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# Environmental Taxes, Climate Finance, And Sustainable Development in Africa

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**Abstract:** Investigation of the relationship between environmental taxes and climate finance and sustainability and climate adaptability in the African context (2015–2026). Using analysis results from environmental tax and climate finance measures from OECD data from 52 countries with 624 observations, a multiple regression model is presented—Environmental taxes ($\beta$ = -0.45) and climate finance ($\beta$ = -0.38) significantly reduce $CO_2$ emissions ($p < 0.001$). Foreign direct investment and GDP growth are positively associated with emissions, highlighting how economic growth may increase environmental degradation. Green innovation and renewable energy adoption are primary mediators where renewable energy had the main inverse contribution to emissions ($\beta$ = -0.52, $p < 0.001$). The study argues that a framework comprising progressive taxation and enhanced climate finance, technological innovation and renewable energy is needed to work on Africa's climate ambitions. It emphasizes the need for improved governance, access to climate finance, and support for the Sustainable Development Goals, and the international community's role in facilitating a climate-neutral economy and inclusive economic growth.

**Keywords:** Environmental taxes, Climate finance, green innovation, $CO_2$ emissions, Sustainable development, Africa, OECD data.

## 1.0 INTRODUCTION

### 1.1 Context and the Global Climate Imperatives

Climate change is a 21st century crisis that humanity is facing, and impacts are felt disproportionately in the developing world, especially in sub-Saharan Africa (Tahlil, 2025). With less than 4% of global carbon emissions, Africa is particularly vulnerable to the impact of climate change due to its geographical location, economic structure, and low adaptive ability (Tamasiga et al., 2023). In 2015, the Paris Agreement established a world consensus to limit temperature rise to 1.5-2 degrees Celsius. It will require unprecedented cooperation between developed and developing countries. Climate and environmental taxes are now twin instruments, used as part of climate change mechanisms both to eliminate climate change's causes and help mitigate its effects (Occhiali, 2023).

Environmental taxing – based upon the 'polluter-pays principle' – is a market-based approach to internalise the negative externalities of economic activities (Shammre et al., 2023). The application of environmental taxes has gained momentum in the world and OECD countries have had the lead in energy taxes, pollution taxes, resource taxes and transport taxes (Wu et al., 2025). But the effectiveness of these as environmental tax measures remains contested. Evidence suggests that their effectiveness depends on thresholds for taxation and complementary policy measures that follow suit (Shammre et al., 2023). Africa's experience of using environmental taxation has been relatively poor: very little comprehensive environmental taxation exists in many African countries, despite considerable potential to attract tax revenues (Occhiali, 2023).

The climate finance sector, financial flows for funding mitigation and adaptation for development in developing countries, has gained a prominent role in global climate negotiations (Schalatek, 2012). The original commitment of $100 billion every year from developed to developing countries has failed on several occasions until today, leaving a funding shortfall of more than $600 billion by 2030 (Isah et al., 2025). For African countries this deficit in financing is especially severe, with adaptation costs alone now expected to surpass $100 billion a year by 2050 (Chirambo, 2021). Green bonds, the Green Climate Fund, and bilateral agreements are some of these mechanisms that are being implemented but are not widely available and often lack effectiveness for countries in the developing world (Ngwenya & Simatele, 2020).

Motivation and scope of the project

This study is framed by a desire to investigate the combined influence of environmental taxes and climate finance on environmental performance in Africa which has not received a lot of empirical attention despite being pivotal to global climate response. Leveraging the OECD-derived data of 52 African countries spanning 2015-2026 we investigate how these policy instruments interact with technological innovation, renewable energy transition and institutional quality to influence carbon emissions and environmental sustainability. This research makes a theoretical and practical contribution to policy analysis for climate action in the post-industrial world and in the developing world.

## 1.2 PROBLEM STATEMENT.

The African Climate and Development Paradox. In sub-Saharan Africa, a paradox has emerged: the region has virtually no role in global greenhouse gas emissions, but is the most vulnerable to climate change (Tahlil, 2025). This asymmetry presents a moral imperative as well as a practical challenge for climate policy design. Increasing temperatures, shifting rainfall patterns, and greater severity of severe weather events threaten agriculture, water security, and economic stability throughout the continent, leading to poverty and food insecurity (Hong et al., 2026). At the same time, numerous African nations rely on carbon-intensive development pathways for alleviating poverty and creating jobs, leading to frictions between direct developmental needs and long-term environmental sustainability (Mpofu, 2022). Lack of Effective Policy and Institutional Capacity. Even with international agreements and policy frameworks, African countries are still unable to carry out environmental taxes effectively (Occhiali, 2023). Numerous barriers in the way have been identified in research: poor data sets as well as analytical capability; inadequate co-ordination between government agencies; weak institutional capacity; and political pushback from constituencies on the carbon-intensive front (Occhiali, 2023). These implementation challenges are further exacerbated by poor governance, corruption and restricted fiscal space for green investment in low-income countries ("Green Finance and Sustainable Development Nexus in Sub-Saharan Africa," 2024).

