ANALYSING THE IMPACT OF DIGITAL BANKING ON SUSTAINABLE INVESTMENT ACCESS IN EMERGING ECONOMIES

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Abstract
Digital banking may provide an enabling infrastructure through which financial institutions and fintech platforms can improve the accessibility and distribution of sustainable financial products. However, the availability and type of such products vary across markets and institutions. Accordingly, this study evaluates the association between digital financial development and a proxy measure of sustainable investment access in emerging economies, with a particular focus on Nigeria. Using secondary data from the World Bank's Global Findex, EFInA's Access to Financial Services Surveys, GSMA's Mobile Money Metrics, and Central Bank of Nigeria reports, the study employs descriptive statistics, correlation analysis, and Ordinary Least Squares (OLS) regression to assess the relationship between digital finance adoption and sustainable investment. The results show that mobile banking, digital payment accounts, and mobile money significantly and positively affect access to sustainable investments, while internet use enables access rather than directly driving it. Notably, trust and customer satisfaction are negatively related, suggesting that reliance on traditional banking confidence may reduce openness to innovative digital platforms. The findings highlight digital finance's transformative potential to bridge investment gaps, mobilise savings, and channel capital into green bonds, renewable energy, and climate-resilient agricultural practices. The study concludes that digital banking is a vital enabler of inclusive, resilient, and sustainable financial systems in emerging markets and recommends expanding internet and mobile coverage, particularly in rural areas, alongside supportive policies to enhance transparency, protect consumers, and foster digital innovation.

Keywords: Digital banking, financial inclusion, internet usage, mobile banking, Nigeria, sustainable investment.

1.0 Introduction

Over the past two decades, digital banking has reshaped financial landscapes across emerging economies, improving financial access and contributing to the Sustainable Development Goals (SDGs) (Mpofu, 2023; Ingale, 2024; Ahmad, 2025). Mobile money, digital payments, and other fintech innovations may also facilitate access to ESG-oriented financial opportunities. Consistent with this, mobile banking, digital payment accounts, and mobile money are positively associated with the Sustainable Investment Proxy Index. However, because the data are aggregate, these relationships indicate association rather than evidence that individual users purchased sustainable investment products(Chen et al., 2021; Roy, 2023). This is especially consequential in emerging markets, where conventional banking

penetration remains limited, and investments in green bonds, renewable energy, and climate-resilient agriculture are critical to addressing both climate change and persistent poverty.

Multilateral institutions such as the World Bank and the United Nations document that digital financial services (DFS) can reduce transaction costs, improve transparency, and mobilise domestic savings for SDG-aligned projectswith the potential to raise GDP by one to two per cent annually by reducing cash dependency. The global shift toward sustainable development has correspondingly intensified efforts to redirect financial flows towards environmentally and socially responsible ventures (Chala and Demidov, 2024).

In emerging economies, the urgency of this redirection is magnified by the dual pressures of rapid economic growth and acute sustainability challenges, including climate change and endemic poverty (Pathiranage, 2024). The proliferation of mobile devices and fintech innovation offers a transformative opportunity to connect financial inclusion with sustainable investment (Tay et al., 2022; Offiong et al., 2025). Digital platforms enable financial institutions to extend investment products to previously unbanked or underserved populations in rural and remote areas (Isukul and Tantua, 2021). This study examines how digital banking can broaden access to sustainable investment and contribute to a more inclusive and resilient financial ecosystem in emerging economies.

Notwithstanding the recognised importance of sustainable investment for attaining the SDGs, a pronounced financing gap persists across emerging markets. Traditional financial systems routinely exclude large segments of the population, particularly small-scale investors, because of high transaction costs, geographic constraints, and limited financial literacy (World Bank, 2017). These exclusions are compounded within sustainable finance by the limited availability of tailored investment products, inconsistent reporting standards, and the pervasive risk of greenwashing (Digital Defynd, 2025; Boning, 2025).

Although digital banking presents a plausible solution to these accessibility challenges, empirical evidence on its impact on sustainable investment remains sparse (Amaliah et al., 2024; Nnaomah et al., 2024). The core research problem is as follows: while digital platforms are extending financial inclusion, it remains unclear whether expanded access translates into meaningful participation in sustainable investment. Key structural barriers include: the absence of small-ticket sustainable investment products for retail investors; the dearth of user-friendly educational tools on digital platforms to inform investors about ESG dimensions; and regulatory and infrastructural deficiencies, such as underdeveloped digital infrastructure and cybersecurity risks, that erode trust and constrain the scalable deployment of sustainable digital finance initiatives (Oluwatoyin and Adekunle, 2024). This study therefore analyses the extent to which digital banking can surmount these systemic barriers and effectively channel capital toward a more sustainable and inclusive future, with insights intended to guide policy interventions, including the design of green digital products, improvement of digital infrastructure, and the creation of supportive regulatory environments.

