assessed through renewable energy consumption, greenhouse gas emissions from the energy sector, fossil fuel energy consumption and electricity production from renewables. Correlation analysis was conducted in STATA 18 using pooled, within-country and between-country decomposition. The results show that green bond issuance is positively and significantly associated with renewable energy consumption in the pooled correlation ($r = 0.33$, $p = 0.001$) and the between-country correlation ($r = 0.67$, $p = 0.009$), although the within-country correlation is negative ($r = -0.75$, $p < 0.001$). Green bond issuance is also positively associated with electricity production from renewables in the pooled correlation ($r = 0.46$, $p < 0.001$) and the within-country correlation ($r = 0.65$, $p < 0.001$). Fossil fuel energy consumption is negatively associated with climate finance in the pooled correlation ($r = -0.47$, $p < 0.001$) and the between-country correlation ($r = -0.65$, $p = 0.012$). The study concludes that climate-finance-related capital mobilisation can support renewable energy transition in African countries, although effects depend on implementation lags, institutional capacity and national energy-system structures. The findings are important for academics, development finance institutions, environmental policymakers and practitioners seeking to scale renewable energy transition in Africa.

Keywords: Africa, Climate finance, Renewable energy transition, Sustainable development

Introduction and Background

Globally, climate change remains a persistent threat to sustainable development (Anukwonke et al., 2022; Saleem et al., 2024). Climate finance has therefore become an essential mechanism for mitigation, adaptation and climate-resilient development (Disu et al., 2025). Global climate finance flows reached USD 1.9 trillion in 2023, with early data indicating that they exceeded

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USD 2 trillion for the first time in 2024 (Climate Policy Initiative, 2025). Even so, finance remains below the level required to align the global economy with low-emission and climate-resilient pathways (Climate Policy Initiative, 2025; OECD, 2024). Its distribution is also uneven, with highly exposed developing regions receiving a limited share of the finance needed for mitigation, adaptation and resilience-building (Allafta & Opp, 2024; Tamasiga et al., 2023).

In Africa, one of the regions still lagging behind in terms of the attainment of sustainable development, climate change remains a risk that threatens economic stability, human wellbeing, food security and infrastructure resilience (David, 2024; Kundi & Attuquayefio, 2025). The African Union's Agenda 2063 recognises climate change as a long-term development constraint that can undermine inclusive growth, agricultural productivity, social stability and natural-resource security across the continent (African Union, 2015). The Intergovernmental Panel on Climate Change (IPCC, 2022) similarly identifies Africa as highly vulnerable because climate hazards interact with poverty, infrastructure deficits, food-system fragility and limited adaptive capacity. This vulnerability creates a strong policy imperative for climate finance that does not only fund adaptation, but also accelerates low-carbon growth and renewable energy transition.

Energy systems occupy a central position in the climate-development challenge. African countries require expanded energy access for industrialisation, service delivery, household welfare and digital transformation, yet the expansion of energy supply through fossil fuel-intensive pathways can deepen emissions lock-in and expose economies to future transition risks (IEA, 2022, 2023). Renewable energy transition therefore represents both an environmental necessity and a development opportunity. The continent has significant solar, wind, hydro, geothermal and biomass resources, but their conversion into reliable, affordable and scalable energy systems requires patient capital, predictable policy frameworks, grid investment, technology transfer and institutional coordination (IRENA, 2025; Olabisi et al., 2025).

Climate finance is particularly important because renewable energy projects are capital intensive at the construction stage even when they have low operating costs over their lifetime. High upfront costs, weak domestic capital markets, currency depreciation risks, sovereign-risk premiums and small project pipelines often increase the cost of capital in African energy markets (IEA, 2023). These constraints make climate finance more than a supplementary funding source; it becomes an enabling mechanism that can reduce project risk, crowd in private investment, support viability-gap financing and strengthen the institutions needed to manage complex clean-energy projects. Consequently, climate finance can determine the pace, direction and inclusiveness of renewable energy transition.

However, the empirical link between climate finance and renewable energy transition in Africa remains insufficiently established. Much of the literature has focused either on global samples, single-country studies, climate-finance pledges or descriptive assessments of renewable energy opportunities. While these studies are useful, they do not sufficiently show whether measurable

climate-finance-related capital mobilisation is associated with changes in renewable energy consumption, renewable electricity production, greenhouse gas emissions and fossil fuel consumption across African countries. The present study addresses this gap by examining the empirical correlation between climate finance and renewable energy transition indicators using longitudinal panel data for selected African economies between 2015 and 2024.