Furthermore, the regressiveness of environmental taxes - that they penalize mostly poor households - have resulted in public opposition without sound compensatory frameworks/reimbursement schemes (Mpofu, 2022). A Lack of and Inequitable Climate-Finance Flows. Climate finance to Africa remains insufficient and unevenly distributed. Countries with the most vulnerability and severe adaptation needs receive the smallest fraction of global climate finance and this is especially true for least-developed countries and fragile states (Garschagen & Doshi, 2022). Some African countries face the constraints of structural barriers (e.g. high co-financing requirements, complicated accreditation processes, and poor absorptive capacity) to access available funds (Mbarga, 2025). Moreover, majority of climate finance takes the forms of loans, rather than grants, which further increases the burden on a country's debt and decreases governments' fiscal spaces, which would otherwise be utilized for vital development investments (Monsod et al., 2023). Missing Knowledge and Research. Although various elements of climate policy in Africa have been studied through the lens of integrated studies, there is little data on the combined impact of environmental taxes, climate finance, green innovation, and the uptake of renewable energy (Tamasiga et al., 2023). Besides, there is limited empirical evidence for the effectiveness of these instruments within the African context, where institutional, economic and environmental circumstances are different than those of OECD countries. This gap is addressed by the present study with quantitative evidence of the relationship between environmental and climate policy and environmental outcomes in African economies.

## 1.3 RESEARCH OBJECTIVES.

1. To analyse the direct effect of emissions from environmental taxes on both $CO_2$ emission and environmental sustainability indicators in African countries from 2015 through 2026, providing a range, which can be counteracted with explanation from economic growth, industrialisation and patterns of trade.

2. To determine the effectiveness of climate finance mechanisms when it comes to reducing the levels of greenhouse gas emissions and encouraging the adoption of renewable energy, we need to consider both direct effects and indirect pathways by focusing on technological innovation and institutional strengthening in the case of sub-Saharan African nations.

3. To determine appropriate policy combinations and institutional arrangements that optimise the joint effectiveness of environmental taxes and climate finance to achieve carbon neutrality while facilitating inclusive economic development across Africa.

## 2.0 LITERATURE REVIEW.

Environmental Taxes and Carbon Emissions:

Theory and Practice

Environmental taxes are based on neoclassical economic theory, specifically the Coasian method in regards to environmental externalities and the Pigouvian tax idea (Shammre et al., 2023). The basic premise is clear: by linking the price of environmental pollution to prices in the market, taxes encourage polluters to cut harmful activities. Environmental taxes are classified into several types, such as energy taxes on fossil fuels, pollution taxes on emissions and effluents, resource taxes on natural resources, and transport taxes on vehicle use (Shammre et al., 2023). Each category is effective if demand is price elastic and substitutes can be offered, together with complementary policies (He, 2024).

2.1.1 Evidence from OECD Countries. In OECD nations, pollution taxes have worked well to cut emissions, although not without some small but meaningful differences. Using a dynamic panel threshold approach of 34 OECD countries (1995-2019), it can be concluded that environmental tax has limited emission decreases as long as a threshold, e.g. 3.002 percent of GDP for environmental taxes, 1.991 percent for energy tax, and 0.377 perent for pollution tax (Shammre et al., 2023). Environmental taxes have limited impacts on the environment at below these numbers. Econometric studies on OECD countries conducted from 1990 to 2022 found that both renewable energy and environmental taxes reduce $CO_2$ emissions markedly both in short and long run, with average elasticity for environmental taxes being about -0.35 (He, 2024). Using advanced econometric approaches, environmental taxes, green innovation, renewable energy in OECD countries was thoroughly examined and found that these technologies and renewable energy in the economy display statistically significant negative association with both ecological footprint and carbon emissions (Wu et al., 2025). Additionally, a cross-sectional augmented autoregressive distributed lag (CSARDL) evaluation of OECD countries revealed the bidirectional linkages between environmental taxation and carbon emissions which suggests a policy feedback role (Wu et al., 2025).

2.1.2 Implementation Difficulties in Developing Countries

Africa's experience of environmental taxation demonstrates major implementation challenges different from those faced by OECD economies. An in-depth qualitative study of interviews with ministries of finance and revenue authorities in six African countries found commonalities: lack of data, inability to analyse, and coordination between environmental managers and government agencies (Occhiali, 2023). The historical prioritisation of revenue generation over environmental results has made policy coherence all the more tenuous. Environmental taxes are also seen as regressive and hinder industrial growth, thus diminishing their political viability despite the support of public opinion for taxing for its benefits to the environment (Occhiali, 2023).

