Financial Inclusion and Green Investment in Nigeria: Evidence from an Autoregressive Distributed Lag Model

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ABSTRACT

Nigeria possesses considerable renewable-energy potential but continues to attract inadequate investment into environmentally sustainable activities. Although financial inclusion may improve the mobilization of savings, access to credit and the allocation of financial resources, its contribution to green investment in Nigeria remains insufficiently understood. This study examines the effect of financial inclusion on green investment in Nigeria using annual time-series data covering the period 1994–2024. Green investment is specified as the dependent variable, while financial inclusion is the principal explanatory variable. Inflation, foreign direct investment, interest rate, gross domestic product per capita growth and access to electricity are incorporated as control variables. The study employs the Autoregressive Distributed Lag bounds-testing approach to determine the existence of a long-run relationship and estimate the short-run and long-run effects of the explanatory variables. The bounds-test result confirms the existence of a stable long-run relationship among the variables. The long-run estimates show that financial inclusion has a positive but weakly significant effect on green investment. Specifically, a one-percentage-point increase in financial inclusion is associated with an approximately 0.34 per cent increase in green investment. The error-correction term is negative and statistically significant, indicating that short-run deviations are corrected towards long-run equilibrium. The study concludes that financial inclusion can support green investment in Nigeria, but its contribution remains limited by inadequate green financial products, restricted access to affordable credit and macroeconomic instability. It recommends the integration of green financing objectives into Nigeria's financial inclusion programmes and the establishment of accessible credit facilities for environmentally sustainable investments.

Keywords: financial inclusion; green investment; sustainable finance; green credit; ARDL; Nigeria

INTRODUCTION

Investment in environmentally sustainable economic activities is gaining more significance due to climate change, environmental degradation and continued energy scarcity. Generally speaking, green investment is the investment of financial resources in projects and technologies that support environmental sustainability, decrease pollution, enhance energy efficiency, and fortify climate change risk resilience. Such investments include renewable energy, climate-smart agriculture, sustainable transportation, waste management, pollution control and environmentally responsible infrastructure (OECD, 2021). Therefore, green investment is a key part of international initiatives to realize sustainable development and to facilitate a low-carbon economy.

Despite the high amount of renewable energy resources and climate change risks in Africa, there are serious constraints in accessing funding for greener solutions. Investment in sustainable projects is constrained throughout the continent due to limited domestic financial resources, weak financial markets, high borrowing costs, policy uncertainty and inadequate institutional capacity. The African Development Bank (2023) notes that Africa requires significant annual investments for climate-resilient development, yet the amount of financing mobilized in Africa is significantly less than what is estimated. The financing shortfall restricts African countries' capacity to increase their renewable-energy capacity, build environmentally resilient infrastructure and support environmentally sustainable production. These are some of the challenges that Nigeria faces as a nation. The country has a lot of resources of solar, wind, hydroelectric and biomass and has implemented some policies that promote renewable energy and sustainable development. However, the amount of green investment flowing into Nigeria is still relatively small compared to some African economies. As of 2021, Nigeria is reported to have received less than US$1.2 billion in renewable-energy investments over the last six years, compared to South Africa, which received more than US$5.5 billion over the same period (BloombergNEF, 2022). Nigeria also needs significant financial investment to achieve the emission reduction pledges and climate targets. The National Determined Contributions (NDC) of the country estimate the cost of meeting their emission reduction targets by 2030 at around US$142 billion (Federal Ministry of Environment, 2021).

The lack of green investment has economic and social implications. The Nigerian population still faces a significant portion of limited or unreliable access to electricity. Petrol and diesel generators, firewood, charcoal and other polluting energy sources are the primary power supply for many homes and small businesses. Solar irrigation, energy efficient equipment, waste recycling technologies and other environmentally friendly investments are also challenging for farmers and small businesses. Lack of adequate financing for these activities is a cause for ongoing energy poverty, environmental degradation, low productivity, and climate-related vulnerabilities.

Financial inclusion may provide an important means of addressing these financing limitations. Financial inclusion is defined as the ability, access and utilization of low-cost formal financial products and services by individuals and businesses, including those that have traditionally been disadvantaged in accessing formal finance. These include services like savings accounts, credit facilities, insurance, and payment platforms and digital financial services such as Demirgüç-Kunt et al., 2022. Financial inclusion goes beyond having a bank account. It also involves the ability of households and firms to access and utilize the right financial services to increase welfare, manage risk and make productive investments.

Financial inclusion may have several channels of impact on green investment. Improved access to formal savings facilities can enhance the mobilization of domestic financial resources. Such savings can be directed through financial institutions to productive and environmentally sustainable investments. Second, better access to credit can allow households and businesses to purchase renewable-energy systems and energy-efficient and climate-smart technologies that demand a significant up-front investment. Last but not least, farmers and businesses are able to benefit from insurance and other risk-management tools that shield them from the effects of climate change, which could make them more likely to invest in environmentally friendly activities. Fourth, digital financial services can enable flexible payment methods for renewable-energy technologies, such as pay-as-you-go solar. Financial inclusion can also promote green investments by addressing information asymmetry and transaction costs. Financial institutions gather data on borrowers, track how money is spent and determine where to invest the funds among competing investment opportunities. Financial inclusion can potentially increase the number of potential investors and better channel resources towards sustainable activities by connecting those who were previously unbanked or underbanked to formal financial institutions. Allen et al. (2016) argue that increased financial access promotes entrepreneurship and risk-taking, which are important for the adoption of new technologies. Likewise, Demirgüç-Kunt et al. (2022) show that formal financial services boost savings mobilization, financial resilience and the ability of households and businesses to make productive investments.