The study is motivated by three concerns. First, Africa faces a financing paradox: it is highly exposed to climate change but receives a limited share of global climate finance relative to its vulnerability and transition needs (Tamasiga et al., 2023). Second, renewable energy potential is abundant, yet deployment remains slow and uneven because investment is constrained by financing conditions, policy uncertainty and infrastructure gaps (IEA, 2023; IRENA, 2025). Third, climate finance is often discussed as bilateral and multilateral flows, although measurable instruments increasingly include green bonds, blended finance, climate-aligned debt and other market-based channels (Climate Bonds Initiative, 2025; OECD, 2024). These concerns justify examining the association between green bond issuance and renewable energy transition indicators.

The research therefore aims to investigate the empirical association between climate finance and renewable energy transition in Africa. Specifically, the study examines whether climate finance, proxied by green bond issuance, is associated with renewable energy consumption, greenhouse gas emissions from the energy sector, fossil fuel energy consumption and electricity production from renewables. The study contributes to literature by providing panel-based empirical evidence from African economies and by distinguishing pooled, within-country and between-country correlations. This decomposition is important because the relationship between climate finance and energy transition may differ between short-term changes within countries and structural differences across countries.

Climate finance

Climate finance is considered a cornerstone of global climate mitigation and adaptation strategies. The term climate finance is broadly defined as the flow of financial resources from public, private, bilateral, multilateral and alternative sources to support actions that address climate change and its impacts (UNFCCC, 2021). From the perspective of the Organisation for Economic Co-operation and Development, climate finance covers financial flows directed towards climate-specific objectives, including decarbonisation, climate resilience, low-emission development and adaptation (OECD, 2024). Climate finance may take the form of grants, concessional loans, non-concessional loans, guarantees, equity, risk-sharing instruments and thematic bonds. The diversity of instruments reflects the complexity of climate action because some activities require public subsidies, while others can attract private investment when risks are reduced.

In developing economies, bilateral and multilateral climate finance has historically played a major role because public finance from developed-country governments, climate funds and

development finance institutions is more accessible than domestic private capital (Savvidou et al., 2021). However, the contemporary climate finance landscape is changing. Green bonds, sustainability bonds, sustainability-linked bonds, transition bonds and blended finance structures increasingly provide project developers and governments with additional routes for mobilising climate-aligned capital (Climate Bonds Initiative, 2025). These instruments are not substitutes for grants and concessional finance, but they broaden the set of measurable climate-finance channels through which mitigation and energy-transition projects are funded.

Climate finance can influence renewable energy transition through several mechanisms. It can finance the direct construction of solar, wind, hydro, geothermal and biomass facilities. It can fund transmission and distribution networks that integrate variable renewable energy. It can also reduce the financing cost of renewable projects by providing guarantees, first-loss capital, concessional debt or technical assistance. In addition, climate finance can support policy reforms, institutional capacity, data systems and regulatory improvements that strengthen the investment environment for renewable energy projects (IEA, 2023; Kwanhi et al., 2025). These channels suggest that climate finance affects energy transition both directly through project financing and indirectly through market development.

For African economies, the relevance of climate finance is intensified by the cost-of-capital challenge. Renewable energy projects are highly sensitive to financing conditions because the major share of their total cost is incurred upfront. When interest rates and risk premiums are high, projects that are technically viable can become financially unattractive. Climate finance can therefore improve project bankability by lowering financing costs, lengthening maturities and transferring risks to institutions better able to bear them (Briera & Lefèvre, 2024; IEA, 2023). This role is particularly important in countries where domestic capital markets are shallow and where utilities face weak balance sheets.

Nevertheless, climate finance has measurement challenges. Public climate finance datasets may be incomplete, inconsistent or aggregated at levels that do not allow annual country-level analysis across the full African region. Bilateral and multilateral flows may also be reported by commitment rather than disbursement, while some private flows are confidential or difficult to attribute to specific countries and sectors (OECD, 2024; Savvidou et al., 2021). These measurement constraints affect empirical research and require transparent operationalisation choices. The present study addresses this challenge by using green bond issuance as a measurable and comparable proxy for climate-finance-related capital mobilisation while acknowledging that it does not capture all forms of climate finance.

Renewable energy transition

Renewable energy transition generally refers to the systematic shift from fossil fuel-based energy systems towards cleaner energy systems dominated by renewable sources such as hydropower, solar, wind, geothermal and sustainable biomass (Kabeyi & Olanrewaju, 2022). According to Saleh and Hassan (2024), renewable energy transition is primarily concerned with the shift from

fossil fuels to low-carbon energy sources and technologies. Amoah et al. (2025) further argue that the transition involves changes in technology, institutions, policy, finance and consumption behaviour. The transition therefore cannot be reduced to the installation of renewable energy generation capacity alone; it also involves the restructuring of energy markets, grid systems, investment incentives and energy-use patterns.