2.2 Mechanisms, Institutional Design and its Effectiveness for Climate Finance.

2.2.1 Global Climate Finance Architecture.

Climate finance works through a complex architecture of multilateral funds, bilateral agreements, and emerging private finance instruments (Adisa et al., 2024). The main multilateral channels are the Green Climate Fund, the Global Environment Facility, bilateral development aid and climate investments from multilateral development banks. Climate finance flows across the world are now increasing from developed to developing countries since 2010, but well under the commitment put forward by parties. By 2023, annual flows were projected to be around $90 billion, far from the pledged $100 billion (Schalatek, 2012).

2.2.2 Efficacy and delivery issues. Cited in Pi & Ngua, 2026) a wide array of research on climate finance flows to 20 African countries (2006-2021) using sound econometric analysis revealed that climate finance has positive overall impacts on resource conservation over the climate resource conservation literature, and its beneficial impact is consistent with the positive effects of alternative green finance schemes (Pi & Ngua, 2026). Renewable energy usage also supports environmental protection, while growth in GDP and industrialisation erode the environment and natural resource utilization through consumption of renewable energy. Importantly, climate finance benefits all countries, irrespective of a country's level of initial conservation, indicating that there is universal applicability of the benefits (Pi & Ngua, 2026). But the distribution of climate finance, it's worth noting, is far from fair. Research on Green Climate Fund allocations to most vulnerable countries indicate that whilst the Fund has provided much resources to least developed nations and small island developing states, funds are insufficient for many most-need, least-capable countries as co-financing requirements are stringent and accreditation procedures are complicated (Garschagen & Doshi, 2022). A decision tree and network analysis of climate finance flows in sub-Saharan Africa revealed disproportionate distribution amongst climate themes, with adaptation finance for vulnerable populations receiving inadequate allocation (Chukwudum, 2024).

2.2.3 Climate Finance for Agricultural Transformation and Food Security Because Africa relies so heavily on agriculture, climate finance focused on agricultural productivity offers a particular opportunity. In a recent survey of 52 African countries (2000-2022), climate finance has a positive and statistically significant impact on agricultural productivity. The transmission mechanisms work by adopting renewable energy and access to the internet, which constitute both essential infrastructure for resilient agriculture to survive in the climatic extremes. This finding is consistent with climate finance effectiveness relying on complementary investments in digital connectivity and energy capabilities. Climate finance boosts food security outcomes, however, not everything is straightforward. By studying food security dimensions across 35 sub-Saharan African countries, it emerged that climate finance contributes most significantly to food availability but falls short in strengthening food access, stability, and utilization (Phiri & Doku, 2024). That indicates that climate finance on its own is not enough, but must be accompanied by social protection and the establishment of economic policy to tackle inequality.

2.3 Green Innovation in Global South, Technological Transfer, and Environmental Impact.

2.3.1 Innovation is a Mediating Mechanism.

Green innovation including process and product innovations designed to mitigate environmental impact is a major mediating variable in climate policy effectiveness (Wu et al., 2025). The CSARDL model used on OECD economies showed that Eco-innovation and process Eco-innovation are statistically significant negative variables that are significantly correlated with ecological footprint, carbon emissions, and greenhouse gas emissions (Wu et al., 2025). Furthermore, causality analyses show one-way causality of GDP to eco-innovation, indicating an effect of economic resources on the innovation capacity.

2.3.2 Quantile heterogeneity in innovation impacts. These innovation effects exhibit heterogeneity across the emissions distribution. Applying the Method of Moments technique to quantile regression, green innovation's impact on GHG emissions is characterized by significant differences across quantiles, with stronger effects at higher emission levels (Khan et al., 2025). This heterogeneity implies that innovation policies should be sector-specific and country-specific rather than being one-size-fits-all.

2.3.3 FDI, Technology Transfer, and Environmental Externalities.

The environmental impact of foreign direct investment is disputed in the literature. Although FDI facilitates technology transfer for clean production processes, it can also facilitate the relocation of pollution intensive industries to countries with lax environmental regulation ("Green Finance and Sustainable Development Nexus in Sub-Saharan Africa," 2024). Studies conducted on sub-Saharan Africa highlighted that environmental quality was adversely affected by FDI because of weak regulatory schemes which enabled multinational corporations to adopt the least effective environmental practices ("Green Finance and Sustainable Development Nexus in Sub-Saharan Africa," 2024). Nevertheless, FDI in renewables and green areas will produce positive environmental externalities, that is, FDI composition determines significantly different environmental outcomes.

2.4 The Transition to Renewable Energy and Carbon Reduction in Africa.

2.4.1 Renewable Resource Endowments and Deployment Constraints.

Africa has high renewable energy prospects, with its high levels of photovoltaic energy and a high rate of renewable energy resources such as solar power being among the highest in the world, and with significant opportunities for wind and hydroelectric energy (Ayorinde et al., 2024). But the deployment of renewable energy is dramatically behind potential. In an analysis of 52 African countries (1990–2023) within the Environmental Kuznets Curve framework, we show that renewable energy production has a U-shaped relationship with economic growth limiting the production of renewable energy (Sarsar & Echaoui, 2025), with turning points estimated between 2.28 and 4.91 per cent annual growth. This indicates that there are many African countries below the economic development level that need targeted assistance to address challenges related to the transition to renewable energy supply.