Nigeria have launched several schemes for financial inclusion. In 2012, the Central Bank of Nigeria (CBN) launched the National Financial Inclusion Strategy, which was later revised to increase access to formal financial services. The rising adoption of mobile banking, agent banking and the fintech sector has also enhanced access to digital payment and financial services. The financial inclusion rate in Nigeria has risen from about 56 per cent in 2020 to about 64 per cent in 2023, according to the Enhancing Financial Innovation and Access survey (EFInA, 2023). Even with these advances, significant parts of the adult population are still not accessing formal financial services. The financial exclusion is very high for people in rural areas, low income groups, women, farmers and small business. Formal credit is also much more limited than payment or savings services. The estimated loan obtained by regulated financial institutions (EFInA 2023) is less than 5 per cent of the Nigerian adult population. Thus, more financial accounts do not necessarily yield more affordable investment finance.

Empirical evidence from existing studies shows that financial inclusion can support environmental sustainability, the use of renewable energy and green economic development. Financial inclusion had a positive impact on green economic growth in developing countries, partly via green innovation, was found by Abbas et al. (2024). Similarly, Liu et al. (2022) found that financial inclusion positively affected the energy efficiency and environmental performance in several economies. Financial deepening and financial access positively facilitated investments in renewable energy in China, according to Zhang and Zhou (2021). The results of cross country studies, however, might not fully reflect the unique financial system, policy setting and macro-economic environment in Nigeria. Few studies have analyzed green finance at the firm level or household level in Nigeria. Sajuyigbe et al. (2024), for instance, explored the link between green finance and environmental performance of SMEs in Lagos. Most of the current evidence, however, is from surveys or observations of particular technologies at the firm level. There has been little focus on the long-term macroeconomic relationship between financial inclusion and green investment in Nigeria.

This leaves an important empirical void. While financial inclusion has grown in Nigeria, it is not clear if this has been significantly contributing to the growth of green investments at the national level. This connection is significant since Nigeria has many sustainable-development financing needs and cannot rely solely on international climate finance. Domestic savings and credit institutions and digital financial platforms also have to be engaged in mobilizing and allocating capital to environmentally sustainable activities. In this context, the effect of financial inclusion on green investment in Nigeria from 1994 to 2024 is examined. The specific objective is to find out if the financial inclusion significantly affects the green investment after controlling inflation, foreign direct investment, interest rate, gross domestic product per capita growth and access to electricity. The study tests the null hypothesis of lack of significant relationship between financial inclusion and green investment in Nigeria.

LITERATURE REVIEW

Financial Inclusion and Green Investment

Green investment is the use of money for projects and activities that support environmental sustainability. These investments cover areas such as renewable energy, energy efficiency, sustainable agriculture, waste management, pollution control and the construction of infrastructure that is resilient to climate change. Green investments are not just financial investments, but also investments that generate environmental benefits, including lower emissions, increased resource efficiency, and increased resilience to climate change. Green projects typically involve a large up-front investment and extended payback periods. These attributes are why it is essential to have access to suitable finance. Both the quantity of financial resources and the characteristics of the financial institution are important for the development of renewable energy, as are the technology's maturity and the risk appetite of investors, Mazzucato and Semieniuk (2018) note. This implies that poor quality or costly financing may constrain green investment, particularly in the developing world.

Financial inclusion is the accessibility and utilization of low-cost formal financial services, such as savings, credit, payment and insurance services. It goes beyond access to accounts to the use of financial services by those who were previously outside the formal financial system by households and businesses (Demirgüç-Kunt et al., 2022). Financial inclusion can promote investment by enabling individuals and enterprises to accumulate savings, obtain credit, manage risks and carry out transactions more efficiently. Financial inclusion can thus also improve the ability of households, farmers and small businesses to make investments that are environmentally friendly. For instance, low cost credit could help farmers obtain solar irrigation systems, and digital payments could help low-income households pay for renewable-energy technology over time.

However, green investment does not necessarily follow financial inclusion. Better access to finance can also lead to an increase in consumption and investment in carbon-intensive activities. Hence, the environmental impact of it will be determined by the sectors to which it is granted credit, as well as by the availability of financial products which are specifically developed for sustainable projects. If this is the case, conventional financial systems could persist in supporting short-term, carbon-intensive investments, unless regulatory and incentive measures are set in place to direct credit away from such investments and in favor of low-carbon investments, according to Campiglio (2016).

This is especially significant for Nigeria. Financial inclusion is improving with mobile banking, agent banking and fintech development but access to productive credit is still limited. In addition, the majority of financial inclusion programmes focus on account ownership and payment services, but not financing renewable energy and other green projects. Therefore, the impact of financial inclusion on green investment could be limited unless financial access is coupled with green credit that is affordable and appropriate financial instruments.

THEORETICAL FRAMEWORK

This research mainly is based on Financial Intermediation Theory and Green Finance Theory. The Financial Intermediation Theory provides a framework for understanding how financial institutions raise funds from savers and use these funds to supply capital to individuals, firms and governments that need it. Financial intermediaries lower the information, monitoring and transaction costs of direct lending, according to Diamond (1984). Financial institutions facilitate the flow of capital in a more efficient manner by screening borrowers, monitoring investments and sharing risk. The theory is relevant to financial inclusion because financial intermediation services are not fully utilized by individuals and businesses not part of the formal financial system. They may rely on informal sources of financing, such as family and friends, or their own capital, which may not be sufficient for larger-scale investments. More financial inclusion means more people are in the formal financial system, and thus can have better access to finance for renewable energy, sustainable agriculture, and other environmentally-friendly activities. Financial Intermediation Theory thus stipulates that there should be a positive correlation between financial inclusion and green investment. The financial system will be mobilizing and allocating more resources to productive investments as more households and firms gain access to savings, credit and payment services. However, the theory does not necessarily specify the use of the money allocated for green or environmentally damaging purposes.

Green Finance Theory overcomes this by acknowledging that traditional financial markets can fail to provide adequate financing for environmentally-friendly projects. Social returns are frequently associated with green investments, for example, cleaner air and less carbon emissions, which investors might not necessarily be able to see as private returns. They can also be seen as risky due to their high up-front costs, long repayment terms and policy uncertainty. The theory thus highlights the need for specialized financial products and policies, such as green credit, concessional loans, credit guarantees and green bonds. They can lower costs and risks associated with sustainable investments and incentivize financial institutions to invest more in environmentally friendly projects.

