

The Nexus between Green Finance, Climate Finance, and Sustainable Development in Nigeria: An ARDL Bounds Testing Approach

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Research Article

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Abstract

This study investigates the role of green and climate finance in promoting sustainable development in Nigeria, focusing on their scale, structure, trends, and empirical effects. Using annual data covering 1990-2023, the paper applies the Autoregressive Distributed Lag (ARDL) model to examine both the short-run and long-run dynamics between the Sustainable Development Index (SDI) and key explanatory variables - Green Finance Index (GFI), Climate Finance (CF), Foreign Direct Investment inflows (FDI_IN), Inflation (INF), and Domestic Credit to the Private Sector (DC_PS). Descriptive statistics, correlation analysis, and diagnostic stability tests complement the econometric analysis. Results show that both green finance and climate finance exert positive and significant long-run effects on sustainable development in Nigeria, confirming the study's hypothesis. In the short run, green finance maintains a positive but marginal effect, while climate finance initially exerts a negative influence, likely due to transitional implementation costs and institutional inefficiencies. Control variables reveal mixed outcomes: FDI inflows negatively influence sustainability in the short run, inflation undermines stability, whereas domestic credit expansion supports sustainable growth. The error-correction term indicates rapid adjustment to long-run equilibrium, and diagnostic tests confirm model reliability. The study concludes that although green and climate finance are key catalysts for sustainability, their current scale and structure remain inadequate to meet Nigeria's climate and development goals. Policy recommendations emphasize strengthening institutional coordination, diversifying financing instruments, expanding private-sector participation, and enhancing transparency and monitoring frameworks to close the financing gap and accelerate progress toward the country's 2030 and 2060 climate targets.

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1. Introduction

Over the past decade, the pursuit of sustainable development has gained unprecedented global attention in response to escalating environmental challenges such as climate change, ecosystem degradation, and the depletion of natural resources. The United Nations Sustainable Development

Goals (SDGs) underscore the need for an integrated approach that balances economic growth, environmental protection, and social inclusion to achieve long-term prosperity (Biggeri et al., 2019). Within this global framework, green finance - encompassing environmentally responsible financial instruments such as green bonds, green loans, carbon credits, and sustainability-linked securities, has emerged as a critical mechanism for financing the transition toward low-carbon, climate-resilient economies (Pat-Natson et al., 2025; Climate Bonds Initiative [CBI], 2022). Complementing this, climate finance, which refers to both domestic and international financial flows targeted at climate change mitigation and adaptation, serves as a vital tool for supporting vulnerable sectors and facilitating the shift toward sustainable growth (Climate Policy Initiative [CPI], 2025; Nguyen & Le, 2025). Developed economies such as the United States, China, and members of the European Union have spearheaded the implementation of innovative green finance mechanisms, including sustainable lending policies, carbon pricing frameworks, and fiscal incentives for renewable energy investments (Flammer, 2021; Bolton & Kacperczyk, 2021; Sun et al., 2023). These strategies have successfully catalyzed low-carbon transitions, enhanced energy efficiency, and supported sustainable infrastructure development. By contrast, developing and emerging economies, particularly in Africa, are still at nascent stages in their adoption of green finance, though progress is steadily increasing. Countries like South Africa, Kenya, and Morocco have emerged as continental leaders in green bond issuance and renewable energy financing. At the continental level, the African Development Bank (AfDB) has played a pivotal role through its Climate Change Action Plan, aimed at mobilizing capital and strengthening climate resilience (Taghizadeh-Hesary et al., 2022). Nonetheless, many African nations continue to face systemic financial, institutional, and policy-related obstacles that hinder the scaling up of green finance. Weak financial systems, limited access to private capital, and inadequate policy coherence remain critical challenges (Miranda-García & Segovia-Vargas, 2024).

Nigeria, as Africa's most populous nation and West African largest economy, reflects both the promise and the constraints of sustainable development. The country's economic structure remains heavily dependent on fossil fuels, coupled with widespread deforestation, pollution, and inefficient industrial practices that have significantly degraded the environment (Akpan & Chuku, 2011). In recent years, Nigeria has launched several green finance initiatives, such as the Green Bond Programme, renewable energy policies, and sustainability reporting frameworks, to drive its environmental transition. However, these initiatives face persistent hurdles, including weak institutional capacity, limited access to green credit facilities, and insufficient policy coordination (Pat-Natson et al., 2024). The Nigeria Development Bank (NDB), established to support sustainable investments, has also struggled to meet its objectives due to undercapitalization, bureaucratic bottlenecks, and poor risk management (Otalí & Monye, 2023).

One of Nigeria's most urgent environmental challenges is environmental degradation, characterized by deforestation, industrial pollution, and poor waste management practices. These issues have led to increased greenhouse gas emissions, biodiversity loss, and ecosystem decline (Olowoyeye, 2023). Green bond financing presents a vital opportunity to address these challenges by supporting reforestation, renewable energy generation, and waste recycling programs that foster ecological restoration and sustainable livelihoods. In the energy sector, Nigeria's infrastructure remains insufficient to meet domestic demand, as power generation is dominated by non-renewable sources, leading to high production costs and frequent power outages (Aliyu et al., 2013). Expanding access to green loans and concessional financing for renewable projects such as solar, hydro, and wind energy could reduce the nation's reliance on fossil fuels while promoting industrial productivity and social welfare.

Financial exclusion remains a significant barrier to inclusive growth. Many small and medium-sized enterprises (SMEs), which form the backbone of the Nigerian economy, struggle to access affordable financing due to high interest rates, collateral requirements, and limited financial infrastructure (Kigbu, 2025). The introduction of sustainability-linked credit mechanisms and concessional loans within green finance frameworks could alleviate these challenges, allowing SMEs to adopt sustainable and energy-efficient business models. Likewise, in the agricultural sector, climate change and land degradation have led to erratic rainfall patterns and declining productivity, threatening food security and rural livelihoods (Ononogbo et al., 2024). Green finance - through green bonds, credit lines, and climate-smart agricultural funding, offers viable solutions for supporting irrigation systems, organic farming, and agroforestry practices that promote environmental conservation and long-term resilience. Institutional weaknesses, governance issues, and corruption have further undermined Nigeria's capacity to implement sustainability initiatives effectively (Eze & Mbah, 2024). Strengthening regulatory frameworks, improving policy coordination, and enhancing transparency in green finance allocation, such as through independent verification systems, could significantly boost investor confidence and accountability. Additionally, green finance has the potential to enhance climate resilience by funding infrastructure that mitigates the impacts of floods, droughts, and extreme weather events that frequently disrupt economic activities in Nigeria (Akogwu, 2025). Industries facing pollution challenges (Ebong et al., 2023) can also benefit from green credit lines supporting clean production technologies and circular economy models.

Nigeria's transportation sector, which relies heavily on fossil fuels, is a major contributor to carbon emissions (Akujor et al., 2022). Green investments in electric vehicles, mass transit systems, and non-motorized transport infrastructure could reduce emissions while improving mobility and urban air quality. Likewise, water resource management presents another opportunity for sustainability-oriented investment. Persistent water scarcity, pollution, and poor infrastructure continue to threaten both livelihoods and public health (Isukuru et al., 2024). Green finance initiatives directed toward water recycling, sanitation, and desalination projects can strengthen resource efficiency and ensure equitable access to clean water. Rapid urbanization compounds Nigeria's environmental challenges, with increased energy demand, waste generation, and unplanned settlements intensifying sustainability pressures (Aliyu et al., 2017). Green bonds and sustainable construction financing for eco-friendly housing, smart grids, and low-carbon infrastructure can promote efficient resource use and improve living standards. However, the effective adoption of such financial instruments depends heavily on awareness, education, and institutional capacity building. Limited understanding among policymakers, businesses, and investors regarding the potential of green finance hinders its integration into national development planning (Eke & Oghene, 2025). Promoting environmental literacy and financial education is therefore essential to unlocking the full potential of sustainability-oriented finance.

Recent reports and empirical studies reveal that despite some progress, Nigeria's green and climate finance landscape remains underdeveloped relative to its sustainability needs. The *Landscape of Climate Finance in Nigeria (2025)* report by the Climate Policy Initiative (CPI) estimates that Nigeria attracted approximately USD 2.5 billion in tracked climate finance flows during 2021-2022, a 32 percent increase from previous years. However, the country still faces an annual climate finance gap exceeding USD 27 billion, underscoring the insufficiency of current financing flows to meet its climate and sustainability targets (CPI, 2025). Most of these funds are sourced from public or concessional channels, highlighting limited participation from domestic private investors and overreliance on international institutions.