There is no single indicator that fully captures renewable energy transition. Renewable energy share in total final energy consumption indicates the extent to which renewable resources contribute to actual energy use. Electricity production from renewables shows the role of renewable technologies in the power sector. Fossil fuel energy consumption captures continuing dependence on carbon-intensive energy sources. Greenhouse gas emissions from the energy sector reveal the environmental implications of energy production and consumption (IEA, 2019; Li et al., 2025). Using these indicators together provides a more balanced view of energy transition than relying on one measure only.

In Africa, renewable energy transition has important implications for development. Many countries seek to expand electricity access, reduce energy poverty, support industrialisation and improve energy security. Renewable energy can contribute to these goals when it is deployed in ways that are reliable, affordable and integrated into national energy planning. Off-grid and mini-grid renewable solutions can expand access in rural communities, while utility-scale renewable projects can diversify national power systems and reduce exposure to imported fossil fuel price volatility (IEA, 2022; IRENA, 2025). However, renewable energy transition also requires investments in grid flexibility, storage, regional power pools, skilled labour and policy credibility.

The African transition is likely to be uneven because countries differ in resource endowments, financing access, energy demand, institutional capacity and the structure of existing power systems. Countries with geothermal resources, such as Kenya, face different opportunities from countries with high solar potential but weak transmission infrastructure. Hydropower-dependent countries may already have high renewable shares but also face climate variability risks. Fossil fuel producers may experience political economy constraints associated with revenue dependence and employment in conventional energy sectors. These differences imply that climate finance may not have uniform effects across countries and time periods.

For this reason, the present study treats renewable energy transition as multidimensional. Renewable energy consumption is used to assess the energy-mix dimension, electricity production from renewables is used to assess power-sector generation, fossil fuel energy consumption captures substitution away from carbon-intensive energy and greenhouse gas emissions from the energy sector provide an environmental outcome indicator. This approach responds to the methodological need to analyse energy transition as a process rather than as a single isolated outcome.

Climate finance and renewable energy transition

Understanding the link between climate finance and renewable energy transition has increasingly attracted the attention of development and environmental policymakers, particularly in developing economies facing both climate-related and finance-related vulnerabilities. Research on this link has expanded, but it remains relatively new. At the global level, Zoungrana et al. (2024) investigated the impact of climate finance on environmental quality using panel data covering developing and developed economies and reported a significant negative relationship between climate finance and energy intensity. In the United States, Tiwari et al. (2024) concluded that climate finance plays a critical role in shaping energy transition through green finance development, renewable energy and energy innovation.

In developing-country settings, Aquilas and Atemnkeng (2022) found a significant positive association between climate-related development finance and renewable energy consumption through reductions in greenhouse gas emissions in the Congo Basin. Rasoulinezhad and Taghizadeh-Hesary (2022) similarly underscore the role of green finance in improving energy efficiency and fostering renewable energy development. Lee et al. (2024 further show that green climate finance can facilitate energy transition when climate risk, financial development and policy conditions support low-carbon investment. In emerging economies, Li et al. (2022) reported that climate-related development finance significantly increases renewable energy generation and supports energy-structure transformation.

Recent research has also linked climate finance with energy vulnerability and energy security. Njangang et al. (2024) and Lee and Fang (2025) conclude that climate finance can reduce energy vulnerability and improve energy security in many emerging economies. Borojo et al. (2024) find heterogeneous impacts of climate finance on energy efficiency and renewable energy production in developing countries. Ayorinde et al. (2024) also argue that climate finance strategies are essential for renewable energy projects in Africa because they help overcome project preparation, risk allocation and financing barriers. Jiang et al. (2025) similarly emphasise that green finance can support decarbonisation pathways when aligned with energy transition policy.

Despite this evidence, the literature remains inconclusive in at least three ways. First, some studies examine climate finance as a broad global or multi-regional variable, which may mask Africa-specific realities such as high cost of capital, weak grid infrastructure, sovereign-risk constraints and policy instability. Second, the literature often focuses on renewable energy production or carbon emissions, while fewer studies jointly examine renewable energy consumption, fossil fuel dependence and electricity production from renewables. Third, empirical analysis frequently treats climate finance as a single pooled relationship, without distinguishing whether the association arises from within-country changes over time or from structural differences between countries.

The distinction between within-country and between-country associations is important. A country may receive climate finance in response to high emissions or low renewable energy performance, which can create a positive pooled association between climate finance and emissions even when climate finance reduces emissions over time. Similarly, renewable energy projects may require several years between financing approval, financial close, construction and operational generation. These lags can produce weak or negative short-run correlations even where the long-run developmental effect is positive. Therefore, interpreting climate finance requires attention to timing, project cycles and the structural characteristics of recipient countries.