The two theories are complementary to each other. Financial Intermediation Theory provides an explanation of how financial inclusion can mobilize and distribute financial resources, and Green Finance Theory provides an explanation for why deliberate policies might need to be instituted to guide those resources to sustainable activities. The study thus anticipates that financial inclusion will positively impact green investment, but the strength of the impact can vary depending on the green financial products available and the overall macroeconomic conditions.

Empirical Review

The evidence on the environmental impacts of financial inclusion is inconclusive. There is some evidence that financial inclusion has a positive impact on renewable energy and sustainable development, and some evidence that financial inclusion can have a negative impact. Dai, et al. (2022) studied selected countries in the Regional

Comprehensive Economic Partnership and identified positive relationship between financial inclusion and consumption of renewable energy in both short term and long term. The authors found that greater financial access led to lower financing constraints and facilitated financing of low carbon energy. Likewise, Li et al. (2022) explored Chinese provinces and discovered that financial inclusion was conducive to the development of renewable energy. Their results showed that the effect was particularly evident through increased wind and solar-power generation. The study argues that increased access to finance can help to drive the scale-up of renewable-energy projects.

Similarly, financial inclusion positively impacted sustainable development, especially in conjunction with green finance (Oanh, 2024). This suggests that the environmental impacts of financial inclusion are greater when financial access is associated with instruments and policies that are explicitly aimed at fostering green activities. Nevertheless, Tufail et al. (2022) found that the financial inclusion led to rise in carbon emissions in BRICS economies. They said that there was a possibility that increased financial access would increase energy use and fossil fuel dependent industrial activities. This discovery highlights the fact that financial inclusion can have negative environmental impacts.

To date, most studies are based on cross country or regional panel data and use carbon emissions or ecological footprints or consumption of renewable energy as environmental measures. While these studies offer helpful insights, they do not directly demonstrate that financial inclusion leads to the allocation of capital towards green investment. The results could also mask significant country-to-country variations. Once again, research on financial inclusion in Nigeria has been mainly about economic growth, poverty alleviation, household welfare and small business development. The literature on green finance has mainly focused on renewable energy uptake and corporate environmental management and green bonds. The relationship between financial inclusion and green investment has received little attention in the literature, which has focused mainly on the microeconomic level.

METHODOLOGY

Research Design

The study adopted a quantitative ex post facto research design because it relied on historical macroeconomic data that had already occurred and could not be manipulated by the researchers. Annual time-series data for Nigeria covering 1994–2024 were used to examine the short-run and long-run relationship between financial inclusion and green investment. Green investment was specified as the dependent variable, while financial inclusion was the principal explanatory variable. Inflation, foreign direct investment, lending interest rate, gross domestic product per capita growth and access to electricity were included as control variables because they may influence the volume and direction of green investment. The working dataset drew on the World Bank's World Development Indicators and financial databases, the Global Findex Database, the Central Bank of Nigeria Statistical Bulletin, the United Nations Conference on Trade and Development and the International Energy Agency. Green investment and foreign direct investment were transformed into natural logarithms, while the remaining variables were retained in percentage form.

Sample Adequacy, Data Frequency and Structural Context

The 1994–2024 period provides 31 annual observations. This is a relatively small sample for a multivariate time-series model, but the Autoregressive Distributed Lag approach is appropriate where the regressors are a mixture of I(0) and I(1), none is I(2) and the model is kept parsimonious. The maximum lag length was therefore restricted to two. Even so, the limited number of observations reduces the available degrees of freedom and statistical power, particularly for coefficients that are close to conventional significance thresholds. The estimates should consequently be interpreted as average dynamic relationships over the study period rather than as highly precise estimates that are necessarily generalisable beyond the sample.

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Annual data are suitable for examining broad long-run macroeconomic relationships, but they cannot capture seasonal behaviour or short-lived changes in credit conditions and project expenditure within each year. The results may also be sensitive to the selected start and end dates because the period contains several major changes in Nigeria's financial and macroeconomic environment: the 2005 banking-sector consolidation, the 2008–2009 global and domestic banking crisis, the 2016 recession, the 2020 COVID-19 recession, and the petrol-subsidy and foreign-exchange reforms introduced in 2023 (Central Bank of Nigeria, 2007; International Monetary Fund, 2013; National Bureau of Statistics, 2017, 2020; World Bank, 2023). With only 31 observations, introducing several break dummies or estimating separate regimes would substantially reduce degrees of freedom. These episodes are therefore used as qualitative context rather than treated as formally estimated structural breaks. Future studies using quarterly, project-level or sectoral data should test for break dates, parameter instability and sensitivity to alternative sample periods.

Definition and Measurement of Variables

Green Investment

Green investment (GI), the dependent variable, was defined as annual financial expenditure on environmentally sustainable projects and activities. The intended coverage comprised renewable energy, energy efficiency, sustainable agriculture, waste management, pollution control and green infrastructure. The working series was expressed in millions of United States dollars and transformed into its natural logarithm to reduce differences in scale and permit a semi-elasticity interpretation of the estimated coefficients.

The variable after the transformation is given by:

$$LGI_t = \ln(GI_t)$$

where LGI_t is the natural logarithm of green investment in year t.

Construction and Limitations of the GI Measure

Green investment is challenging to measure in developing countries because the investment in the environment is not necessarily aggregated in one and consistent statistical category. The green-investment variable, in this study, was created using recorded expenditure recorded in World Development Indicators (WDI). The annual series spans 1994 to 2024, and comprises all recorded expenditure on renewable-energy projects, energy-efficiency activities, environmentally sustainable agriculture, waste management, pollution control and green infrastructure. If information was drawn from a number of sources, the reported values were harmonized in millions of United States dollars.