Empirical findings by Pat-Natson et al. (2025) confirm that green credit, carbon finance, and green securities significantly influence environmental sustainability by reducing greenhouse gas emissions and promoting renewable energy investments. Nonetheless, weak institutional capacity, fragmented policy frameworks, and insufficient investor awareness continue to impede large-scale progress. The integration of green finance and climate finance thus represents a strategic pathway for Nigeria to mobilize both public and private resources toward achieving its Nationally Determined Contributions (NDCs) and broader sustainable development goals. While climate finance primarily addresses macro-level adaptation and mitigation, green finance serves as its market-driven complement, mobilizing private capital and fostering innovation in environmental solutions (Rasoulinezhad & Taghizadeh-Hesary, 2022). The financial sector- through instruments such as green bonds, sustainability-linked loans, and ESG-aligned investments, plays a crucial role in influencing corporate behavior and channeling capital toward low-carbon and inclusive growth.

Despite the growing significance of these mechanisms, there remains a shortage of empirical research exploring the combined impact of green and climate finance on Nigeria's sustainable development. Existing literature often treats these domains separately, focusing either on environmental outcomes or on financial development in isolation without fully examining their interconnected effects on sustainable development (economic growth, environmental quality, and social welfare). This study, therefore, seeks to bridge that gap by empirically analyzing how green and climate finance jointly influence sustainable development in Nigeria, drawing on recent data from domestic financial institutions, the World Bank, and international climate finance databases. The findings are expected to offer valuable policy insights on how green and climate finance contribute in advancing Nigeria's sustainability agenda.

In pursuit of this objective, the study is guided by the following research questions:

1. What is the current scale, structure, and trend of green and climate finance in Nigeria?
2. How do green finance instruments (green credit, green securities) and climate finance influence sustainability development indicators? In line with this research question, the main hypothesis of the study is green finance and climate finance positively impact sustainable development both in the long and short-run in Nigeria.
3. To what extent does climate finance contribute to Nigeria's progress in climate adaptation and mitigation goals?
4. What are the key barriers preventing effective mobilization and utilization of green and climate finance in Nigeria?
5. How can Nigeria strengthen its institutional and policy framework to enhance the impact of sustainable finance on development outcomes?

The remainder of this paper is organized as follows. Section 1.1 describes the current scale, structure, and trends of green and climate finance in Nigeria. Section 1.2 examines the extent to which climate finance contributes to Nigeria's progress in climate adaptation and mitigation goals. Section 1.3 briefly discusses the key barriers preventing the effective mobilization and utilization of green and climate finance in Nigeria. Section 2 presents the literature review on the impact of green and climate finance on sustainable development in Nigeria. Section 3 outlines the research methodology, including data collection and the theoretical and mathematical frameworks for model analysis.

Section 4 presents the research results and discussion, while Section 5 provides the conclusions, highlights the study's limitations, and offers recommendations for future research and policy.

1.1. Current Scale, Structure, and Trend of Green and Climate Finance in Nigeria

Green and climate finance have become central to Nigeria's efforts to transition toward a sustainable and low-carbon economy. These financial mechanisms encompass a range of public and private investments aimed at supporting projects that mitigate greenhouse gas emissions, enhance climate resilience and promote environmental sustainability. Despite Nigeria's significant exposure to climate risks such as droughts, flooding and desertification, the country's access to climate-related finance remains limited compared to its developmental needs (Climate Policy Initiative [CPI], 2025). Understanding the scale, structure and trend of these financial flows is therefore critical for assessing their potential contribution to sustainable development.

1.1.1. Scale of Green and Climate Finance in Nigeria

According to the Climate Policy Initiative 2025 report, Nigeria mobilized approximately USD 2.5 billion in climate-related finance during the 2021-2022 period, representing a 32 percent increase compared to USD 1.9 billion recorded in 2019-2020 (CPI, 2025). This upward trend demonstrates growing attention to sustainable financing within the country, particularly from international and multilateral institutions. However, the report also reveals that Nigeria faces an annual climate finance gap of about USD 27.2 billion, suggesting that current inflows account for less than 10 percent of the estimated financing required to achieve its Nationally Determined Contributions (NDCs) and Sustainable Development Goals (SDGs) (CPI, 2025). Complementary evidence from Connected Development (2025) shows that between 2015 and 2021, Nigeria received USD 4.93 billion across 828 climate-related projects, with 75 percent of this funding disbursed as loans. This loan-heavy composition raises concerns about the sustainability of Nigeria's debt burden and highlights the limited availability of grants and concessional finance for climate action. Compared to other African economies, Nigeria's climate finance inflows remain modest. For context, the Climate Policy Initiative [CPI] (2024) report notes that total climate finance to Africa rose by 48 percent to USD 44 billion in 2021-2022, yet this amount still represents only a quarter of the continent's estimated annual requirement. This comparison emphasizes the need for Nigeria to strengthen domestic mobilization and attract greater private-sector participation.

1.1.2. Structure of Green and Climate Finance

The structure of Nigeria's climate finance flows is characterized by a dominance of public-sector contributions and multilateral development finance institutions (DFIs). The CPI (2025) report indicates that public actors accounted for about 70 percent of total climate finance flows in 2021-2022, while private sector participation contributed approximately 30 percent, marking a gradual but notable improvement from 23 percent in 2019-2020. This shift suggests an emerging recognition of the private sector's role in financing sustainable development, although it remains significantly below global benchmarks. In terms of financial instruments, loans constitute the bulk of Nigeria's climate finance portfolio, followed by grants and equity investments. The predominance of debt-based instruments underscores the limited use of innovative financing tools such as blended finance, guarantees and green securitization, which could better attract private investors. Nigeria has,

however, made notable progress in issuing sovereign green bonds, which have set precedents for sustainable finance in Africa. The first green bond, valued at ₦10.69 billion, was issued in 2017, followed by a second issuance of ₦15 billion in 2019. In 2025, the Debt Management Office (DMO) introduced plans for a third (Series III) green bond program, reinforcing the government's commitment to financing renewable energy, afforestation and sustainable agriculture projects (DMO, 2025). Sectorally, most climate finance flows to Nigeria are concentrated in agriculture, forestry and other land use (AFOLU), water and wastewater management and the energy sector (CPI, 2025). These allocations align with Nigeria's adaptation priorities and reflect ongoing efforts to improve agricultural resilience, enhance irrigation systems and expand access to renewable energy. However, other critical sectors such as waste management, transport decarbonization and coastal protection remain underfunded, indicating a mismatch between national climate vulnerabilities and current financing patterns.

1.1.3. Trends in Green and Climate Finance

Overall, the trend in Nigeria's climate finance demonstrates incremental growth but insufficient scale to close the existing financing gap. Flows have increased consistently by about one-third between 2019/20 and 2021/22 but they remain less than 10 percent of the country's estimated annual climate finance need (CPI, 2025). The composition of finance is slowly diversifying, with Nigeria's green bond issuances marking an important innovation in domestic sustainable finance markets. These issuances have financed projects in renewable energy, efficient transport and afforestation (Adejojo, 2022; Ehlers & Packer, 2017). Moreover, private sector participation, though still limited, has shown positive movement, with domestic banks and investors beginning to explore ESG-aligned investments and green credit facilities. Despite this progress, persistent challenges constrain the expansion of Nigeria's green and climate finance landscape. These include limited technical capacity within financial institutions, weak policy coordination among regulatory agencies, and inadequate data transparency across the project lifecycle, from planning to monitoring. Governance gaps also hinder the crowding-in of private capital, as investors seek clearer regulatory frameworks, predictable returns, and de-risking mechanisms. Addressing these barriers will be crucial for mobilizing sufficient finance to meet Nigeria's climate and sustainability objectives.

1.2. The extent to which climate finance contribute to Nigeria's progress in climate adaptation and mitigation goals

Nigeria's adaptation and mitigation goals are anchored in its updated Nationally Determined Contribution (NDC), which commits to an unconditional 20% reduction below business-as-usual (BAU) emissions by 2030 and a 47% conditional reduction contingent on international support, alongside a 2060 net-zero ambition (UNFCCC/NCCC, 2024; NDC Partnership, 2021). In this context, climate finance - domestic and international flows that support mitigation and adaptation plays a catalytic role in enabling investments that otherwise would not occur at adequate speed or scale. In terms of scale of support relative to need, tracked climate finance to Nigeria increased from about USD 1.9 billion in 2019/20 to roughly USD 2.5 billion in 2021/22, according to Climate Policy Initiative's most recent country landscape (CPI, 2025; CPI, 2022). While this marks clear progress, CPI also documents that current volumes remain far below Nigeria's estimated annual requirements through 2030, leaving a substantial financing gap (CPI, 2025). Global context from UNEP's Adaptation Gap Reports reinforces the magnitude of shortfall facing developing countries: adaptation needs are 12–14× current public flows (UNEP, 2025; see also Ozoemena et al., 2026). For Nigeria,

the implication is that climate finance is material but insufficient, accelerating implementation in priority sectors, yet not at the scale required to fully meet NDC-aligned trajectories.