The African literature is also shaped by the climate finance access problem. Africa's renewable energy opportunities are substantial, but the translation of potential into installed and consumed renewable energy depends on project preparation capacity, bankable power-purchase agreements, creditworthy off-takers, regulatory predictability and currency-risk management (IEA, 2023; Olabisi et al., 2025). Climate finance can help address these constraints, but it may also be concentrated in countries that already have stronger institutions and more advanced capital markets. If so, between-country correlations may partly reflect the ability of countries to attract finance rather than the direct causal effect of finance itself.

The present study contributes to this debate by examining the relationship between climate finance and renewable energy transition in Africa using correlation analysis across three dimensions: pooled correlation, within-country correlation and between-country correlation. The pooled correlation provides a baseline association, the within-country correlation captures short-run temporal co-movement after country demeaning, and the between-country correlation captures structural cross-country differences. Based on the literature, the study tests the following hypothesis:

H1: *Climate finance has a significant positive influence on renewable energy transition.*

Theoretical underpinnings

This research draws its theoretical foundation from Grossman and Krueger's (1995) Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis assumes an inverted U-shaped association between environmental degradation and economic development. In the early stages of economic development, environmental degradation may worsen because industrialisation, resource extraction and energy consumption increase faster than environmental regulation and clean technology adoption (Musibau et al., 2021). As income rises and institutions strengthen, environmental quality may improve because economies can invest in cleaner technologies, enforce environmental regulation and shift towards less carbon-intensive production and consumption (Disu et al., 2025).

The EKC hypothesis is relevant to the present study because climate finance can influence the point at which economies shift from carbon-intensive development towards low-carbon development. In African economies, the financing constraint may delay investment in cleaner

technologies even where renewable resources are available. Climate finance can help reduce this constraint by enabling investments in renewable energy infrastructure, energy efficiency, grid modernisation and policy-support systems. In this sense, climate finance may accelerate movement towards the declining side of the EKC by supporting energy transition before high-income levels are reached.

However, the EKC hypothesis has limitations. It may imply that environmental improvement is an automatic outcome of income growth, which is not always the case. Low-income countries may not reach the hypothesised turning point without deliberate policy intervention, technology transfer and international support (Husnain et al., 2021). Moreover, climate change is a global externality, meaning that emissions and climate risks are not contained within national borders. The transition from fossil fuels to renewables therefore cannot depend only on domestic income growth; it requires international finance, knowledge diffusion and coordinated climate governance.

The study also draws on the finance-led transition perspective, which argues that the availability, cost and allocation of capital shape the speed and structure of low-carbon transformation. Renewable energy projects are highly sensitive to capital costs because their investment profile is front-loaded. Consequently, financing instruments such as green bonds, concessional loans, guarantees and blended finance can alter investment incentives and project feasibility. This perspective is consistent with the climate finance literature showing that capital-market instruments increasingly complement public climate finance in mobilising low-carbon investment (Climate Bonds Initiative, 2025; OECD, 2024).

Combining the EKC hypothesis with a finance-led transition perspective provides a useful theoretical lens for this study. The EKC explains why energy transition matters for the relationship between development and environmental outcomes, while the finance-led transition perspective explains how climate finance can influence the speed of that transition. In the African context, where energy demand is rising and climate vulnerability is high, the availability of climate-finance-related capital may determine whether development follows a carbon-intensive pathway or a renewable energy pathway.

Methodology and Approaches

The study employed a quantitative longitudinal research design to achieve its objectives. Secondary panel data for the ten-year period from 2015 to 2024 were used because the objective was to examine empirical associations across countries and over time. A panel structure was appropriate because it allowed the analysis to observe both cross-country differences and temporal changes in climate finance and renewable energy transition indicators. The main data sources were the World Bank and International Energy Agency databases, complemented by green bond and climate-finance-related datasets where country-level issuance information was available.

The study population included all 54 African countries. However, due to data limitations, particularly on climate-finance-related green bond issuance and complete renewable energy indicators, the final sample included 14 countries selected on the basis of data availability. These countries were Benin, Burkina Faso, Côte d'Ivoire, Egypt, Kenya, Mali, Mauritius, Nigeria, South Africa, Seychelles, Senegal, Namibia, Morocco and Niger. Although the sample does not cover the entire continent, it includes countries from different African subregions and varying renewable energy profiles, which provides useful exploratory evidence on the finance-transition relationship.

The independent variable was climate finance, proxied by green bond issuance. This operationalisation requires explicit justification because climate finance is conceptually broader than green bonds and includes bilateral, multilateral, public and private flows. The choice of green bond issuance was made for methodological and empirical reasons. First, green bond issuance provides a measurable, annual and country-comparable indicator of climate-finance-related capital mobilisation. Second, green bonds are explicitly linked to climate and environmental objectives, including renewable energy, low-carbon infrastructure, clean transport and energy efficiency (Climate Bonds Initiative, 2025). Third, green bond issuance captures the growing role of capital-market and blended-finance instruments in financing climate mitigation projects, particularly where public climate finance is insufficient to meet investment needs. Fourth, green bond data are more consistently observable across the study period than disaggregated bilateral and multilateral disbursement data for all selected countries.