The measure should thus be interpreted as the overall proxy for recorded green investment in the study and not as a national proxy measure of all environmentally sustainable investments that are being made in Nigeria. It encompasses spending which could be identified from the formal records available and categorized within the chosen environmentally related activities. The interpretation is relevant because Nigeria has yet to have a fully consolidated annual account of all public, private, household and informal-sector green investments for the entirety of the study period.

There are certain limitations on the measure. First, some green investments could be included in broader expenditure categories like energy, agriculture, transport, housing, manufacturing or general infrastructure and thus not be classified as green investment separately. Secondly, investments in the informal sector and the household sector may not be fully reflected in formal expenditure statistics. Thirdly, environmental expenditure may be covered or classified differently between reporting institutions and years. Therefore, the apparent changes in the series might partly be due to changes in reporting and classification and not just the actual changes in the level of green-investment activity.

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Financial Inclusion

Financial inclusion (FI), the principal explanatory variable, was measured as the percentage of adults with an account at a formal financial institution. This indicator primarily captures access to an entry point into the formal financial system. A positive relationship was expected because broader formal access may support savings mobilisation, payment efficiency, credit histories and eventual access to finance for environmentally sustainable activities.

$$\frac{\partial GI}{\partial FI} > 0$$

Construction and Limitations of FI

The percentage of adults with an account at a formal financial institution was used as a proxy for the FI variable from WDI. Data on direct account-ownership were not available on an annual basis for the full 1994–2024 period, so were used as an annualized access-based proxy. Existing benchmark observations were put together with supporting indicators of formal financial access and annual values were filled with trend-based extrapolation when found missing. It is generally recognized that there is a need for a broadened measure of financial inclusion, and that account ownership is an easy measure to achieve, and internationally comparable. However, it fails to indicate if an account is in active use, how often it is used, if the account holder saves formally, if the account holder obtains any insurance on the account, if the account holder secures a loan on the account, or if the account holder can obtain a loan on the account at an affordable interest rate, and at a suitable maturity. The estimated relationship may also be weak due to measurement error caused by constructing an annual series from intermittent observations. The coefficient is thus considered as the association between formal account access and green investment and not as the full effect of multidimensional financial inclusion.

A composite index should be used in the future, which will include access, usage and quality. These components are bank branches or agents per adult, deposit and loan accounts, percentage of adults who are saving or borrowing formally, and digital payment usage, as well as credit to households and small firms, loan maturity, effective borrowing cost, rejection rates and distribution of access to bank branches or agents in rural areas, women, and low-income groups. Such measures would be a more robust indicator of the effectiveness of inclusion, going beyond mere ownership to the depth and quality of inclusion, in supporting green investment.

Inflation Rate

Inflation (INF) was calculated as the yearly percentage increase in the Consumer Price Index. It measures the inflation rate of all goods and services. The negative correlation between inflation and green investment is expected as sustained inflation can lead to higher costs of imported equipment, construction materials and other inputs needed for green investments. Also, due to high inflation, there can be uncertainty and less real value of expected investment returns. Thus:

$$\frac{\partial GI}{\partial INF} < 0$$

Foreign Direct Investment

Foreign direct investment (FDI) was calculated as the net inflows of foreign direct investment as a percentage of GDP. The variable represents the foreign capital inflows into productive activities in Nigeria. This was converted to its natural logarithm as follows:

$$LFDI_t = \ln(FDI_t)$$

A positive correlation was predicted, as foreign investment can be used to supply capital, technology and technical expertise for renewable energy and other sustainable ventures. Therefore:

$$\frac{\partial GI}{\partial FDI} > 0$$

Interest Rate

The lending interest rate, referred as INTR, was used as a measure of interest rate. It is defined as the cost to individuals and businesses of borrowing from financial institutions. It should be expected to have a negative impact on green investment. Green projects are typically large in size and need long-term funding. Higher lending costs can make it more expensive to borrow and could potentially deter investment in renewable energy and other sustainable projects. Therefore:

$$\frac{\partial GI}{\partial INTR} < 0$$

GDP per Capita Growth

Gross domestic product per capita growth, denoted by $GDPP$, was measured as the annual percentage growth rate of GDP per person. It shows changes in average economic output and income. GDP per capita growth was expected to have a positive effect on green investment because increased income and economic activity may improve the capacity of households, businesses and the government to finance environmentally sustainable projects. Hence:

$$\frac{\partial GI}{\partial GDPP} > 0$$

Access to Electricity

Access to electricity (ELEC) is the proportion of Nigerian population that had access to electricity. It reflects the extent of energy infrastructure and the potential for investment in energy generation and distribution. It is expected that there will be a positive relationship, as better access to electricity can spur investment in renewable energy and green infrastructure. Thus:

$$\frac{\partial GI}{\partial ELEC} > 0$$

Model Specification

The model is inspired mainly by Financial Intermediation Theory, which focuses on the mobilization of saving and the allocation of financial resources to productive investment carried out by financial institutions. The functional relationship between green investment and financial inclusion and control variables was determined as:

$$GI_t = f(FI_t, INF_t, FDI_t, INTR_t, GDPP_t, ELEC_t) \quad (1)$$

The econometric model is specified as:

$$LGI_t = \beta_0 + \beta_1 FI_t + \beta_2 INF_t + \beta_3 LFDI_t + \beta_4 INTR_t + \beta_5 GDPP_t + \beta_6 ELEC_t + \varepsilon_t \quad (2)$$

where LGI_t is the natural logarithm of green investment in year t; FI_t is financial inclusion; INF_t is the inflation rate; $LFDI_t$ is the natural logarithm of foreign direct investment; $INTR_t$ is the lending interest rate; $GDPP_t$ is GDP per capita growth; $ELEC_t$ is access to electricity; β_0 is the intercept; β_1–β_6 are the coefficients to be estimated; and ε_t is the stochastic error term.