Looking at the contribution to mitigation, climate finance has supported renewable energy, energy efficiency and land-use measures that directly lower emissions. Nigeria pioneered sovereign green bonds in Africa (₦10.69 bn in 2017; ₦15 bn in 2019) whose use of proceeds targeted energy and land-use projects, e.g., solar or energy-efficiency installations and afforestation or reforestation, thereby reducing power-sector emissions and enhancing carbon sinks (Adejo, 2022). These sovereign issuances helped seed Nigeria's labeled-bond market (ALN Nigeria, 2024). CPI's Nigeria landscape further shows that mitigation-relevant sectors such as energy and AFOLU (agriculture, forestry and other land use), attract a significant share of flows, consistent with Nigeria's NDC focus on clean power, efficient cooking, gas flaring reduction and land-use change (CPI, 2025). On the other hand, climate finance has also underpinned adaptation initiatives in agriculture, water/wastewater management and resilience-building, aligning with Nigeria's vulnerability profile (UNDP, 2024; CPI, 2025). Multilateral development finance institutions (MDBs) have been especially important providers of concessional resources and technical assistance for climate-resilient agriculture, irrigation, watershed management and early-warning capacities - investments that reduce climate damages and protect livelihoods. However, consistent with global trends, adaptation finance remains structurally harder to mobilize at scale because cash-flow returns are diffuse or public-good in nature (UNEP, 2025). This helps explain why Nigeria's adaptation needs outstrip available concessional funds, even as adaptation planning has advanced (Ozoemena et al., 2026; AfDB, 2022). Evidence points to three main channels through which climate finance advances Nigeria's goals: (1) project enablement (bringing forward clean-energy, efficiency and resilient-infrastructure investments); (2) market signaling (the green-bond program establishing standards and disclosure that lower future issuance frictions); and (3) institutional capacity building (policy frameworks, MRV systems and pipeline development supported by MDBs). However, CPI highlights limited green fiscal incentives, residual pro-fossil policy distortions, and governance gaps that can deter private capital (CPI, 2025). The financing mix remains loan-heavy, raising debt-sustainability concerns and pointing to the need for more grants, guarantees and blended-finance solutions to de-risk adaptation and frontier mitigation projects (CPI, 2025; CPI, 2022).

Overall, climate finance has meaningfully contributed to Nigeria's mitigation and adaptation progress by financing concrete projects (e.g., renewables, efficiency, afforestation, climate-smart agriculture and water resilience) and by deepening domestic sustainable-finance markets via sovereign and corporate green bonds. Yet, relative to Nigeria's NDC pathway and 2060 net-zero ambition, current volumes and instrument mixes are insufficient. Scaling impact will require: (i) expanding concessional/blended instruments to crowd-in private capital; (ii) strengthening project pipelines and MRV to demonstrate outcomes; (iii) aligning fiscal/sectoral policies with climate objectives (e.g., targeted incentives for clean technologies); and (iv) increasing adaptation allocations where needs are greatest and returns are largely social.

1.3. Key Barriers Preventing Effective Mobilization and Utilization of Green and Climate Finance in Nigeria

Despite the steady growth of green and climate finance in Nigeria over the past decade, the country continues to face significant barriers that hinder both the mobilization and effective utilization of these financial resources. These challenges are multidimensional, cutting across

macroeconomic instability, weak institutional capacity, limited project pipelines, governance deficiencies and policy inconsistencies. Together, these factors have constrained the ability of Nigeria to attract adequate financial flows and channel them toward impactful mitigation and adaptation initiatives.

One of the most persistent barriers is macroeconomic instability, particularly the volatility of exchange rates, high inflation and the rising cost of capital. According to the Climate Policy Initiative (2025), the Nigerian financial environment remains vulnerable to currency depreciation and inflationary pressures, which deter long-term investments in renewable energy and climate-resilient infrastructure. Investors often perceive the macroeconomic risks as too high, leading to higher risk premiums and lower levels of private-sector participation. These challenges also make it difficult for financial institutions to issue long-term, naira-denominated green financial instruments, which are essential for large-scale climate projects. Another critical challenge relates to the limited pipeline of bankable, investment-ready projects. While there is growing interest in renewable energy, sustainable agriculture and climate adaptation, many proposed projects lack feasibility studies, robust financial models, or adequate risk mitigation structures. The Climate Policy Initiative (2024) emphasizes that institutional investors, including pension funds, face real and perceived barriers due to a scarcity of well-structured and de-risked climate projects. Without strong project-preparation facilities and standardized project documentation, private capital remains hesitant to engage in climate-related investments in Nigeria.

The financing structure of Nigeria's climate finance also constrains its effectiveness. Current flows are dominated by debt instruments, particularly concessional loans from multilateral institutions, while the share of grants, equity and guarantees remains limited (World Bank, 2020; AFDB, 2024). This heavy reliance on debt financing raises concerns about debt sustainability and restricts access to early-stage or higher-risk sectors such as climate-smart agriculture and small-scale renewable energy. A more diversified financing mix, incorporating blended finance and risk-sharing instruments, could enhance capital mobilization and reduce dependence on public funds. Institutional and regulatory challenges further undermine the mobilization of green finance. Although Nigeria introduced the Nigerian Sustainable Banking Principles (NSBP) in 2012 and has since made progress in mainstreaming environmental and social risk management across banks, enforcement remains inconsistent, and sectoral policies are not always aligned with climate objectives (Central Bank of Nigeria, 2012; Citibank Nigeria, 2024). The absence of harmonized fiscal incentives, such as tax breaks for renewable energy projects or carbon pricing mechanisms, has also limited investor enthusiasm.

The Climate Policy Initiative (2025) notes that fragmented governance across ministries and agencies often leads to policy duplication and inefficiencies in climate finance coordination. Weaknesses in disclosure, measurement, reporting, and verification (MRV) systems also impede transparency and investor confidence. Adejo (2022) observed that while Nigeria's pioneering sovereign green bonds in 2017 and 2019 established a foundation for sustainable finance, public reporting on project outcomes and environmental impacts remains limited. Without reliable data on emissions reductions, adaptation results, or financial performance, investors find it difficult to assess the credibility of green investments, increasing the perceived risk of "greenwashing." Although Nigeria has committed to adopting the International Sustainability Standards Board (ISSB) reporting framework, the Financial Reporting Council has granted companies a four-year transition period, meaning full implementation will not be immediate (Reuters, 2024). This transitional phase perpetuates inconsistency in corporate climate disclosures. Governance and transparency issues

compound these obstacles. The United States Department of State (2025) notes that regulatory uncertainty, procurement opacity, and corruption continue to deter foreign direct investment and increase transaction costs. These governance risks raise due diligence costs and discourage investors from engaging in long-term green infrastructure projects. Additionally, institutional capacity gaps within banks and financial regulators limit their ability to design, appraise, and monitor climate-aligned projects effectively. Although training programs and policy frameworks like the NSBP have improved awareness, smaller financial institutions still lack the technical expertise to evaluate environmental and climate risks in lending decisions (Citibank Nigeria, 2024; David-West & Adedeji, 2024).

Sector-specific structural issues also constrain utilization. In the power sector, unreliable grid infrastructure and offtaker risk hinder renewable integration, while in the agriculture and land-use sectors, land tenure insecurity and fragmented value chains deter private investment. The Climate Policy Initiative (2025) highlight that addressing such sectoral fundamentals, alongside financial structuring, is essential for unlocking private capital. Moreover, Nigeria's green bond and labeled-finance markets remain nascent, with few instruments offering sufficient liquidity or credit ratings to attract institutional investors. Pension funds, though large, face portfolio restrictions that prevent substantial allocations to climate-aligned assets (Heinrich-Böll-Stiftung & CJID, 2024). Overall, the barriers preventing the effective mobilization and utilization of green and climate finance in Nigeria are systemic and interrelated. Macroeconomic instability discourages long-term investment, a lack of bankable projects restricts pipeline development, and an overreliance on debt-based finance exacerbates fiscal vulnerabilities (Eyraud, Clements & Wane, 2013). Inconsistent regulation, weak transparency, governance risks, and low institutional capacity further compound these issues. Addressing them requires a multifaceted approach that includes macroeconomic stabilization, stronger coordination among institutions, expansion of blended finance mechanisms, transparent MRV systems, and capacity-building across the financial ecosystem. Such reforms would enhance Nigeria's ability to attract sustainable finance at scale and channel it toward achieving its climate adaptation and mitigation goals.