2.0. Conceptual, Theoretical Framework and Empirical Review

The conceptual framework proposes that digital banking can help develop an enabling environment for sustainable investment by reducing transaction, information, and geographic barriers to financial participation (World Bank, 2022; Mpofu, 2023). Key dimensions of digital banking, including internet usage, mobile banking, digital payment accounts, and mobile money, are therefore expected to be associated with greater financial connectivity and potentially improved access to investment-related financial services (Demirgüç-Kunt et al., 2022; Ingale, 2024). However, the framework does not assume that digital banking platforms uniformly provide or directly facilitate the purchase of specific sustainable investment

products across all countries in the sample. Instead, digital banking is conceptualised as financial infrastructure that may improve the channels through which individuals and institutions access information, conduct transactions, and engage with financial markets where sustainable investment opportunities are available.

Trust and customer satisfaction may further shape engagement with digital financial services by influencing users' willingness to adopt and continue using digital financial channels (EFInA, 2023). At the same time, the framework distinguishes between digital banking access, digital financial utilisation, and actual sustainable investment behaviour. Digital banking indicators capture the availability and use of technology-enabled financial services, whereas the Sustainable Investment Proxy Index captures the broader country-level environment associated with sustainable investment. Consequently, a positive association between digital banking and the proxy index should not be interpreted as evidence that individuals who use digital banking necessarily purchase sustainable investment products.

Given the aggregate nature of the data, the framework captures country- or system-level relationships rather than individual investment decisions. The Sustainable Investment Proxy Index is therefore interpreted as a proxy for the broader sustainable investment environment, financial-market development, and related enabling conditions, rather than a direct measure of purchases, holdings, or participation in specific sustainable investment products. This distinction matters because the empirical analysis identifies associations between digital banking development and the sustainable investment environment, whereas aggregate data cannot directly identify individual-level mechanisms such as product awareness, risk preferences, trust, affordability, cybersecurity concerns, and actual investment decisions.

Theoretical Framework

This study is anchored in Diffusion of Innovation (DOI) Theory and Financial Inclusion (FI) Theory, which together explain how digital banking may create favourable conditions for sustainable investment in emerging economies. DOI Theory, developed by Rogers (1962), explains how innovations are adopted and diffused within societies. In this study, DOI Theory provides a basis for understanding the spread of digital banking technologies, including mobile banking, internet platforms, digital payments, and fintech services. As adoption increases, digital technologies can reduce transaction, information, and geographic barriers to financial participation (Kaminski, 2011; Maythu et al., 2024).

FI Theory complements DOI by explaining how improved access, use, affordability, and quality of financial services can broaden participation in formal financial markets, particularly among previously underserved populations (Allen et al., 2016; Ozili, 2020; Sharma and Changkakati, 2022). Digital banking can therefore strengthen financial inclusion by making financial services more accessible and convenient, potentially improving conditions for participation in sustainable investment markets.

The two theories are complementary: DOI explains the diffusion of digital banking, while FI explains how this diffusion may reduce barriers to financial access. However, digital banking adoption does not necessarily translate into purchases of sustainable investment products, as this also depends on product availability, trust, affordability, financial literacy, and institutional conditions. Given the aggregate nature of the data, the framework therefore focuses on the relationship between digital banking development, financial inclusion, and the broader sustainable investment environment rather than on individual investment behaviour.

Empirical Literature Review

Recent empirical research has increasingly examined the relationship between digital finance, financial inclusion and sustainable development, although relatively few studies directly

investigate whether digital banking facilitates access to sustainable investment opportunities. Khera et al. (2021) developed a digital financial inclusion index for 52 emerging and developing economies, using indicators of both access to and use of digital financial services. The index covers mobile money, internet banking and other technology-enabled financial services, and shows substantial cross-country variation in digital financial inclusion. Importantly, the authors distinguish access from actual usage, noting that greater access does not necessarily translate into effective financial inclusion. This distinction is particularly relevant to the present study, as the availability of digital banking infrastructure should not be taken as automatic evidence that individuals purchase or use sustainable investment products.