The expected signs of the estimated coefficients were:

$$\beta_1 > 0, \qquad \beta_2 < 0, \qquad \beta_3 > 0, \qquad \beta_4 < 0, \qquad \beta_5 > 0, \qquad \beta_6 > 0$$

The main hypothesis tested in the article was:

$$H_0: \beta_1 = 0$$

Financial inclusion has no significant effect on green investment in Nigeria.

The alternative hypothesis was:

$$H_1: \beta_1 \neq 0$$

Financial inclusion has a significant effect on green investment in Nigeria.

The research adopted Pata & Samour (2022) model that applied ARDL and cointegration techniques to test how renewable energy sources, FDI and urbanization interact in determining carbon outcomes and (by implication) renewable deployment for a sample including developing economies.

Estimation Procedure

The analysis was conducted using descriptive statistics, unit-root tests, the Autoregressive Distributed Lag bounds-testing approach and post-estimation diagnostic tests.

Descriptive Statistics

Descriptive statistics were used to summarize the characteristics of the variables. The statistics included the mean, minimum, maximum, standard deviation, skewness and kurtosis. These measures provided preliminary information about the distribution and variation of the data.

Unit-Root Test

The Augmented Dickey–Fuller test was employed to determine whether each variable was stationary at level or after first differencing. The general form of the Augmented Dickey–Fuller equation was specified as:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Y_{t-i} + \mu_t \qquad (3)$$

where ΔY_t is the first difference of the variable being tested; α_0 is the constant term; t is the time trend; Y_{t-1} is the lagged level of the variable; p is the number of lagged differences; γ_i represents the coefficients of the lagged differences; and μ_t is the error term.

The hypotheses for the unit-root test were:

$$H_0: \delta = 0$$

The variable contains a unit root and is therefore non-stationary.

$$H_1: \delta < 0$$

The variable does not contain a unit root and is therefore stationary. The null hypothesis was rejected where the probability value was less than 0.05.

Autoregressive Distributed Lag Bounds Test

The Autoregressive Distributed Lag approach developed by Pesaran et al. (2001) was employed because the variables were integrated at different orders, comprising a combination of $I(0)$ and $I(1)$ variables. The method is also suitable for relatively small samples and permits the use of different lag lengths for the variables. The unrestricted error-correction representation of the ARDL model was specified in expanded form as:

$$\begin{aligned}\Delta LGI_t &= \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, \Delta LGI_{t-i} + \sum_{i=0}^{q_1} \alpha_{2i}\, \Delta FI_{t-i} + \sum_{i=0}^{q_2} \alpha_{3i}\, \Delta INF_{t-i} \\ &+ \sum_{i=0}^{q_3} \alpha_{4i}\, \Delta LFDI_{t-i} + \sum_{i=0}^{q_4} \alpha_{5i}\, \Delta INTR_{t-i} + \sum_{i=0}^{q_5} \alpha_{6i}\, \Delta GDPP_{t-i} \\ &+ \sum_{i=0}^{q_6} \alpha_{7i}\, \Delta ELEC_{t-i} + \lambda_1 LGI_{t-1} + \lambda_2 FI_{t-1} + \lambda_3 INF_{t-1} \\ &+ \lambda_4 LFDI_{t-1} + \lambda_5 INTR_{t-1} + \lambda_6 GDPP_{t-1} + \lambda_7 ELEC_{t-1} + \mu_t \end{aligned} \tag{4}$$

The coefficients attached to the differenced variables measure the short-run effects, while the coefficients attached to the lagged level variables are used to test for a long-run relationship. The null hypothesis of no long-run relationship was stated as:

$$H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = 0$$

The alternative hypothesis was:

$$H_1: \text{at least one } \lambda_j \neq 0, \qquad j = 1,2,\dots,7$$

The calculated F-statistic was compared with the lower- and upper-bound critical values. Cointegration was established where the calculated F-statistic exceeded the upper-bound critical value. Where the statistic was below the lower bound, the null hypothesis of no cointegration was not rejected. A result between the two bounds was considered inconclusive.

A maximum lag length of two was considered because of the annual frequency and the limited sample. The final lag structure was selected using the Akaike Information Criterion, Schwarz Bayesian Information Criterion, Hannan–Quinn Information Criterion and Final Prediction Error. Although ARDL performs comparatively well in small samples, this advantage does not eliminate low statistical power or sensitivity to lag choice, endpoint selection and structural change. The estimates and associated probability values are therefore interpreted cautiously alongside the diagnostic and stability tests.

Error-Correction Model

Following confirmation of cointegration, the short-run error-correction model was estimated in expanded form as:

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$$\Delta LGI_t = \gamma_0 + \sum_{i=1}^{p} \gamma_{1i}\,\Delta LGI_{t-i} + \sum_{i=0}^{q_1} \gamma_{2i}\,\Delta FI_{t-i} + \sum_{i=0}^{q_2} \gamma_{3i}\,\Delta INF_{t-i}$$

$$+ \sum_{i=0}^{q_3} \gamma_{4i}\,\Delta LFDI_{t-i} + \sum_{i=0}^{q_4} \gamma_{5i}\,\Delta INTR_{t-i} + \sum_{i=0}^{q_5} \gamma_{6i}\,\Delta GDPP_{t-i}$$

$$+ \sum_{i=0}^{q_6} \gamma_{7i}\,\Delta ELEC_{t-i} + \phi ECM_{t-1} + \mu_t$$

where ECM_{t-1} represents the lagged error-correction term and ϕ measures the speed at which short-run deviations return to long-run equilibrium. The coefficient of the error-correction term was expected to be negative and statistically significant:

$$-1 < \phi < 0$$

A larger absolute value of ϕ indicates a faster adjustment from short-run disequilibrium to long-run equilibrium.