2. Literature Review on the Impact of Green Finance and Climate-Finance on Sustainable Development in Nigeria

The relationship between green finance, climate finance, and sustainable development has gained growing attention in the academic and policy discourse, particularly in developing economies such as Nigeria, where the twin challenges of economic growth and environmental degradation are acute. The scholarship on sustainable finance in Nigeria has expanded rapidly in the last few years, converging on the proposition that green finance and climate finance can accelerate progress toward environmental quality, resilient growth, and social well-being - core dimensions of sustainable development. Two strands dominate the literature. The first examines instrument-level effects of green credit, carbon finance, and green securities on environmental outcomes. The second maps systemic finance flows such as their scale, sources, and sectoral allocation, and evaluates whether these flows align with Nigeria's mitigation and adaptation priorities under the Paris Agreement and its nationally determined contributions (NDCs). Green finance generally refers to financial mechanisms and instruments designed to support environmentally sustainable projects, including renewable energy, sustainable agriculture, waste management, and pollution control. It aims to align economic development with ecological protection by directing capital flows toward low-carbon and

resource-efficient investments (Ezegwu, 2014). This approach extends beyond the narrower concept of climate finance, encompassing initiatives that mitigate greenhouse gas emissions while improving biodiversity, air and water quality, and overall environmental sustainability (Ayeni, 2025; Ekere & Chukwu, 2026).

In Nigeria, green and climate finance have emerged as central policy tools for achieving the Sustainable Development Goals (SDGs) and the country's Nationally Determined Contributions (NDCs). Theoretical and empirical research suggests that well-structured financial interventions such as green bonds, green credit, carbon markets, and sustainable banking policies, can foster inclusive growth while reducing environmental risks. According to Pat-Natson, Ezeaku, and Okafor (2025), green finance significantly improves environmental sustainability indicators by channeling funds toward environmentally friendly projects and reducing carbon emissions. Their study found that green credit, carbon finance, and green securities positively influence environmental quality in Nigeria by facilitating investment in renewable energy and low-carbon infrastructure. Similarly, Adeyemi et al. (2024) argue that green finance stimulates financial innovation, enhances investment in clean technology, and improves environmental performance across Nigerian banks, highlighting a direct linkage between sustainable financial practices and national development outcomes.

The Climate Policy Initiative (2025) provides an extensive overview of the flow, structure, and sectoral allocation of climate finance in the country. The report reveals that Nigeria mobilized approximately USD 2.5 billion in climate-related finance between 2021 and 2022, up from USD 1.9 billion in 2019-2020, signifying increased engagement with climate-aligned investments (Climate Policy Initiative [CPI], 2025; UNEP, 2016). Despite this growth, the report underscores a significant annual financing gap of about USD 27 billion required to meet Nigeria's mitigation and adaptation targets, indicating that the current flow of funds remains insufficient for achieving sustainable development at scale. The structure of these flows, dominated by concessional loans from multilateral development institutions, illustrates the limited involvement of domestic private investors and the need for blended finance instruments to reduce investment risk and attract long-term private capital (CPI, 2025).

Empirical research from other developing regions reinforces the potential of green and climate finance as catalysts for sustainable transformation. Studies across Africa and the BRICS economies have shown that green finance promotes environmental quality through technological innovation, renewable energy deployment, and industrial upgrading (Udeagha & Ngepah, 2023). Green innovation is a key driver of sustainable development because it enables economies to decouple growth from pollution by promoting efficient resource use and cleaner production processes (Ma & Chang, 2023). In Nigeria, green finance policies and sustainable banking frameworks encourage financial institutions to adopt environmental risk assessments and green credit guidelines that support projects with measurable ecological benefits (Central Bank of Nigeria, 2012). These frameworks have helped to direct financial resources toward energy transition and sustainable agriculture, two of Nigeria's most climate-sensitive sectors. The country's sovereign green bond program represents a landmark innovation in Africa's sustainable finance landscape. Nigeria issued Africa's first sovereign green bond in 2017 (₦10.69 billion) and a second in 2019 (₦15 billion), with proceeds allocated to renewable energy, afforestation, and energy-efficiency projects (Adejojo, 2022). The Debt Management Office (2025) notes that a third issuance (Series III) is under consideration to sustain investment momentum. Evaluations of the program have found that the bonds helped establish a regulatory and market precedent for other green instruments while signaling Nigeria's commitment to low-carbon growth. However, scholars also emphasize the need for improved measurement,

reporting, and verification (MRV) mechanisms to enhance transparency and ensure accountability in the use of proceeds (Heinrich-Böll-Stiftung & CJID, 2024).

From a theoretical perspective, green and climate finance are often situated within the broader framework of sustainable development finance theory, which integrates environmental, social, and economic objectives. The flow of green finance facilitates environmental protection by incentivizing industries to adopt cleaner technologies and comply with sustainability standards (Alhassan, 2024). It also supports economic diversification by encouraging investments in green industries such as renewable energy, eco-tourism, and sustainable agriculture, which can generate employment and foster inclusive growth (Campiglio, 2016; Zheng et al., 2025). At the governance level, sustainable finance promotes greater transparency, accountability, and risk management, as financial institutions and corporations are required to adhere to environmental and social safeguards (UNEP, 2018, 2025).

While the positive impacts of green finance on sustainable development are widely acknowledged, the literature also highlights several challenges that hinder its full potential in Nigeria. These include weak institutional frameworks, data limitations, inconsistent policy enforcement, and limited technical capacity among financial institutions to assess and manage environmental risks (CPI, 2025). Macroeconomic volatility, exchange rate instability, and high inflation further discourage long-term investments in sustainable sectors. Additionally, the lack of standardized taxonomies and disclosure frameworks has led to low investor confidence and concerns about greenwashing (Reuters, 2024; Taghizadeh-Hesary & Yoshino, 2019). Addressing these challenges through stronger regulation, targeted fiscal incentives, and improved coordination between public and private actors is critical to scaling up the effectiveness of green and climate finance.

Although existing literature has made significant contributions to understanding the nexus between green finance, and sustainable development, substantial research gaps remain, particularly in the context of Nigeria and similar emerging economies. Most prior studies have focused on either environmental performance or financial development in isolation, without integrating the multidimensional impacts of green and climate finance on sustainable development (economic growth, environmental resilience, and social inclusion). For instance, Pat-Natson et al. (2025) and Adeyemi et al. (2024) provided valuable insights into the role of green credit and carbon finance in improving environmental quality, yet they did not empirically examine how these instruments jointly influence broader sustainable development outcomes, such as economic growth and improve human development. Similarly, while the Climate Policy Initiative (2025) offered a comprehensive mapping of climate finance flows in Nigeria, its analysis remained descriptive and lacked an econometric exploration of how these flows translate into measurable sustainability outcomes over time. The novelty of this study lies in its integrated and empirically grounded approach to assessing the combined impact of green finance and climate finance on sustainable development in Nigeria. Unlike prior works that treat these financial streams separately, this study examines their joint and interactive effects on key dimensions of sustainability - economic growth, Co2 emission, adjusted net saving and human development, using recent and comprehensive datasets drawn from both domestic and international sources.

3. Research Methodology

This study adopts a quantitative research approach to examine the effects of climate finance and green finance on sustainable development. The analysis employs secondary data obtained from relevant international databases and is structured around dependent, independent, and control variables. Sustainable development is measured using a composite Sustainable Development Index

(SDI), while climate finance and the Green Finance Index constitute the main explanatory variables. Selected macroeconomic and financial indicators are incorporated as control variables to account for other factors that may influence sustainable development. The variables are normalized to ensure comparability across different measurement scales, while appropriate econometric techniques are employed to estimate the relationships among the variables. Additional model specifications and control variables are subsequently introduced to assess the robustness of the estimated results.

3.1. Data Descriptions

For the purpose of the model analysis, the dataset is organized into three main categories: dependent variables, independent variables, and control variables.