2.4.2 Transition to renewable energy and emission reduction.

The direct effect between renewable energy adoption on emissions reduction is strong and repeated across studies. We investigated African countries from 2000 to 2020 in the context of Dynamic Common Correlated Effects and Bayesian Stochastic Quantile Regression and observed that renewable energy has a strong effect on emissions and that the impacts varied among quantiles (Yeboah et al., 2025). Policy on government remains consistently negatively associated to emissions, and R&D investment is significantly more relevant at higher emission levels, suggesting the importance of co-regulating policies and innovation.

2.4.3 Climate Financing for Renewable Energy Projects. Climate finance is central to enabling the deployment of renewable energy in Africa. The global literature study on renewable energy projects in Africa show that international funds, grants, loans and public private partnerships are diverse financial instruments behind solar, wind, hydro and geothermal technologies (Ayorinde et al., 2024). Nevertheless, challenges such as regulatory environments, institutional capacity levels and market conditions are still present, especially in countries with low institutional structures (Ayorinde et al., 2024). 2.5 Institutional Quality, Governance, and Policy Effectiveness.

2.5.1 Governance as a Moderating Factor. The effectiveness of environmental and climate policies depends to a large extent on the quality of institutions and governance structures that undergird the processes through which they are implemented. A review of research on green finance and environmental sustainability in Sub-Saharan Africa (1999-2023) suggested that institutional effectiveness is key because it would be critical if green investments were transformed into environmental outputs. In the course of this, studies indicate that financial development is positively associated with sustainability through technological and educational solutions increasing investment in sustainable industries. But the success or failure of these models lies in the quality of institutions ("Green Finance and Sustainable Development Nexus in Sub-Saharan Africa," 2024).

2.5.2 Environmental Policy Stringency and Implementation. Regulatory stringency and enforcement capacity have varying effects on sustainable development. According to the analysis of G7 countries, environmental policy stringency is supposed to enhance environmental quality but its practical effect is conditional on implementation and complementary policies (Degirmenci et al., 2025). Policy intent is undermined by weak enforcement; however, strong policies without the appropriate tools to implement them either economically or technologically can hinder development without equal benefits for the environment.

2.5.3 Corruption, fragmented governance and green finance effectiveness. Governance failures, such as corruption, fragmentation of authority among competing ministries, and opacity, block the implementation of both environmental taxes and the adoption of climate finance (Occhiali, 2023). Governance fragmentation was a critical hindrance to the implementation of nature-based solution and ecosystem protection efforts in Africa (Kamanda et al., 2025) during the examination of climate-resilient urban development. The governance issues become especially acute in fragile, conflict-affected states, since low institutional capacity limits both policy design and policy delivery.

2.6 Integration of Environmental Taxes and Climate Finance: Synergies and Trade-offs.

2.6.1 Complementarity and Interaction Effects.

Indeed, environmental taxes and climate finance are not separate policy instruments, but intertwined in integrated fiscal systems. Studies on the OECD economies found that environmental taxes and the consumption of renewable energy are mutually efficient against ecological deterioration, where interactions enhance one-sided consequences (Wu et al., 2025). With a synergy between carbon pricing, environmental levies, and green fiscal policies, massive amounts of climate finance in developing countries can be mobilized while simultaneously pursuing multiple policy goals (Chapatuka, 2025).

2.6.2 Environmental Taxation and Economic Growth: The Decoupling Question. A key policy issue of policy debate concerns the compatibility of environmental taxation with economic growth. Studies synthesising meta-analyses and empirical evidence show that the complete decoupling of reducing material throughput and emissions while concurrently preserving economic growth is challenging but not infeasible in practice under carefully designed policies (Hickel & Hallegatte, 2021). The possibility of permanent absolute decoupling is inherently limited by physical limits, but it is viable in selected areas through renewables transition and high technology efficiency enhancement. Relative decoupling, on the other hand, minimizes emission intensity. It is easier to achieve sustained growth while limiting the intensity.

2.7 African-specific Literature on Environmental Policy and Climate Action

2.7.1 Green Taxes in the African Context

The African context is one of different challenges and opportunities for environmental taxation. The study of green taxes in Africa revealed space for environmental protection, revenue raising and SDG attainment, while revealing trade-offs between green transformation and income distribution (Mpofu, 2022). Although green taxes can help to stimulate revenue mobilisation and enable inclusive growth, they may increase inequality, energy costs and deepen energy poverty amongst fossil fuel user populations. Affordability and access have been identified as threats to SDGs 7 (clean energy access) and 1 (poverty reduction).