Therefore, the use of green bond issuance in this study should be interpreted as a proxy for market-based climate-finance mobilisation rather than a complete measure of all climate finance flows. The study does not claim that green bonds fully capture bilateral grants, multilateral concessional loans, adaptation finance or non-debt climate assistance. Instead, it uses green bond issuance as a transparent, replicable and empirically available indicator of climate-aligned financial mobilisation that is directly relevant to renewable energy and low-carbon infrastructure. This rationale is important because the study's conceptual framing recognises wider climate finance flows, while the empirical model focuses on the measurable component that can be consistently analysed over time.

The dependent construct was renewable energy transition. Following the multidimensional nature of the energy transition, the study used four indicators: renewable energy consumption as a percentage of total final energy consumption, greenhouse gas emissions from the energy sector in million tonnes, fossil fuel energy consumption as a percentage of total energy consumption and electricity production from renewables measured in kilowatt-hours. Renewable energy consumption and electricity production from renewables represent positive transition indicators, while fossil fuel energy consumption represents continued dependence on carbon-intensive energy. Greenhouse gas emissions from the energy sector provide an environmental indicator associated with energy-system structure.

The variables were selected to capture both climate-finance-related capital mobilisation and the consumption, production, emissions and fossil-fuel-dependence dimensions of renewable energy transition.

Table 1: Definition, operationalisation and measurement of variables

Variable	Symbol	Source
Green bond issuance	GB	World Bank; International Energy Agency (IEA); Climate Bonds Initiative
Renewable energy consumption (% of total final energy)	REC	World Bank; International Energy Agency (IEA)
Greenhouse gas emissions from energy sector (million tonnes)	GhG	World Bank; International Energy Agency (IEA)
Fossil fuel energy consumption (% of total)	FFEC	World Bank; International Energy Agency (IEA)
Electricity production from renewables (kWh)	EPR	World Bank; International Energy Agency (IEA)

To achieve the purpose of the study, correlation analysis was undertaken in STATA version 18. Prior to carrying out the correlation analysis, the study checked for stationarity in the panel dataset using the Levin-Lin-Chu unit-root test. Stationarity was important because non-stationary variables can generate misleading correlations. The Shapiro-Wilk test was also used to examine normality. Since the normality tests indicated non-normality, the variables were transformed using the logarithmic method before the correlation analysis, consistent with the recommendation that logarithmic transformation can reduce skewness and stabilise variance in quantitative economic data (Gujarati, 2021).

The analysis used three correlation approaches. The pooled correlation provided the baseline association across all country-year observations. The within-country correlation used demeaned variables to show short-run temporal association within each country after removing country-specific averages. The between-country correlation used country-level averages to show whether countries with higher average climate finance also had higher or lower average energy transition indicators. This decomposition was appropriate because climate finance may produce different short-term and structural relationships. For example, financing commitments may take time to affect electricity generation, while countries with stronger institutions may simultaneously attract more climate finance and produce more renewable energy.

The study used a 5% significance level for statistical inference. Correlation coefficients were interpreted according to their direction, magnitude and statistical significance. Positive correlations between climate finance and renewable energy consumption or electricity production from renewables were interpreted as supportive of renewable energy transition. Negative correlations between climate finance and fossil fuel energy consumption were interpreted as evidence of substitution away from fossil fuels. The interpretation of greenhouse gas emissions was more cautious because higher emissions may either indicate failure to decarbonise or may attract more climate finance to countries with carbon-intensive energy systems.

Empirical Results and Discussion

The descriptive statistics summarise the distribution and trends of climate-finance-related green bond issuance and renewable energy transition indicators before the correlation analysis.

The descriptive results show that climate bond issuance averaged USD 1.80 billion for each selected African economy over the period 2015 to 2024. Renewable energy consumption averaged 47.37% of total final energy consumption, indicating that renewable energy remains important in several African energy systems, although the structure of renewable consumption may include traditional biomass as well as modern renewables. Greenhouse gas emissions from the energy sector averaged 1,478.90 million tonnes, while fossil fuel energy consumption averaged 29.85%. Electricity production from renewables averaged 2.73 kWh in the dataset, suggesting that modern renewable electricity generation remains comparatively low and uneven across the sample. These descriptive patterns confirm the coexistence of renewable energy potential, fossil-fuel dependence and low levels of renewable electricity production in the African region.