3.1.1. Dependent variable

The dependent variable in this study is the Sustainable Development Index (SDI), which is constructed through a systematic two-step procedure involving normalization and aggregation of key sustainability indicators. In the first step, all variables are normalized using the z-score method, which standardizes their values with mean of zero and standard deviation of one to ensure comparability across different scales and units. For most indicators, higher values correspond to better sustainability outcomes. However, since higher carbon dioxide (CO₂) emissions indicate lower sustainability, the CO₂ variable is inverted during normalization so that higher normalized scores consistently represent better sustainability performance. In the second step, the Sustainable Development Index is calculated as the simple average of four normalized indicators: the Human Development Index (HDI), Gross Domestic Product (GDP) growth rate, adjusted net savings, including particulate emission damage (current us\$) (ANS), and CO₂ emissions per capita. Each indicator is assigned equal weight in the aggregation process. The resulting SDI values range between zero and one, where higher scores reflect a greater level of sustainability.

3.1.2. Independent Variables

Two independent variables are employed in this study: Climate Finance and the Green Finance Index. Both variables are used to capture the role of environmentally related financial flows in promoting sustainable development, and each was normalized using the same z-score procedure applied to the dependent variable.

1. Climate Finance

Climate finance is proxied by the Official Development Assistance (ODA) Climate-Tagged data, obtained from the OECD's Rio Markers database, for Nigeria. This variable represents the total amount of ODA directed toward activities that target climate-related objectives, such as mitigation and adaptation projects. The data are expressed in constant U.S. dollars (USD) and reflect the financial commitments of donor countries to environmentally focused development programs. Higher values indicate greater international financial support for climate-related initiatives.

2. Green Finance Index

The Green Finance Index is a composite indicator constructed to capture the scale of environmentally supportive domestic financing. It combines two key components:

- Green Credit, represented by IBRD loans and IDA credits (DOD, current USD), reflecting financial flows provided through international development lending that support sustainable or green projects.
- Green Securities, represented by electricity production from hydroelectric sources (% of total), which reflects the degree to which the country's energy portfolio relies on renewable energy sources.

Both components were normalized using the z-score method to a 0-1 range to ensure comparability. The normalized values were then averaged to obtain the Green Finance Index, where higher scores denote a greater level of green financial engagement and renewable energy orientation.

3.1.3. Control Variables

To account for other macroeconomic and structural factors that may influence sustainable development, several baseline control variables are included in the model. These comprise domestic credit to the private sector (% of GDP), inflation (CPI, % of GDP) and foreign direct investment (FDI) inflows (% of GDP). These variables are incorporated to control for the effects of financial depth, price stability, external sector integration, investment inflows, and institutional quality on sustainability outcomes. Each variable is expressed as a percentage of gross domestic product (GDP) to ensure comparability across countries and over time. In addition to the baseline controls, additional variables will be introduced in subsequent model specifications to test the robustness of the results and to assess whether the inclusion of these supplementary factors alters the estimated effects of green finance and climate finance on sustainable development.

3.2. Data Sources and Data Period

The data were sourced from the databases listed in Table 1. The dataset covers the period from 1990 to 2023.

Table 1: Data and Sources

Variables	Labels	Sources
Human Development Index (HDI) proxied by GDP per capita (PPP)	HDI	UNDP
Gross Domestic Product (GDP) growth rate	GDP_Rate	The World Bank
Adjusted net savings, including particulate emission damage (current us\$)	ANS	The World Bank
CO ₂ emissions per capita, in Kilotonnes	CO	Global Carbon Budget (2024)
Climate finance	CF	The OECD's Rio Markers database
Green credit	GC	The World Bank
Green Securities	GS	The World Bank

Domestic credit to the private sector (% of GDP)	DC_PS	The World Bank
Inflation (% change CPI),	INF	The World Bank
Foreign direct investment (FDI) inflows (% of GDP)	FDI_IN	UNCTAD

Source: Author's compilation

3.3. Model Specification

3.3.1. Stationarity and Cointegration Tests

Prior to model estimation, the time-series properties of the variables were examined to determine their order of integration and suitability for econometric modeling. Stationarity was tested using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and DF-GLS (Elliott, Rothenberg, and Stock, 1996) unit root tests. These tests were applied to identify whether the variables were stationary at levels, denoted as $I(0)$, or became stationary after first differencing, denoted as $I(1)$. In addition, the Johansen and Juselius (1990) cointegration test was employed to determine the existence of a long-run relationship among the variables. The outcomes of the unit root and cointegration tests revealed a mixture of $I(0)$ and $I(1)$ variables and the presence of cointegration. This combination implies that the Autoregressive Distributed Lag (ARDL) modeling framework, as developed by Pesaran, Shin, and Smith (2001), is appropriate for the analysis. The ARDL approach is particularly advantageous because it allows estimation when variables are integrated of different orders, provided none are integrated of order two, $I(2)$.

3.3.2. The ARDL Model

Following Banerjee et al. (1993) and Pesaran et al. (2001), the ARDL model is as follows:

$$SDI_t = \alpha_0 + \sum_{i=1}^p \rho_i SDI_{t-i} + \sum_{j=0}^{q_1} \beta_{1j} GFI_{t-j} + \sum_{k=0}^{q_2} \beta_{2k} CF_{t-k} + \sum_{m=0}^{q_3} \gamma_m X_{t-m} + \varepsilon_t,$$

where SDI_t is the dependent variable at time t , α_0 is the constant term, $\sum_{i=1}^p \rho_i SDI_{t-i}$ is the lagged values of the dependent variable, $\sum_{j=0}^{q_1} \beta_{1j} GFI_{t-j}$ is the distributed lags of explanatory variable 1 (GFI), $\sum_{k=0}^{q_2} \beta_{2k} CF_{t-k}$ is the distributed lags of explanatory variable 2 (CFI), $\sum_{m=0}^{q_3} \gamma_m X_{t-m}$ are the control variables (X) with lags, ρ_i , β_{1j} , β_{2k} and γ_m are the model coefficients to be estimated, and ε_t is the error term. The corresponding Error Correction Model (ECM) form of ARDL in the presence of cointegration is as follows:

$$\Delta SDI_t = \alpha_0 + \sum_{i=1}^{p-1} \phi_i \Delta SDI_{t-i} + \sum_{j=0}^{q_1-1} \theta_{1j} \Delta GFI_{t-j} + \sum_{k=0}^{q_2-1} \theta_{2k} \Delta CF_{t-k} + \sum_{m=0}^{q_3-1} \gamma_m \Delta X_{t-m} + \lambda(SDI_{t-1} - \beta_0 - \beta_1 GFI_{t-1} - \beta_2 CF_{t-1} - \beta_3 X_{t-1}) + \varepsilon_t,$$

where Δ denotes the first-difference operator, λ is the error-correction coefficient measuring the speed at which deviations from the long-run equilibrium are corrected, and β_1 , β_2 and β_3 represent the long-run coefficients implied by the estimated ARDL parameters. The coefficients associated with the first-differenced variables capture the short-run dynamics. For convergence toward the long-run equilibrium, the error-correction coefficient is expected to be negative and statistically significant.

3.3.3. Lag Length Selection Criteria

The appropriate lag length for the ARDL model is determined before estimation. According to Blanchard and Quah (1989), an excessively large lag length may result in an over-fitted model, producing inefficient and unreliable estimates, while an overly short lag length may lead to an under-fitted model, omitting important dynamic relationships. Therefore, lag length selection is guided by statistical information criteria that balance model fit and complexity. The most widely used criteria include the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and the Hannan–Quinn Criterion (HQ), defined respectively as:

$$AIC = -2 \ln (L) + 2m$$

$$BIC = -2 \ln (L) + m \ln (n)$$

$$HQ = -2 \ln (L) + 2m \ln (\ln (n))$$

where L is the maximum value of the likelihood function of the estimated model, m denotes the number of estimated parameters, and n represents the number of observations. The model with the lowest value of the information criterion is selected as the optimal lag structure. Among these, the AIC (Akaike, 1998) is used in this ARDL modeling because it tends to favor more efficient models, particularly in small samples.

3.3.4. The ARDL Bounds Testing Approach

The ARDL model incorporates both the short-run and long-run dynamics of the relationship between the dependent and explanatory variables. The framework is based on the bounds testing approach to cointegration proposed by Pesaran et al. (2001), which tests the null hypothesis of no long-run relationship among the variables. The null and alternative hypotheses of the bounds test are specified as:

$$H_0: \beta_1 = \beta_2 = \dots = \beta_{k+1} = 0 \text{ (no cointegration)}$$

$$H_1: \beta_i \neq 0 \text{ for at least one } i \text{ (cointegration exists)}$$

The test statistic used is an F-statistic derived from a Wald test. The decision rule is based on comparing the calculated F-statistic with the critical value bounds provided by Pesaran et al. (2001):

- If the F-statistic is below the lower bound (I(0)), the null hypothesis of no cointegration cannot be rejected.
- If the F-statistic lies between the lower (I(0)) and upper (I(1)) bounds, the result is inconclusive.
- If the F-statistic is above the upper bound (I(1)), the null hypothesis is rejected, confirming the existence of a long-run relationship among the variables.