Diagnostic and Stability Tests

Post-estimation diagnostic tests were performed to check the validity of the estimated model. The serial correlation among the residuals was tested using the Breusch–Godfrey Lagrange Multiplier test. The null hypothesis was that the residuals were not serially correlated. To check for the consistency of the variance of the residuals, the Breusch–Pagan heteroscedasticity test was applied. The null hypothesis was that the residuals were homoscedastic. The Jarque–Bera or skewness–kurtosis test was employed to determine if the residuals were normally distributed. The Ramsey RESET test was used to investigate for functional-form misspecification and omitted-variable bias. Finally, the stability of the estimated parameters in the study period was evaluated by using the cumulative sum and cumulative sum of squares tests. The model was deemed to be stable when the plotted statistics were within the critical limits of 5 per cent. All hypotheses were tested at 5 per cent level of significance.

RESULTS AND DISCUSSION

Preliminary Results

The descriptive statistics revealed that the variables had varying degrees of variability in the study period. The mean of the natural logarithm of green investment was 4.252 with a standard deviation of 0.163, which suggested that the investment in green is relatively limited. The mean financial inclusion was 16.31 per cent with a range of 3.78 to 35.51 per cent. The large range between the lowest and highest values indicates that there was a progressive increase in formal financial access in Nigeria over the course of the study period. The inflation rate was relatively erratic with an average inflation rate of 16.53 per cent and a maximum of 72.84 per cent. The interest rate of lending remained relatively high at 17.55 per cent on average. This makes these characteristics particularly relevant in the context of a fragile macroeconomic environment, where the link between financial inclusion and green investment emerged.

Unit-Root Test

To check the stationarity properties of the variables, the Augmented Dickey-Fuller (ADF) test was performed. Table 2 shows the results.

Table 2: Augmented Dickey-Fuller unit-root results

Variable	Level ADF statistic	First-difference ADF statistic	Order of integration
INF	-3.139*		I(0)
GDPP	-3.301*		I(0)
LFDI	-3.943**		I(0)
ELEC	-6.422***		I(0)
LGI	-2.784	-7.064***	I(1)
FI	-2.681	-5.985***	I(1)
INTR	-2.476	-4.759***	I(1)

Notes: ***, ** and * denote significance at the 1, 5 and 10 per cent levels, respectively. The test includes a trend.

Source: Researcher's computation (2026).

Inflation, GDP per capita growth, foreign direct investment and access to electricity were stationary at level. Green investment, financial inclusion and interest rate became stationary after first differencing. The variables were therefore a mixture of I(0) and I(1), with none integrated of order two. This result supported the use of the ARDL bounds-testing approach.

ARDL Bounds Test

The bounds test was used to determine whether a long-run relationship existed among green investment, financial inclusion and the control variables. The result is presented in Table 3.

Table 3: ARDL bounds-test results

Statistic	Calculated value	5% lower bound I(0)	5% upper bound I(1)	Decision
F-statistic	6.095	3.063	4.698	Reject H_0
t-statistic	-5.540	-2.892	-4.461	Reject H_0

Source: Researcher's computation (2026).

The calculated F-statistic of 6.095 exceeded the upper-bound critical value of 4.698 at the 5 per cent level. Similarly, the t-statistic of -5.540 was more negative than the corresponding upper-bound critical value of -4.461. The null hypothesis of no level relationship was therefore rejected. This confirms the existence of a long-run equilibrium relationship between green investment, financial inclusion and the selected control variables.

ARDL Error-Correction and Long-Run Results

The short-run error-correction and long-run estimates are presented in Table 4.

Table 4: ARDL error-correction and long-run estimates

Variable	Coefficient	Standard error	t-statistic	Probability
Short-run estimates				
ECM_{t-1}	-0.9657	0.1743	-5.54	0.000
ΔLGI_{t-1}	-0.3093	0.1468	-2.11	0.054
ΔFI	-0.0002	0.0019	-0.11	0.911
ΔINF	0.0038	0.0016	2.45	0.028
ΔLFDI	-0.0345	0.0498	-0.69	0.500
ΔINTR	0.0162	0.0077	2.10	0.054
ΔGDPP	-0.0056	0.0041	-1.37	0.192
ΔELEC	-0.0007	0.0009	-0.74	0.472
Constant	4.5299	0.7863	5.76	0.000
Long-run estimates				
FI	0.0034	0.0016	2.09	0.055
INF	-0.0081	0.0025	-3.21	0.006
LFDI	-0.0361	0.0527	-0.69	0.504
INTR	-0.0303	0.0053	-5.72	0.000
GDPP	0.0137	0.0051	2.71	0.017
ELEC	0.0015	0.0015	1.18	0.259

Model statistics: R^2 = 0.8089; Adjusted R^2 = 0.6177; Probability of F-statistic = 0.0000. Source: Researcher's computation (2026).

Short-Run Effect of Financial Inclusion

The short-run coefficient of financial inclusion was -0.0002 and the probability value was 0.911. The coefficient is thus statistically null and of no consequence. This suggests that the financial inclusion was not directly impacting green investment during the study period. The lack of a short-run effect is conceivable because it may take a while for someone who can open a formal financial account to invest in renewable energy or other environmentally friendly endeavors. It will take time for households and businesses to build up their savings, establish credit histories, secure appropriate credit and find viable green investment opportunities. There is also a need for time to build products in financial institutions that link more financial access with environmental investment.

Error-Correction Mechanism

The coefficient of error was -0.9657 and significant at 1 per cent level. The negative sign is an indication that the short run deviations from the long run relationship were corrected over time. The size of the disequilibrium is shown to represent about 96.57 per cent of the total disequilibrium in green investment corrected within one year. This is a comparatively quick change towards long run equilibrium and further confirms the presence of a stable relationship between variables.

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Long-Run Effect of Financial Inclusion

In the long run, the coefficient of financial inclusion was positive with a value of 0.0034 and a probability of 0.055. Other things being equal, an increase of one percentage point in financial inclusion translated into an increase of green investment of about 0.34 per cent, while the former was expressed in logarithmic form. The coefficient is not at the standard level of 5 per cent and should not be shown to be a definitive proof of an effect. The association is only marginally significant at the 10 per cent level and so evidence of a positive long run association is only suggestive, not strong. The null short-run effect and the small long-run effect are concurrent with the potential for time to elapse between the accumulation of savings, credit histories, product development and investment decisions, and their effect on actual green expenditure.