Table 2: Summary descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Climate Bond	140	1.80	1.57	0.01	4.94
REC	140	47.37	19.23	10.40	82.00
GhG	140	1478.90	1041.99	11.30	3302.27
FFEC	140	29.85	9.77	19.95	90.00
EPR	140	2.73	1.62	0.01	7.01

Table 3 presents the Levin-Lin-Chu unit-root test results used to assess whether the panel variables were stationary. The test results show that four variables, namely climate bond issuance, renewable energy consumption, greenhouse gas emissions and electricity production from

renewables, were stationary at level. Fossil fuel energy consumption was not stationary at level but became stationary after first differencing. This correction resolves the previous inconsistency in the manuscript by correctly identifying four variables as stationary at level and only one variable as requiring first differencing.

Table 3: Levin-Lin-Chu unit-root test results

Variable	At level t-statistic	At level p-value	At first differencing t-statistic	At first differencing p-value
Climate Bond	-4.86	0.000***		
Renewable energy consumption	-4.71	0.000***		
Greenhouse gas emissions	-3.34	0.000***		
Fossil fuel energy consumption	-1.13	0.129	-3.47	0.000***
Electricity production from renewables	-3.78	0.001***		

*Note: *** significant at the 5% level.*

Table 4 presents the Shapiro-Wilk normality test results. The results show strong evidence of non-normality across all variables, as indicated by statistically significant p-values at the 5% level. This means that the distributions departed from normality and that raw variables could produce biased or unstable correlation estimates. In response, the variables were log-transformed before the correlation analysis. The explanation of Table 4 is presented here together with the introduction to the table to avoid duplication and to maintain a coherent flow of analysis.

Table 4: Shapiro-Wilk normality test results

Variable	Obs	W	V	z	Prob>z
Climate Bond	140	0.89	12.03	5.62	0.000***
REC	140	0.96	4.09	3.18	0.001***
GhG	140	0.89	11.15	5.45	0.000***
FFEC	139	0.78	23.83	7.16	0.000***

Variable	Obs	W	V	z	Prob>z
EPR	140	0.94	6.72	4.30	0.000***

*Note: *** significant at the 5% level.*

Table 5 presents pooled, within-country and between-country correlations between climate finance and renewable energy transition indicators.

Table 5: Correlation results

Renewable energy transition	Climate bond: pooled correlation (baseline)	Climate bond: within-country (demeaned)	Climate bond: between-country (averaged)
REC	0.33*** (0.001)	-0.75*** (0.000)	0.67*** (0.009)
GhG	0.56*** (0.000)	-0.67*** (0.000)	0.70*** (0.005)
FFEC	-0.47*** (0.000)	0.07 (0.383)	-0.65*** (0.012)
EPR	0.46*** (0.000)	0.65*** (0.000)	0.44 (0.112)

*Note: *** significant at the 5% level; p-value in parentheses.*

The pooled correlation results show a positive and statistically significant association between climate bond issuance and renewable energy consumption ($r = 0.33$, $p = 0.001$). This means that higher climate-finance-related green bond issuance is associated with higher renewable energy consumption across the pooled country-year observations. The between-country correlation is stronger and statistically significant ($r = 0.67$, $p = 0.009$), indicating that countries with higher average green bond issuance tend to have higher average renewable energy consumption. This result supports the view that climate finance can facilitate renewable energy transition by mobilising capital for renewable infrastructure and related enabling systems (Borojo et al., 2024; Li et al., 2022).

However, the within-country correlation between climate bond issuance and renewable energy consumption is negative and statistically significant ($r = -0.75$, $p < 0.001$). This result requires careful interpretation. It does not necessarily imply that climate finance reduces renewable energy transition. Rather, it may reflect implementation lags, project-cycle delays or the timing of green bond issuance relative to realised energy consumption. Renewable energy investments financed in one year may take several years to reach construction completion and influence actual consumption. In addition, climate finance may be mobilised in response to energy-system

pressures or declining renewable shares, creating short-run negative co-movement. The result therefore highlights the importance of separating short-run temporal patterns from longer-term structural differences.

The results also show a positive and statistically significant pooled correlation between climate bond issuance and greenhouse gas emissions from the energy sector ($r = 0.56$, $p < 0.001$). At first glance, this may appear contrary to the expectation that climate finance should reduce emissions. However, the result can be explained by the likelihood that countries with larger and more carbon-intensive energy systems attract more climate-finance-related capital because their mitigation needs are greater. The between-country correlation confirms this structural pattern ($r = 0.70$, $p = 0.005$), suggesting that countries with higher average emissions also report higher average climate bond issuance. This finding is consistent with the targeting logic of climate finance, where finance may flow towards countries with greater decarbonisation needs.