Once cointegration is established, both restricted and unrestricted error correction models (ECM) are estimated. The ECM incorporates the error correction term (ECT), which measures the speed at which the dependent variable returns to equilibrium after short-run shocks. A negative and statistically significant ECT coefficient confirms the existence of a stable long-run relationship.

3.3.5. Model Application and Justification

According to Hill et al. (2012), the ARDL model serves as a powerful tool for investigating dynamic relationship among variables, forecasting and multiplier analysis. Forecasting provides policymakers with reliable projections of economic variables for planning purposes, while multiplier

analysis quantifies both the magnitude and duration of the effect of one variable on another over time. Given that the variables in this study exhibit a combination of I(0) and I(1) integration orders and a confirmed long-run relationship, the ARDL bounds testing approach is the most appropriate technique. It enables the simultaneous estimation of short-run dynamics and long-run equilibrium relationships, ensuring robust and policy-relevant empirical results.

4.0. Model Results and Discussion

Table 2 presents the descriptive statistics of the study variables. The Sustainable Development Index (SDI) has a mean value of 1178.74 with a moderate variation (S.D. = 266.44), indicating some disparity across observations. Green Finance Index (GFI) shows a wide dispersion (S.D. = 1.86×10^9) with a mean of 2.49×10^9 . Climate Finance (CF) records a mean of 827.67, but with a high standard deviation (1117.81), implying substantial variability in environmental emissions. Foreign Direct Investment inflows (FDI_IN) average 1.3% of GDP, showing low variability (S.D. = 0.84) and values ranging from -0.04 to 2.9. Inflation (INF) averages 18.27%, with a relatively large dispersion (S.D. = 15.9), reflecting instability in price levels. Finally, Domestic Credit to Private Sector (DC_PS) has a mean of 10.41% and a standard deviation of 3.48, indicating moderate variability in credit accessibility across the sample period.

Table 2: Data descriptive statistics

Variable	N	Mean	S.D.	Min	Median	Max
SDI	34	1178.74	266.44	831.35	1193.38	1552.89
GFI	34	2493095565	1860535194	929347016.2	1669200889	7805701011
CF	34	827.67	1117.81	24.99	295.64	4051.61
FDI_IN	34	1.3	0.84	-0.04	1.29	2.9
INF	34	18.27	15.9	5.4	12.95	72.8
DC_PS	34	10.41	3.48	4.96	10.07	19.63

Source: Computed by the author.

In Table 3, we present the results of the correlation analysis among the study variables. The Sustainable Development Index (SDI) exhibits a strong positive and significant correlation with Green Finance index (GFI) ($r = 0.616$, $p < 0.001$), Climate Finance (CF) ($r = 0.625$, $p < 0.001$), and Domestic Credit to the Private Sector (DC_PS) ($r = 0.722$, $p < 0.001$), indicating that higher public green finance, climate finance increase and credit expansion are associated with greater levels of sustainable development. Conversely, SDI is negatively correlated with Inflation (INF) ($r = -0.391$, $p < 0.05$), suggesting that rising inflation may hinder sustainability outcomes.

Table 3: Correlation analysis

Variable	SDI	GFI	CF	FDI_IN	INF	DC_PS
SDI	1	0.616***	0.625***	-0.188	-0.391*	0.722***
GFI	0.616***	1	0.866***	-0.582***	-0.031	0.346*
CF	0.625***	0.866***	1	-0.503**	-0.116	0.348*
FDI_IN	-0.188	-0.582***	-0.503**	1	0.04	0.141
INF	-0.391*	-0.031	-0.116	0.04	1	-0.303.
DC_PS	0.722***	0.346*	0.348*	0.141	-0.303.	1

Signif. codes: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; . $p < 0.10$; ns (not significant) = $p \geq 0.10$ **

Source: Computed by the author.

GFI is highly and positively correlated with CF ($r = 0.866$, $p < 0.001$), implying that increased green finance may coincide with higher climate finance. FDI inflows (FDI_IN) show significant negative associations with GFI ($r = -0.582$, $p < 0.001$) and CF ($r = -0.503$, $p < 0.01$), suggesting that greater foreign investment may relate to lower green and climate finance. Inflation (INF) generally shows weak and insignificant relationships with most variables. Overall, the correlations indicate strong interlinkages among green finance, climate finance, and other macroeconomic factors that collectively influence sustainable development.

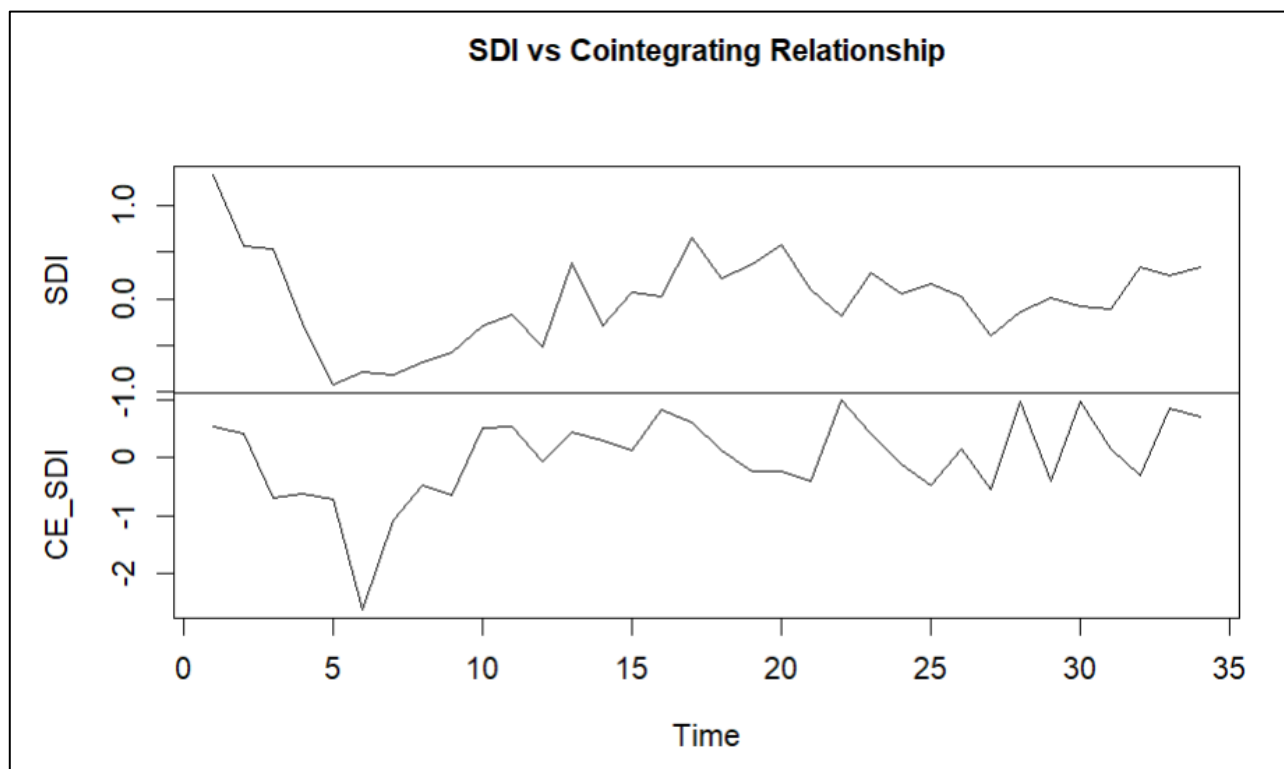


Figure 1: SDI vs Cointegrating relationship.

Source: Computed by the author.

The Figure 1 above illustrates the relationship between the Sustainable Development Index (SDI) and its cointegrating equation (CE_SDI) over time. The figure shows that while SDI exhibits fluctuations around its long-run equilibrium, deviations represented by CE_SDI tend to converge toward zero over time. This suggests the presence of a stable long-term equilibrium relationship, indicating that short-term variations in SDI eventually adjust back to the long-run path implied by the cointegration model.