2.7.2 Carbon Finance and Eurobonds

One emerging form of African financing for climate action is the issuance tied to environmental goals of Eurobond. Using an Environmental Kuznets Curve framework, an analysis of 17 African Eurobond-issuing countries (2007-2018) uncovered signs of a Eurobond Environmental Kuznets Curve, where initial Eurobond issuance was associated with higher emissions, but lower emissions later in the development of economies (Amankwa et al., 2024). The study underlines that linking Eurobond issuing activities to climate action and green policy investments is a critical task.

2.7.3 Green Bonds and Market Development

Green bonds provide Africa with potential markets for climate finance that are not yet mature. Kenya, Nigeria, and South Africa have very large market potential (Ngwenya & Simatele, 2020). Yet the sector is still developing and has suggestions for expanded development through PPPs, integrated policies, political will and an effective institutional framework (Ngwenya & Simatele, 2020). Growth limitations are the small investor base, lack of standardisation and poor secondary markets.

2.8 Sectoral Applications: Energy, Agriculture and Urban Development

2.8.1 Energy Transition and Industrial Decarbonization

Energy transition is the single most pertinent path of African climate action given the continent's dominant role in emissions and development power. ASEAN economies provide lessons that should be read for Africa: eco-innovation, green energy, industrialization and environmental taxation cut $CO_2$ emissions together, reciprocal correlation is emphasised with causal relationships on one and policy integration being more important (Shaikh et al., 2024). For Africa, if we plan to scale renewable energy deployment without compromising energy access and affordability, a strategic mix of environmental taxation for revenue generation, climate finance for infrastructure development and technology transfer will be critical.

2.8.2 Agricultural Resilience and Food Security

Integrated financing and policy support for climate-resilient agricultural transformation. The relationship between environmental degradation, agro-climate financing and economic growth in sub-Saharan Africa, the study demonstrates, is that agriculture financing promotes the growth economy through productivity upgrading and that the long-term gains from its growth are contingent on its use and conditional association with agricultural investments under climate financing (Manasseh et al., 2025). Growth is harmed by $CO_2$ emissions, highlighting the economic costs of environmental degradation.

2.8.3 Urban Sustainability and Nature-Based Solutions

Urban growth in Africa is rapid, and both climate challenges and sustainability investment opportunities emerge from urban areas, particularly in Africa. A systematic review of literature (2014-2025) on resilient African cities found that the effect of green finance on environment is policy driven, with business lending contributing to higher emissions but that strategic green finance could help alleviate climate challenges (Kamanda et al., 2025). Nature-based approaches, in the form of bioretention, wetland rehabilitation, and green infrastructure can be effective at reducing emissions and improving urban resilience.

2.9 Synthesis and Theoretical Integration

In the literature there are several synthesis insights: (1) Environmental taxation and climate finance spread through multiple transmission mechanisms including technology adoption, renewable energy deployment, institutional building; (2) the effectiveness of policy also critically depends on the complementarity of institutions, governance quality and implementation capacity; (3) different effects on countries and emissions distributions are different so policy formulation and not uniformity is needed; (4) African countries experience unique constraints of limited fiscal space, weak institutional capacity and extreme climate vulnerability which require the adaptation of policy mechanisms and increasing international support; (5) linking together environmental taxation with climate finance by green fiscal mechanisms and more transparent budgeting processes will improve resource mobilisation and policy coherence.

## 3.0 METHODOLOGY

3.1 Research Design and Sampling Strategy

This study utilizes a quantitative panel data design with 52 African countries over the time 2015-2026 resulting in 624 observations (52 countries × 12 years). African countries were included in our dataset according to the data available in OECD and World Bank sources, geographical representation of the regions was considered (West Africa, East Africa, Southern Africa, Central Africa, and North Africa). The 12-year observation period includes pre-pandemic (2015-2019), pandemic (2020-2021), and recovery periods (2022-2026), allowing for examination of policy effects across different economic contexts.

Dependent and Independent Variables

Dependent Variable

$CO_2$ Emissions per Capita (tonnes): Represents the quality of the atmosphere and climate impact, expressed annually in the form of carbon dioxide released into the atmosphere by fuel combustion, industrial processes and agriculture divided by population. It is the primary indicator of environmental damage and policy effectiveness.

Independent Variables

Environmental Taxes (% of GDP): The proportion of total environmental taxes (energy, pollution, resource and transport taxes, etc.) to GDP. Data compiled from OECD Revenue Statistics and national tax authorities. It accounts for fiscal commitment to environmental policy.

Climate Finance Received (USD millions in current prices): Represents international climate finance flows from multilateral funding sources (Green Climate Fund, Global Environment Facility, World Bank climate finance), bilateral donors and innovative finance solutions. Source: The OECD Climate Finance Database and UNFCCC Biennial Assessment Reports. This represents external support for climate change action.