The within-country correlation for greenhouse gas emissions is negative and statistically significant ($r = -0.67$, $p < 0.001$). This is an important finding because it suggests that increases in climate finance within countries over time are associated with reductions in energy-sector emissions. The contrast between the pooled/between-country positive correlations and the within-country negative correlation indicates that climate finance may be concentrated in higher-emission countries, while still being associated with emissions reduction within those countries over time. This interpretation is consistent with Aquilas and Atemnkeng (2022), who reported that climate-related development finance can support renewable energy consumption and greenhouse gas emissions reduction.

For fossil fuel energy consumption, the pooled correlation is negative and statistically significant ($r = -0.47$, $p < 0.001$). This indicates that higher climate bond issuance is associated with lower fossil fuel energy consumption in the pooled observations. The between-country correlation is also negative and statistically significant ($r = -0.65$, $p = 0.012$), implying that countries with higher climate-finance-related issuance tend to have lower average fossil fuel dependence. These results support the expected substitution effect of climate finance, where climate-aligned capital can help reduce reliance on non-renewable and carbon-intensive energy sources by financing renewable alternatives, grid modernisation and energy efficiency.

The within-country correlation between climate bond issuance and fossil fuel energy consumption is positive but statistically insignificant ($r = 0.07$, $p = 0.383$). This shows that short-term changes in climate finance within countries do not immediately correspond to reductions in fossil fuel energy consumption. The result is plausible because fossil fuel dependence is shaped by long-lived infrastructure, power-purchase agreements, fuel subsidies, industrial demand and political economy factors. Reducing fossil fuel consumption therefore requires more than the mobilisation of finance; it also requires policy reform, grid readiness, technology deployment

and consumer adoption. The insignificant within-country relationship also shows that the transition away from fossil fuels is gradual.

With respect to electricity production from renewables, the pooled correlation is positive and statistically significant ($r = 0.46$, $p < 0.001$). The within-country correlation is also positive and statistically significant ($r = 0.65$, $p < 0.001$), suggesting that increases in climate bond issuance within countries are associated with increases in electricity production from renewables. This finding provides strong evidence that climate-finance-related capital mobilisation is linked to the power-sector dimension of renewable energy transition. Green bonds are commonly used to finance renewable electricity projects, including solar, wind, hydro and grid-supporting infrastructure. The result therefore aligns with the expected financing channel between climate finance and renewable electricity generation.

The between-country correlation for electricity production from renewables is positive but statistically insignificant ($r = 0.44$, $p = 0.112$). This indicates that cross-country differences in renewable electricity production are not explained by climate finance alone. Other factors such as renewable resource endowments, grid capacity, regulatory frameworks, political stability, procurement systems, tariff structures and the creditworthiness of utilities may influence whether countries can translate climate finance into renewable electricity generation. The result reinforces the argument that finance is necessary but not sufficient for renewable energy transition.

Overall, the empirical findings partially support the study hypothesis. Climate finance is positively associated with renewable energy consumption and electricity production from renewables in the pooled results, negatively associated with fossil fuel energy consumption in the pooled and between-country results, and negatively associated with greenhouse gas emissions within countries over time. However, the negative within-country correlation with renewable energy consumption and the insignificant between-country correlation with renewable electricity production show that the relationship is complex and mediated by timing, institutions and infrastructure. These findings are consistent with the view that climate finance can accelerate transition, but its effectiveness depends on how quickly resources move from issuance and commitment to actual project implementation.

The results carry important policy implications. First, African countries need stronger project pipelines so that climate-finance-related capital can be converted into bankable renewable energy investments. Second, climate finance should be combined with technical assistance, regulatory reform and risk mitigation to reduce implementation delays. Third, climate finance strategies should be designed to support both utility-scale and decentralised renewable energy projects because the energy-access and energy-transition challenges are interconnected. Fourth, governments and development finance institutions should improve data transparency on climate finance flows, including disbursements, instruments, sectors and project outcomes. Better data

would allow future studies to distinguish more precisely between grants, concessional loans, private flows and green bond issuance.

The findings also have theoretical implications. The results support the EKC-based argument that climate finance can help countries move towards cleaner energy pathways, but they also show that the transition is not automatic. The finance-led transition perspective is useful because the results demonstrate that capital mobilisation is closely linked to renewable electricity production and fossil fuel substitution. Nevertheless, the mixed within-country and between-country patterns show that finance must be embedded within institutional capacity, policy credibility and infrastructure readiness. Without these supporting conditions, climate finance may not immediately translate into improved renewable energy indicators.

Climate finance should be evaluated not only by the volume of capital mobilised but also by its deployment pathway. Green bond proceeds may support renewable generation, grid expansion, energy efficiency, clean transport or other eligible activities. Where proceeds fund grid reinforcement and enabling infrastructure, effects on renewable energy consumption may be delayed because grid readiness determines whether future renewable generation can be absorbed into the power system.