In the long-run estimates from the ARDL (2,2,2,2,2) model in Table 4, the coefficient on the lagged Green Finance Index (GFI) is $+0.0514$ ($p = 0.0156$), indicating that a 1-unit increase in green finance is associated with a 0.0514-unit increase in the Sustainable Development Index (SDI) in Nigeria, holding other factors constant. This positive and statistically significant effect implies that greater deployment of green finance instruments such as green bonds, renewable-energy lending, and other environmentally-targeted financial flows, contributes to enhancing sustainable development in Nigeria. Similarly, the coefficient on the lagged Climate Finance (CF) variable is $+0.4059$ ($p = 0.0326$). This indicates a much larger long-run effect: for every one-unit increase in climate finance

flows, the SDI rises by about 0.4059 units. Thus, investments directed explicitly at climate-related mitigation or adaptation (e.g., climate-resilient infrastructure, carbon finance) appear to have a strong and positive impact on the sustainability outcome in Nigeria.

Table 4: Long-run relationship estimates, ARDL (2,2,2,2,2) based on uecm.

Variable	Estimate	p-value
Intercept	-0.0323 (0.0564)	0.5759
L(SDI,1)	-0.5924 (0.2246)	0.0195*
L(GFI,1)	0.0514 (0.2164)	0.0156*
L(CF, 1)	0.4059 (0.1712)	0.0326*
L(FDI_IN, 1)	0.3399 (0.1623)	0.0549.
L(INF, 1)	-0.3231 (0.0969)	0.0049**
L(DC_PS, 1)	-0.2265 (0.1397)	0.1274
Multiple R-squared	Adjusted R-squared	Residual standard error
0.7768	0.5057	0.2681

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1, standard error are in parentheses.

Source: Computed by the author.

These findings suggest that while both green finance and climate finance matter for sustainable development, climate finance appears to have a substantially larger long-run coefficient in this model. For Nigeria, a country with pressing environmental and sustainability challenges (such as reliance on fossil fuels, vulnerability to climate change, and the need to diversify the economy), this result is particularly relevant: mobilising climate-finance flows can have a strong multiplier effect on achieving sustainable development goals. Among the control variables, foreign direct investment (FDI_IN) shows a positive but weakly significant impact, suggesting that inflows of foreign capital may support sustainability when aligned with green objectives. In contrast, inflation (INF) exerts a significant negative effect, implying that macroeconomic instability undermines sustainable progress. Domestic credit to the private sector (DC_PS) also shows a negative but insignificant coefficient, indicating that credit allocation may not yet be effectively channeled toward sustainable sectors.

It’s also notable that the model gives an R-squared of 0.7768, indicating that approximately 77.7% of the variation in SDI is explained by the long-run model, which supports the robustness of the estimates. Although the adjusted R-squared drops to 0.5057 (accounting for degrees of freedom), the magnitudes and significance of the coefficients still present meaningful policy implications. Relating to the Nigerian context: empirical literature also supports the role of green and climate finance in Nigeria’s sustainability agenda. For example, a recent study found that green finance instruments (green bonds, green loans, renewable energy investments) significantly promote sustainable economic growth in Nigeria (Ike & Oghene, 2025). A policy-analysis piece also highlights that Nigeria’s green finance ecosystem remains under-developed, pointing to the need for stronger regulatory frameworks and enhanced mobilisation of climate finance (Wokoma & Okoh, 2025). Thus,

the present estimates align with this broader literature by quantifying the long-run positive effect of scaling up such financing.

In Table 5, we present the short-run ARDL estimates for the determinants of sustainable development in Nigeria. The results reveal that green finance (GFI) exerts a positive and marginally significant short-run effect on the Sustainable Development Index (SDI) ($\beta = 0.5869$, $p < 0.10$). This suggests that short-term increases in green financial flows such as green bonds, renewable energy investments, and environmentally focused credit enhance sustainable development outcomes in Nigeria. In contrast, climate finance (CF) has a negative and statistically significant short-run coefficient ($\beta = -0.2347$, $p < 0.01$), indicating that increased climate-related funding may initially exert a contractionary effect on sustainability. This short-run negative relationship could reflect transitional adjustment costs, project implementation delays, or inefficiencies in the disbursement and utilisation of climate funds, which often precede long-term gains.

Table 5: Short-run relationship estimates, ARDL (2,2,2,2,2) based on recm.

Variable	Estimate	p-value
Intercept	-0.0323 (0.0436)	0.4679
d(L(SDI,1))	-0.2709 (0.1187)	0.0342*
d(L(GFI,1))	0.5869 (0.2845)	0.0531.
d(L(CF, 1))	-0.2347 (0.0797)	0.0084**
d(L(FDI_IN, 1))	-0.1715 (0.0760)	0.0358*
d(L(INF, 1))	-0.0473 (0.0696)	0.5049
d(L(DC_PS, 1))	0.4223 (0.0903)	0.0002***
Ect	-0.5924 (0.0993)	0.0000***
Multiple R-squared	Adjusted R-squared	Residual standard error
0.7768	0.6358	0.2302

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1, standard error are in parentheses.

Source: Computed by the author.

The error correction term (ECT) is negative and highly significant (-0.5924 , $p < 0.001$), confirming the presence of a stable adjustment process. Approximately 59% of any short-run disequilibrium in sustainable development is corrected within a period, demonstrating a strong speed of adjustment toward the long-run equilibrium path.

Regarding the control variables, foreign direct investment (FDI_IN) shows a negative and significant effect ($\beta = -0.1715$, $p < 0.05$), implying that in the short run, FDI inflows may not immediately support sustainable outcomes, possibly due to concentration in non-green or extractive sectors. Domestic credit to the private sector (DC_PS) exerts a strong positive and significant effect ($\beta = 0.4223$, $p < 0.001$), suggesting that improved credit access stimulates short-run growth in sustainability through increased private investment. Inflation (INF), however, remains insignificant ($\beta = -0.0473$, $p > 0.10$),

indicating that short-term price fluctuations have limited immediate influence on sustainable development in Nigeria.

Overall, the short-run results imply that while green finance contributes positively to Nigeria's sustainable development, the immediate effects of climate finance are mixed and may take time to materialise as long-run benefits. These findings align with previous empirical evidence such as Pat-Natson et al. (2025), who found that green finance positively affects environmental sustainability in Nigeria, though institutional and structural inefficiencies can delay the impact of climate-oriented investments. Therefore, policymakers should prioritise strengthening Nigeria's climate finance governance and implementation frameworks to ensure that short-term disruptions are minimised and long-term sustainability gains are realised.

4.1. Model Stability and Diagnostic Tests Checks

The Figure 2 below presents the results of the model stability diagnostics using the Recursive CUSUM, CUSUM of Squares, and MOSUM tests. In all three plots, the recursive residuals (black lines) remain within the 5% critical bounds (red lines) throughout the sample period, indicating that the estimated ARDL model is structurally stable.

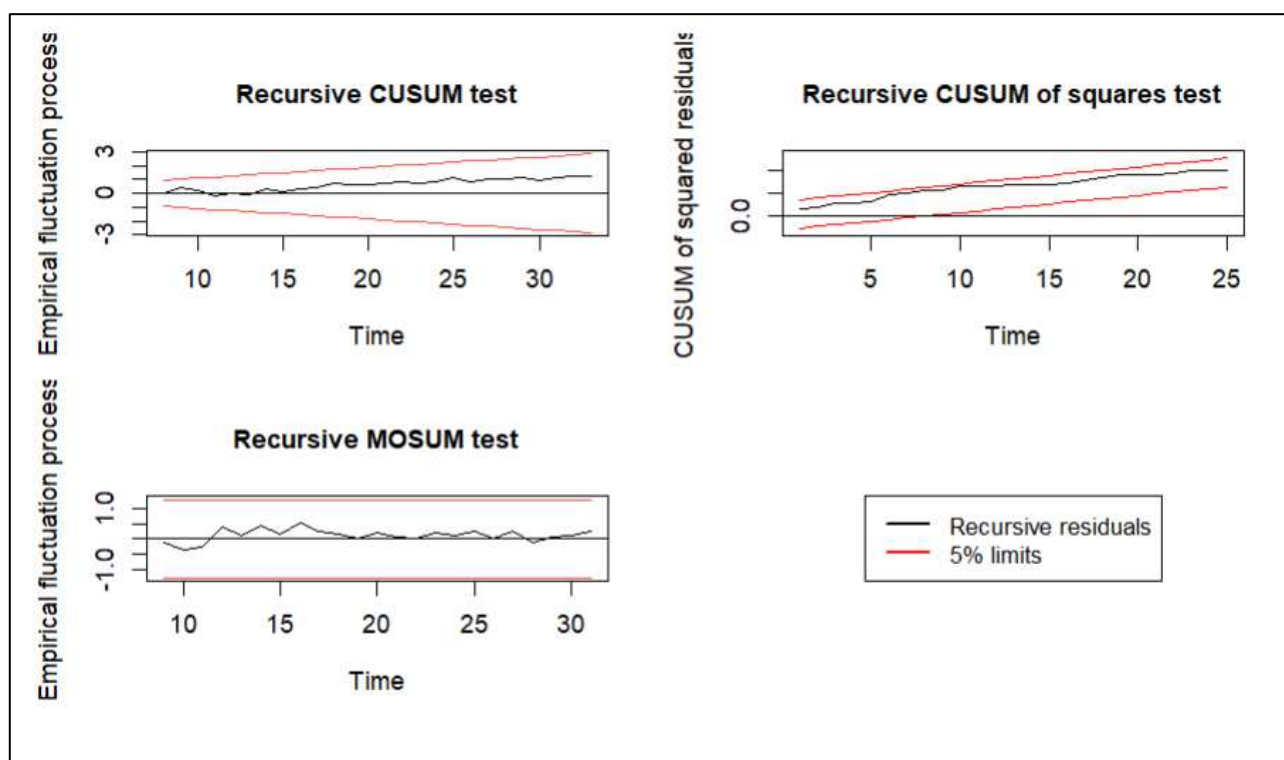


Figure 2: Model stability test.