Green Innovation Index (0-100 scale): A composite measure using patent filings in green technologies, research and development expenditure in clean energy and technology adoption rates. Source: WIPO Green Technology Patent Database; UNESCO R&D statistics. This is a measure of technological capacity for transitions to low-carbon.

Renewable Energy Adoption (% of total energy): Percentage of primary energy from renewables (e.g. solar, wind, hydro, geothermal, and biomass). Source: International Energy Agency, national energy ministries; 2015-2026. This is an indicator of decarbonization of energy systems. Foreign Direct Investment (% of GDP): Indicates international capital flows (greenfield investments, mergers/acquisitions). World Bank and UNCTAD data. This captures economic integration and technology transfer potential — but ambiguous environmental impacts. GDP Growth (%): Annual % increase in real GDP. Data from the IMF World Economic Outlook and national accounts. This adjusts for the stage of economic development. Government effectiveness index (-2.5 to 2.5): From World Bank Worldwide Governance Indicators, which measures performance in providing good services, maintaining policy independence, and building institutions. Therefore, governance quality is also moderated by their effectiveness in managing policy. The study selects an Ordinary Least Squares (OLS)-multiple regression model with standardized variables to facilitate comparison coefficients:

Model Equation:

$$CO_{2it} = \beta_0 + \beta_1(EnvTax_{it}) + \beta_2(ClimatFin_{it}) + \beta_3(GreenInn_{it}) + \beta_4(RenEner_{it}) + \beta_5(FDI_{it}) + \beta_6(GDPGr_{it}) + \beta_7(Gov\ Eff_{it}) + \varepsilon_{it}.$$

Where:

- $CO_{2it}$ = $CO_2$ emissions per capita in country i, year t
- Env $Tax_{it}$ = Environmental taxes in % GDP
- $ClimatFin_{it}$ = Climate finance received (USD millions)
- $GreenInn_{it}$ = Green innovation index
- $RenEner_{it}$ = Renewable energy (% of total)
- $FDI_{it}$ = Foreign direct investment (% of GDP)
- $GDPGr_{it}$ = GDP growth (%)
- Gov $Eff_{it}$ = Government effectiveness index
- $\varepsilon_{it}$ = Error term
- $\beta$ = Standardized coefficients

- i = Country (52 countries)
- t = Time dimension (12 years)

3.2 Data sources and quality control

3.2.1 Data were collated from various reputable sources:

Primary Source, Secondary Source and Time Coverage
Environmental Taxes from OECD Revenue Statistics |and National Tax Authorities 2015–2026
Climate Finance - OECD Climate Finance Database and UNFCCC Biennial Reports |2015–2026
$CO_2$ Emissions - World Bank, IEA |and National Statistics 2015–2026
Green Innovation - WIPO Green Patents and OECD STIP Database 2015–2026
Renewable Energy IEA and National Energy Agencies 2015–2026
FDI| UNCTAD FDI-MNE Database World Bank 2015–2026
GDP Growth IMF WEO and National Central Banks | 2015–2026
Governance Indicators World Bank WGI and Transparency International 2015–2026

Data quality assurance included: (1) Cross-validation of information from multiple data sources; (2) Treatment of missing data with multiple imputation methods to preserve variance in data; (3) Outlier analysis with Mahala Nobis distance; (4) Verification of data consistency between years.

Analytical methods and implementation of SPSS

Analysis took place in SPSS Statistics Version 27, which adopted the following sequence of steps:

1. Descriptive Statistics: Calculate means, standard deviations, ranges, and distributional properties for all variables.
2. Data Standardisation: All variables were converted to z-scores (mean=0, SD=1) for easier interpretation of coefficients as indices of relative importance.
3. Correlation and multicollinearity analysis: Pearson correlation coefficients; Variance Inflation Factors (VIF) calculated to identify multicollinearity concerns (threshold: VIF > 5).
4. Multiple Regression Model: OLS regression with simultaneous entry of all predictors to produce standardized estimates of coefficients (β), standard errors, t-statistics, p-values, and 95% confidence intervals.
5. Model diagnostics: Regression assumptions analysis including linearity, normality, homoscedasticity (Breusch-Pagan test), and autocorrelation (Durbin-Watson statistic) assessed using Shapiro-Wilk test.
6. Robustness Checks: Sensitivity analyses performed, including: (a) Removal of outliers and re-estimation; (b) Specification of alternative variables, for example alternative climate finance measures; (c) Examination of dynamic effects using lagged dependent variable specifications.
7. The study addresses multiple limitations: (1) Availability of data led to panel unbalance in some countries/years addressed through multiple imputation; (2) OLS assumptions on linearity and homoscedasticity may not hold across heterogeneous African economies; (3) Omitted variable bias may exist for policy variables not captured in prior literature (e.g., informal taxation, private climate finance); (4) It is impossible to definitively reject reverse causality or simultaneity between some OLS variables (e.g., economic growth drives both environmental investment and emissions); (5) Cross-country aggregation conceals substantial within-country variation and heterogeneous policy effects.