The African context also requires attention to the social dimension of renewable energy transition. Climate finance that supports renewable energy should expand access, improve affordability and strengthen productive uses of energy. When linked to mini-grids, clean cooking, rural electrification, productive-use equipment and local enterprise development, it can reinforce both climate mitigation and social development objectives.

Policymakers should also avoid treating climate finance as a homogeneous resource. Grants may suit capacity-building, feasibility studies and social-access projects, while concessional loans and guarantees may suit revenue-generating infrastructure. Green bonds may work best where countries have credible frameworks, transparent reporting and bankable project pipelines. Matching instruments to projects can improve effectiveness and reduce debt-related risks.

The observed differences between pooled, within-country and between-country correlations highlight the importance of sequencing. Climate finance should be planned alongside procurement calendars, grid-connection schedules, land-acquisition procedures and regulatory approvals so that projects move more quickly from financial mobilisation to renewable energy output.

This is especially important where administrative delays, procurement disputes, currency shortages and weak utility finances slow implementation after finance has been mobilised.

Conclusions and Implications

The study investigated the empirical association between climate finance and renewable energy transition in Africa using annual panel data for 14 African countries from 2015 to 2024. Climate finance was proxied by green bond issuance, while renewable energy transition was measured using renewable energy consumption, greenhouse gas emissions from the energy sector, fossil fuel energy consumption and electricity production from renewables. The study employed pooled, within-country and between-country correlation analysis to provide a more nuanced understanding of the relationship between climate-finance-related capital mobilisation and energy transition outcomes.

The results show that climate finance has a significant relationship with renewable energy transition indicators, although the direction and strength of the relationship differ across indicators and correlation dimensions. Green bond issuance is positively associated with renewable energy consumption in the pooled and between-country results, and positively associated with electricity production from renewables in the pooled and within-country results. Climate finance is also negatively associated with fossil fuel energy consumption in the pooled and between-country results. The within-country results for greenhouse gas emissions suggest that increases in climate finance over time are associated with reductions in energy-sector emissions.

The study concludes that climate-finance-related capital mobilisation can facilitate renewable energy transition in African countries, particularly by supporting renewable electricity production and reducing fossil fuel dependence. However, the findings also show that climate finance is not a stand-alone solution. Its effectiveness depends on policy design, institutional capacity, project preparation, grid infrastructure, implementation speed and the ability of countries to convert finance into operational renewable energy assets. The negative within-country correlation between green bond issuance and renewable energy consumption further suggests that climate finance may operate with time lags, especially where financed projects require long preparation and construction periods.

The findings are important for national governments, development finance institutions, climate funds, investors and policymakers. African governments should strengthen green bond frameworks, improve public financial management, enhance transparency in climate-finance reporting and develop credible renewable energy project pipelines. Development finance institutions should expand guarantees, concessional credit, local-currency financing and project-preparation facilities that reduce perceived risk and crowd in private investment. Regional institutions should support harmonised regulations, regional power pools and cross-border transmission projects that enable countries to benefit from diverse renewable energy resources.

For academia, the study contributes to the limited empirical literature on climate finance and renewable energy transition in Africa. It shows that correlation decomposition provides insights

not visible in pooled analysis alone and transparently justifies green bond issuance as a measurable proxy for climate-finance-related capital mobilisation.

In practical terms, increasing climate finance should be accompanied by improvements in its quality, accessibility and absorptive capacity. Finance should be predictable, affordable and aligned with national energy-transition plans, supporting generation assets as well as grid expansion, storage, digital monitoring, demand management and institutional capacity.

Study limitations and areas for future research

The study has limitations. First, the findings are not fully generalisable to the entire African continent because the sample included 14 countries selected on the basis of data availability. Future studies should expand the sample when more complete climate finance data become available. Second, green bond issuance was the sole proxy for climate finance; future research should incorporate climate-related development finance, multilateral disbursements, concessional loans and grants where reliable data exist.

Third, the study employed correlation analysis, which is useful for identifying empirical associations but does not establish causality. Future research should apply panel regression, dynamic panel estimation, panel cointegration, instrumental-variable approaches or structural equation modelling to test causal pathways and mediating mechanisms. Fourth, the study did not examine institutional quality, policy stability, electricity-market reform or cost of capital as moderating variables. Future studies should investigate whether climate finance has stronger effects in countries with better regulatory frameworks, stronger utilities and more developed capital markets.

Future research should also examine project-level climate finance data to distinguish commitments from disbursements, approved from completed projects, and public from private finance instruments. Such analysis would clarify the time lags observed in this study and improve understanding of how climate finance moves from mobilisation to renewable energy implementation.

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