Source: Computed by the author.

This implies that there are no significant structural breaks or parameter instabilities over time, and the short-run and long-run relationships between sustainable development, green finance, and climate finance in Nigeria are consistent and reliable within the study period.

In Table 6, we reports the results of the post-estimation diagnostic tests for the ARDL (2,2,2,2,2) model. The Breusch-Godfrey LM and Ljung-Box tests show p -values of 0.0608 and 0.121, respectively, indicating the absence of serial correlation in the model's residuals. The Studentized Breusch-Pagan test for heteroskedasticity ($p = 0.53$) confirms that the residuals have constant

variance, suggesting homoskedasticity. Additionally, the Shapiro–Wilk normality test ($p = 0.2448$) indicates that the residuals are normally distributed.

Table 6: Diagnostic test of ARDL (2,2,2,2,2) in residuals.

Test name	test for	test value	p-value
Breusch-Godfrey (LM) Test	serial correlation	5.442	0.0608
Ljung-Box (X-squared)	serial correlation	2.4045	0.121
Studentized Breusch-Pagan test	heteroskedasticity	10.004	0.53
Shapiro-Wilk	normality	0.95818	0.2448

Collectively, these results imply that the ARDL model is well-specified, free from major econometric problems, and suitable for reliable inference on the relationship between green finance, climate finance, and sustainable development in Nigeria.

5.0. Conclusion, Recommendations, and Limitations

This section presents the major conclusions drawn from the findings of the study. It also provides relevant policy recommendations based on the empirical results and highlights the key limitations of the study, as well as areas that may require further research.

5.1. Conclusion

This study examined the dynamics of green and climate finance in Nigeria, focusing on their scale, structure, trends, and long- and short-run impacts on sustainable development. The analysis also explored how climate finance contributes to Nigeria’s climate adaptation and mitigation goals, identified the major barriers to effective mobilization and utilization of sustainable finance, and proposed policy pathways to strengthen institutional and regulatory frameworks. Empirical evidence from the ARDL (2,2,2,2,2) model reveals that both green finance and climate finance play significant roles in promoting sustainable development in Nigeria. In the long run, green finance exerts a positive and significant impact on the Sustainable Development Index (SDI), indicating that the expansion of green credit and green securities enhances environmental quality and socio-economic sustainability. Similarly, climate finance demonstrates a strong positive long-run effect, suggesting that increased financial flows into climate mitigation and adaptation projects contribute to Nigeria’s sustainable development trajectory. In the short run, however, green finance maintains a positive influence, while climate finance exhibits a temporary negative effect, likely due to transitional implementation costs and institutional inefficiencies that delay the realization of benefits. The descriptive and correlation analyses reinforce these findings by showing strong interlinkages between green finance, climate finance, and sustainability indicators. The error-correction term confirms a rapid adjustment toward equilibrium, underscoring the stability of the long-term relationship. Diagnostic and stability tests further validate that the ARDL model is well-specified, free from serial correlation and heteroskedasticity, and structurally stable over time.

From a contextual standpoint, Nigeria’s green and climate finance landscape has shown incremental growth, with total climate-related inflows reaching USD 2.5 billion in 2021-2022, representing a 32 percent increase compared to 2019-2020. Nevertheless, this amount accounts for less than 10 percent of the country’s estimated annual financing need of USD 27.2 billion to achieve its NDC and SDG targets. The structure of financing remains public-sector dominated, with limited

private-sector engagement and a heavy reliance on debt instruments. Sectorally, most flows are directed toward agriculture, forestry, water management, and energy, aligning with Nigeria's adaptation and mitigation priorities, but key sectors such as waste management, transport decarbonization, and coastal resilience remain underfunded. The findings demonstrate that climate finance has contributed meaningfully to Nigeria's mitigation and adaptation outcomes, particularly through renewable-energy projects, afforestation, and climate-resilient agriculture, but its scale remains insufficient relative to Nigeria's 2030 and 2060 climate goals. Persistent barriers such as macroeconomic instability, limited project pipelines, weak institutional coordination, and inadequate transparency mechanisms continue to constrain effective mobilization and utilization. Overall, the study concludes that while green and climate finance are catalytic drivers of sustainable development in Nigeria, the current scale and structure of financing are inadequate to close the country's significant climate investment gap. Strengthening institutional capacity, diversifying financing instruments, and aligning fiscal and regulatory frameworks with sustainability goals are therefore critical to unlocking Nigeria's green-finance potential.

5.2. Policy Recommendations

Based on the empirical findings and contextual analysis, we propose the following policy recommendations to enhance the effectiveness of green and climate finance in promoting sustainable development in Nigeria:

1. Scale Up Domestic Resource Mobilization and Private-Sector Participation

- Introduce targeted incentives such as tax credits, green-bond guarantees, and interest-rate rebates, to attract domestic investors and corporates into sustainable finance.
- Encourage pension funds and insurance companies to allocate a share of their portfolios to certified green assets through regulatory reform and risk-mitigation frameworks.

2. Diversify Financing Instruments and Strengthen Blended-Finance Mechanisms

- Shift from the current debt-dominated structure toward a more balanced mix that includes grants, equity, guarantees, and blended-finance tools.
- Establish a National Green Investment Facility to de-risk early-stage climate projects and catalyze private capital inflows.

3. Enhance Institutional and Regulatory Frameworks

- Strengthen coordination among the Ministry of Environment, the Central Bank of Nigeria (CBN), and the Debt Management Office (DMO) to streamline green-finance governance.
- Accelerate implementation of the International Sustainability Standards Board (ISSB) reporting framework to ensure consistent and transparent disclosure of climate-related financial information.

4. Expand Project Preparation and MRV (Monitoring, Reporting, and Verification) Capacity

- Develop specialized project-preparation facilities to generate bankable, investment-ready projects, especially in renewable energy, transport decarbonization, and adaptation sectors.
- Build institutional capacity in MRV systems to track climate finance flows, assess impact, and enhance investor confidence.

5. Promote Fiscal and Policy Alignment with Climate Objectives

- Integrate climate criteria into fiscal policy and national budgeting by introducing green fiscal incentives and phasing out fossil-fuel subsidies that distort investment signals.
- Mainstream sustainability objectives into national development plans and financial-sector policies to ensure coherence between economic growth and environmental stewardship.

6. Strengthen International Partnerships and Access to Concessional Finance

- Deepen collaboration with multilateral development banks (MDBs), climate funds, and bilateral partners to expand access to concessional and blended climate finance.
- Leverage Nigeria's sovereign green-bond program to attract further global investors by improving transparency, reporting, and credit ratings.

5.3. Research Limitations and Areas for Further Study

Despite providing valuable insights, this study has certain limitations. First, the availability and consistency of data on green and climate finance flows in Nigeria remain limited, particularly for private-sector investments and project-level outcomes. The analysis therefore relies on aggregated national data, which may obscure sector-specific nuances. Second, the study focuses on Nigeria as a single-country case, which limits cross-country comparability and generalization of results across Africa. Third, while the ARDL model captures both short- and long-run dynamics, it does not explicitly account for potential nonlinearities or structural regime changes that could influence the relationship between finance and sustainability outcomes.

Future research could extend this work by employing panel or nonlinear models across multiple African economies to identify regional drivers of sustainable finance. Further studies should also explore the impact of institutional quality and governance indicators on the effectiveness of green and climate finance, as well as the distributional implications of financing instruments across sectors and regions within Nigeria.

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