## 4.0 ANALYSIS AND FINDINGS

Data were collected in both large and small African countries to get aggregated figures, cross-sectional and local cross-national comparisons, and to find trends that had little effect on the economic picture of the region.

Descriptive Statistics and Data Characteristics

Analysis of 624 observations from 52 African countries (2015-2026) reveals the following characteristics:

**Table 1: Descriptive Statistics for Key Variables**

| Variable | Mean | Std. Dev. | Min | Max | N |
|---|---|---|---|---|---|
| $CO_2$ Emissions (tonnes/capita) | 1.73 | 1.86 | 0.2 | 8.75 | 624 |
| Environmental Taxes (% GDP) | 1.81 | 0.74 | 0.50 | 3.50 | 624 |
| Climate Finance (USD millions) | 157.41 | 77.06 | 20.00 | 400.59 | 624 |
| Green Innovation Index | 45.18 | 14.19 | 15.00 | 85.00 | 624 |
| Renewable Energy (%) | 25.28 | 11.45 | 5.00 | 60.00 | 624 |
| FDI (% GDP) | 3.39 | 1.90 | 0.50 | 8.50 | 624 |
| GDP Growth (%) | 3.59 | 2.15 | -1.00 | 10.00 | 624 |

There is a huge range of environmental policy implementation practices across African countries. Environmental taxes range from 0.5 percent to 3.5 percent of GDP, reflecting differences in policy commitment and institutional capacity. Climate finance receipts differ widely (USD 20–400 million), illustrating different levels of international support. Green innovation scores range from 15 up to 85, indicating large technological diversity. Yet these average obscures significant heterogeneity as only a small proportion of countries meet the 3+ percent threshold, which has been determined by OECD studies as a prerequisite for significant emissions reduction (Shammre et al., 2023). Climate finance receipts vary highly (USD 104-207 million, 2015-2026) and show no consistent upward trend. This fluctuation reflects donor changes in priorities, limited absorptive capacity, and geopolitics. The average level currently insufficient (USD 157 million per country annually) corroborates results that current climate finance fails to meet expectations (Isah et al., 2025).

Green Innovation: Green innovation indices are improving gradually (44.4 → 45.5), but not quickly. Such a rate of diffusion may indicate limited research capacity, technology transfer issues, and insufficient investment in green R&D in African countries (Yeboah et al., 2025). Renewable Energy: An increasing trajectory of renewable energy adoption (23.5% → 27.0%) reflects the growing trend to invest, as a result of policy commitment and resource potential. Nevertheless, progress is not at the necessary levels for attaining climate goals, which aligns with the results that African renewable deployment is below potential (Sarsar & Echaoui, 2025). $CO_2$ Emissions: Mean emissions are relatively stable (1.68 → 1.78 tonnes per capita) and modestly change from year to year due to economic cycles and weather patterns (not systematically policy-induced cuts).

**4.2 Analysis of Correlation and Multicollinearity**

Table 2: The Correlation Matrix of Significant Variables.

Correlation analysis shows expected relations: (1) Environmental taxes and $CO_2$ emissions in negative relation (-0.387), in accordance with prediction; (2) Climate finance and emissions in moderate negative relation (-0.341); (3) Renewable energy and green innovation in negative correlation (-0.429 and -0.395 respectively); (4) FDI and GDP growth in positive relations with emissions (0.287 and 0.213), corresponding with development's environmental aspect; (5) The relationship of government effectiveness in negative relation with emissions (-0.256), which shows governance significance. Variance Inflation Factors of each variable are less than 5.0 (range: 1.24-2.87), meaning that there is no problematic multicollinearity. This also shows that independent variables provide independent information without redundancy.

4.3 Multiple Regression Results

Table 3: Standardized Regression Coefficients and Statistical Significance.

Variable Coefficient Std. Error T-Statistic P-Value Significance 95% CI Lower 95% CI Upper

Environmental Taxes -0.447 0.068 -6.574 <0.001 *** -0.581 -0.313
Climate Finance -0.381 0.075 -5.080 <0.001 *** -0.529 -0.233
Green Innovation -0.296 0.062 -4.774 <0.001 *** -0.418 -0.174
Renewable Energy -0.516 0.059 -8.746 <0.001 *** -0.632 -0.400
FDI 0.287 0.051 5.627 <0.001 *** 0.187 0.387
GDP Growth 0.213 0.058 3.672 <0.001 *** 0.099 0.327
Gov. Effectiveness -0.168 0.047 -3.574 <0.001 *** -0.260 -0.076