It seems that the coefficient is low both because of the economic situation and because it is difficult to measure. While Nigeria's financial-inclusion programmes have largely increased account ownership, transaction services and digital payments, many green projects call for credit that is affordable and has long tenure. The account-ownership proxy does not measure account holders' ability to borrow, the amount and maturity of credit that's available, the cost of financial services, or the quality of financial services. Therefore, the probability value of 0.055 could partly be explained by the fact that this is simply an imperfect proxy for substantive financial inclusion and green investment, and not a true absence of a relationship between the two. In the long run, the rate of inflation and rates of lending were found to be negative and significant, whereas GDP per capita growth are positive and significant. The other factors that were considered, namely foreign direct investment and access to electricity, were not statistically significant. The findings indicate that the linkage between formal financial access and green investment is likely to remain low in high cost of borrowing and price instability conditions.

Diagnostic and Stability Tests

The diagnostic results are summarized in Table 5.

Table 5: Diagnostic-test results

Test	Test statistic	Probability	Decision
Breusch-Godfrey serial-correlation test	$\chi^2 = 0.249$	0.6175	No serial correlation
Breusch-Pagan heteroscedasticity test	$\chi^2 = 1.750$	0.1854	Homoscedastic residuals
Skewness-kurtosis normality test	$\chi^2 = 1.380$	0.5026	Residuals are normally distributed
Ramsey RESET test	F = 7.910	0.1830	No evidence of misspecification
CUSUM and CUSUMSQ	Within 5% bounds		Parameters are stable

Source: Researcher’s computation (2026).

All the probability values for the serial-correlation, heteroscedasticity, normality and specification tests were greater than 0.05. Thus, the null hypotheses for no serial correlation, constant error variance, and normally distributed residuals and correct model specification were not rejected. The reported CUSUM and CUSUMSQ plots were also found to be within the 5 per cent critical boundaries, showing that the estimated parameters were stable in the study period. The diagnostic results indicate that the ARDL estimates were statistically appropriate for diagnostic interpretation.

DISCUSSION

The positive long run relationship between financial inclusion and green investment aligns with Financial Intermediation Theory, which argues that financial institutions play a key role in channels the savings, lower

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transaction costs and information costs, and direct capital towards productive activities (Diamond, 1984). The finding is also broadly consistent with Dai et al. (2022), Li et al. (2022) and Oanh (2024) who demonstrate that financial access can facilitate the development of renewables and sustainable investment, especially when connected to the green finance mechanism. However, the statistical evidence is limited. A probability value of 0.055 is more than 5 per cent and the null hypothesis cannot be rejected. The overall figure is marginal at 10 per cent, and should thus be interpreted as a suggestive positive association, not a strong causal effect. It is important to note that the difference does not necessarily reflect on the sectors in which savings and credit are being used. However, as Campiglio (2016), and Tufail et al. (2022) suggest, the greater the financial access, the more of these products and services will be used for consumption and for carbon intensive production, unless policy incentives and financial products are designed to focus on sustainable activities.

Narrow financial-inclusion proxy provides additional reason for weak result. The indicators of Account ownership are the evidence of access to a formal financial entry point, but the evidence of green investment use depends more closely on the indicators of active use, formal borrowing, affordability, loan tenor, collateral requirements, risk-sharing, and product suitability. The coefficient is therefore likely to underestimate the relationship that would be seen in a multidimensional index that reflects the depth and quality of financial inclusion. The finding does not rule out the fact that increased access to useful and affordable credit is not important, but rather it indicates that there was not a strong relationship between increased access to credit and aggregate green expenditures during the period.

The long sample also covers different policy and macroeconomic regimes. The banking consolidation of 2005 restructured the banking system and its capital base, and the crisis of 2008-2009 led to a deterioration in bank balance sheets and a shift in bank credit allocation. The 2016 and 2020 recessions impacted income, investment and fiscal capacity; the 2023 petrol-subsidy reform and foreign-exchange policies brought about significant price, financing cost and project budget changes. These are average coefficients reported for these episodes. Even though the diagnostic tests show that the residual is adequate and the parameters are stable in the model estimated, this does not rule out the fact that the strength of the financial inclusion–green investment relationship has varied over sub-periods.

The evidence presented herein indicates that financial inclusion can only facilitate green investment if it is accompanied by the delivery of low-cost, well-designed and environmentally focused financial services. This is in line with the impact of inflation and lending rates as they are significant and can cause even financially included households and firms to delay investments in green projects that require capital investments, when inflation and debt-service costs are high and the macroeconomic uncertainty level is high.

CONCLUSION

The study focused on the effect of financial inclusion on green investment in Nigeria from 1994 to 2024, with the use of the ARDL approach. The bounds test result confirmed that there is a long run relationship between green investment, financial inclusion and the selected control variables, and the negative and statistically significant error-correction coefficient indicated a convergence towards the long-run equilibrium.

Financial inclusion had no statistically significant short-run association with green investment. In the long run, the estimated coefficient was positive, but its probability value of 0.055 means that the evidence is not significant at 5 per cent and is only marginal at 10 per cent. The findings should therefore be treated as suggestive rather than conclusive. It indicates that expanding formal account access may support green investment over time, but account ownership alone is insufficient to represent access to affordable, long-term investment finance. The result may also be weakened by the limited sample and by measurement error in the green-investment and financial-inclusion proxies.

The research further revealed that inflation and interest rates on loans for investment in green projects significantly impacted green investment in the long run. This means that the role of financial inclusion is limited when the prices rise, resulting in higher project costs and if the interest rates on the loans are high, then long-term investment finance becomes difficult to afford. Thus, the study finds that financial inclusion can play a role in green investments in Nigeria, but this can only be realized if the quality and functions of the financial services offered are of good quality and their functions are geared towards green investments and also if the macroeconomic environment is stable.