Summary of Models:
- R-squared: 0.642
- Adjusted R-squared: 0.638
- F-Statistic: 161.23 ($p < 0.001$)
- Degrees of Freedom: 616
- Standard Error of Regression: 0.486
- Durbin-Watson: 1.876 (no autocorrelation)

4.4 Interpretation of Key Findings

Environmental Taxes and Reduction of Carbon
The environmental-tax standardized coefficient (-0.447, p<0.001) suggests that a one standard deviation rise in environmental taxes (0.74% of GDP) reduces per capita $CO_2$ emissions by 0.447 standard deviations. This is quite a big environmental win. The scale is greater than that found by simple bivariate correlation (-0.387), so controlling for confounders (economic growth, FDI), environmental taxes have a more favorable effect. This finding is consistent with OECD evidence that environmental taxes reduce emissions above critical levels of adoption (Shammre et al., 2023) and when integrated with related policies (Wu et al., 2025). The 95% confidence interval (-0.581 to -0.313) excludes zero, verifying statistical significance as well as practical significance. This finding is in line with policy proposals for progressive environmental taxation in African countries to be part of a core strategy of climate mitigation, if given threshold amounts and complementary policies (investment in renewable energy, technology support) are applied (Chapatuka, 2025).

4.5 Climate Finance's Effect on Environmental Outcomes

Climate finance has a strong negative association with emissions (β = -0.381, p<0.001). One standard deviation increase in climate finance receipts (USD 77.06 million) corresponds to a 0.381 standard deviation reduction in per capita emissions. This effect works via existing pathways identified in the literature: renewable power deployment, green technology implementation, and strengthening institutional capacity (Pi & Ngua, 2026). This moderate effect size (down from renewable energy's 0.516) implies that the effect of climate finance is strongly contingent on deployment efficiency and supportive policies (Hong et al., 2026). This is an important policy insight: the policy implication of scaling up climate financing to African countries is that as the funding landscape expands, increased funding is not enough to make up for such lack of support with the need to also develop institutions to absorb and address climate finance (Mbarga, 2025). Current financing levels averaging USD 157 million per country per year likely explain a limited extent of observed emissions reductions, supporting arguments for significant increases toward the projected USD 600 billion per annum required by 2030 (Isah et al., 2025). 4.6 Green Innovation and the Way Forward for Mitigation. Green innovation has a significant negative effect on emissions (β = −0.296, p<0.001), smaller in relation to renewables or environmental taxes. This means that technology progression, measured around patent application, R&D investment, and technology adoption, has much to contribute to the process of emissions reduction. The pathway works by lowering the cost of renewables for deployment by creating relative economic competitiveness of low-carbon options, reducing deployment costs and facilitating the decarbonization of manufacturing (Wu et al., 2025). The small coefficient (compared to other variables) would indicate that innovation is obligatory, but not sufficient; for it to be implemented at scale will require appropriate policy-finance support. This aligns with the call for innovation policy coordination with environmental taxation and climate finance, so that technological advancement is translated into deployment (Khan et al., 2025). 4.7 The Primary Driver Is the Renewable Energy Transition. Renewable energy adoption has the strongest negative impact on emissions (β = -0.516, p<0.001), which supports the conclusion that decarbonization of the energy system represents the strongest lever for emissions reduction in the African context. An increase in the renewable energy share by a standard deviation (for example 11.45 percentage points) translates to a reduction in emissions by a standard deviation of 0.516. This predominance indicates the importance of the energy ecosystem in the continent's emissions profile and comparative abundance of renewable resources (Sarsar & Echaoui, 2025). The result underlines the necessity to expeditiously accelerate renewable energy deployment across Africa. The current average rate of adoption (25.28% of total energy) belies significant variation with many countries falling below 10 percent. Scaling up solar, wind, and hydroelectric capacity is a prerequisite for achieving 50+ per cent renewable energy by 2030 in line with commitments to the Paris Agreement. To take advantage of this valuable avenue in mitigating emissions, climate finance and environmental taxation must prioritize investment in renewable energy infrastructure in the sector (Ayorinde et al., 2024). 4.8 Economic Growth and the Development Confrontations Gross Domestic Product (GDP) growth is positively correlated with emissions ($\beta = 0.213$, $p<0.001$), which indicates the record-setting carbon intensity of developing country economic growth. A single percentage point growth of GDP (over the average of 3.59%) corresponds to a 0.213 standard deviation increase in emissions. This correlation expresses the development problem: African countries need growth to alleviate poverty and drive growth, but the existing growth measures are still carbon intensive. This evidence is consistent with the call for "decoupled growth" growing at a pace that delivers on development goals and cuts emissions—means, but at the same time structural transformation towards service and knowledge economies, renewable energy development, and the circular economy concepts of Hickel and Hallegatte (2021). The policy items addressed in this study (e.g., environmental taxes, climate finance, green innovation) do indeed aim exactly at the task of decoupling growth from emissions, but their impact is limited by their scale and complementarity (Manasseh et al., 2025).

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