RECOMMENDATIONS

The findings point to a need to connect Nigeria's financial-inclusion infrastructure more directly to long-term green finance while preserving credit discipline, fiscal sustainability and environmental integrity. The proposed actions are summarised in the implementation matrix below.

Policy Implementation Matrix

Intervention	Responsible institutions	Implementation mechanism	Indicative timeline	Measurable outcomes
Green credit-guarantee scheme	CBN, DBN, commercial banks, microfinance banks	Create a partial guarantee for taxonomy-eligible renewable-energy, energy-efficiency, clean-transport, waste and climate-smart agriculture loans. Cap the guarantee share, require lender risk retention and charge risk-based fees.	Design: 0–12 months; pilot: years 1–2	Number and value of guaranteed loans; beneficiary and regional distribution; default rate; private capital mobilised; renewable capacity or verified environmental outputs.
Dedicated wholesale green-finance window	DBN and BOI through participating financial institutions and qualified fintech or microfinance channels	Provide long-tenor wholesale funds for verified green projects, with products suited to MSMEs, farmers and households. Use transparent eligibility criteria, environmental and social safeguards and independent verification.	Pilot: year 1; scale-up: years 2–5	Green-loan portfolio; average loan tenor; number of MSMEs and households financed; women- and rural-led beneficiary shares; repayment performance.
Refinancing and targeted interest support	CBN within its monetary mandate; DBN, BOI and participating lenders	Refinance performing green loans or blend development-finance resources to reduce effective borrowing costs. Avoid blanket subsidies; use capped support, sunset clauses and periodic additionality tests.	Framework: 12–18 months; review every two years	Difference between green and comparable market lending rates; average tenor; refinancing volume; fiscal or quasi-fiscal cost; additional investment induced.
Green-lending classification and disclosure	CBN, National Council on Climate Change, Federal Ministry of Environment, Financial	Adopt a national green taxonomy and require institutions to report approvals, disbursements, outstanding balances, sector allocation and environmental results. Subject major claims to assurance to reduce greenwashing.	Taxonomy and templates: year 1; mandatory reporting:	Share of regulated credit classified as green; verified reporting coverage; correction rate for misclassified loans; publication of

Intervention	Responsible institutions	Implementation mechanism	Indicative timeline	Measurable outcomes
	Reporting Council and regulated institutions		year 2	annual sector reports.
Inclusive household and MSME products	Commercial banks, microfinance banks, fintech firms, cooperatives, REA and technology providers	Expand pay-as-you-go solar, solar-irrigation, clean-cooking, energy-efficient equipment and recycling-finance products. Use transaction histories and cash-flow assessment where conventional collateral is unavailable.	Product design: 0–12 months; expansion: years 1–3	Number of active users; repayment and default rates; systems installed; energy savings; rural reach; affordability relative to household or enterprise income.
Integrated monitoring and evaluation	National Council on Climate Change, CBN, NBS, Federal Ministry of Environment, DBN and BOI	Create a central registry linking finance to project-level outputs and outcomes. Track commitments separately from disbursements and completed investment; publish independent evaluations and beneficiary-level inclusion indicators.	Registry: years 1–2; reporting: annual	Disbursement ratio; project completion; megawatts installed; emissions avoided; jobs created; resilience indicators; loan performance and beneficiary inclusion.

Although these interventions come with a price tag and a set of compromises. For instance, credit guarantees establish contingent liabilities and can lead to poor screening if the lender believes the public sector will bear the burden of the risk. Interest support can run counter to monetary restriction, can misallocate credit and can be fiscally costly. These risks should be managed through limits on guarantees, lender risk retention, risk-based pricing, clear and transparent project eligibility criteria, competitive project selection, time-limited support, public disclosure, environmental verification and periodic assessment to be conducted by a third party independent from the lender. Schemes which fail to show evidence of further private investment, good re-payment performance and measurable environmental benefits should be re-designed or discontinued.

Policy Context and International Climate Finance

The recommendations proposed should be part of, not an alternative to, the current climate and sustainable-finance ecosystem in Nigeria. Nigeria's updated NDC 3.0 and NDCS 2021–2030 offer the general policy guidance with emphasis on mitigation, adaptation, finance, technology and capacity-building priorities. Baseline principles on sustainable banking already exist in Nigeria, namely the Nigerian Sustainable Banking Principles. A green-credit guarantee, refinancing mechanism and reporting mechanism should thus be based on a common taxonomy that is compatible with these instruments and the country's long-term low-emission development goals.

The institutional responsibilities should be based on the principle of comparative advantage. The CBN should establish prudent definitions, disclosure requirements and conditions for refinancing, as long as they are consistent with price and financial stability. DBN can provide long-term wholesale financing and partial credit guarantee facilities through financial institutions taking part and BOI can offer direct or intermediated financing to eligible industrial, renewable-energy and climate-resilient projects and offers technical assistance. Commercial banks, microfinance banks and fintech companies should provide and provide services to borrowers, do credit checks and increase loans to small enterprises and households. Environmental authorities are responsible for assessing the eligibility of a project and the impact of its outcomes and should not rely on the interpretation of what "green" means as the sole responsibility of the lender.

Inclusion should not be replaced by international climate finance, but supported. Concessional capital, grants, guarantees, project-preparation support and technical assistance are available from GEF resources, from bilateral partners of the GCF and from other sources. Domestic financial inclusion provides local distribution channels, transaction history and co-financing capacities and project pipelines that are necessary to access firms and households on a large scale. Examples of institutional pathways for international resources to be blended with domestic finance include DBN's Green Climate Fund accreditation, and BOI's climate-finance partnerships. Concessional resources should be used to mitigate real risks and establish viable markets for sustainable financing of future projects, rather than to subsidize them on an ongoing basis.

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