The empirical literature has since shifted towards more rigorous econometric methods to assess the sustainability implications of digital finance. Bakry et al. (2024), for example, analysed 52 developing economies from 2010 to 2019 using an instrumental-variable generalised method of moments (IV-GMM) framework to address potential endogeneity. Their results indicate an inverted U-shaped relationship between digital finance and carbon emissions, suggesting that the environmental consequences of digital financial development are not necessarily linear. This finding is important because it challenges the assumption that greater digitalisation automatically produces sustainable outcomes and highlights the importance of the institutional and economic conditions surrounding digital financial expansion.

More recent African evidence also shows the growing use of dynamic panel techniques to analyse the digital finance sustainability nexus. A study by Faton et al. (2026) covering 46 Sub-Saharan African countries from 1990 to 2023 employed System-GMM and quantile regression to examine the relationship between FinTech development and green growth. The findings indicate that FinTech development is associated with improved green-growth outcomes on average, while the magnitude and direction of the relationship vary across the distribution of environmental performance. The use of both System-GMM and quantile regression underscores the importance of accounting for endogeneity, dynamic effects and cross-country heterogeneity when examining digital finance and sustainability.

Similarly, Eshun and Kočenda (2025) examined financial inclusion and green sustainability across 38 African countries from 2000 to 2021 using System-GMM. Their study constructs composite measures of financial inclusion and environmental pollution and investigates their dynamic relationship across African economies. This evidence further suggests that the sustainability implications of financial inclusion should be examined within a dynamic framework rather than through simple contemporaneous correlations.

Other recent African research has emphasised the role of institutional conditions in shaping the effectiveness of digital financial inclusion. Okoli (2025), using panel data for 41 African economies over 2004-2022, applied principal component analysis and System-GMM to examine institutional quality as a transmission mechanism linking digital financial inclusion to financial inclusion outcomes. The study reinforces the importance of institutional quality when assessing the broader development effects of digital financial technologies.

Thus, the empirical literature establishes a growing relationship between digital finance, financial inclusion and sustainable development outcomes, but three important gaps remain. First, much of the existing evidence focuses on environmental outcomes, such as carbon emissions or green growth, rather than on access to sustainable investment opportunities. Second, several studies focus on digital financial inclusion at the aggregate level, without clearly distinguishing between access to digital banking infrastructure and the actual use or purchase of sustainable financial products. Third, the recent literature increasingly employs

IV-GMM, System-GMM, quantile and other dynamic techniques to address endogeneity and heterogeneity, whereas country-specific evidence for Nigeria remains limited.

The present study addresses this gap by examining the relationship between digital banking indicators and a Sustainable Investment Index for Nigeria. Importantly, the Sustainable Investment Index is treated as a system-level proxy for the sustainable-investment environment and access, rather than as a direct measure of individual purchases of green or sustainability-themed financial products. This distinction prevents equating digital banking availability with actual sustainable-investment behaviour and offers a more appropriate interpretation of the empirical relationship.

3.0. Methodology

This study examines the impact of digital banking on access to sustainable investments in emerging economies, with Nigeria serving as the primary case study. Nigeria is a fitting setting for several reasons: it is Africa's largest economy, hosts a burgeoning fintech sector, and confronts persistent challenges of financial exclusion, poverty, and climate vulnerability. Over the past three decades, the country has undergone substantial digital transformation, characterised by expanding internet penetration, widening mobile network coverage, and innovations in mobile money, digital lending, and payment systems. These developments create a compelling environment for examining how digital financial services can close investment gaps and promote inclusive, sustainability-oriented finance.

The study spans 1990 to 2024, tracing the co-evolution of digital banking and sustainable investment trends in Nigeria. Data come from international sources, including the World Bank Global Findex, the International Telecommunication Union (ITU), and the GSMA, as well as national sources, notably the Central Bank of Nigeria (CBN) and the Enhancing Financial Innovation and Access (EFInA) organisation. While the study is geographically anchored in Nigeria, its findings have broader applicability to other emerging economies facing analogous challenges of limited financial infrastructure, high exclusion, and pressing sustainable development imperatives. The analysis does not extend to developed economies, where digital banking is more mature and sustainable investment patterns differ substantially.

Data Sources and Description

The study draws on a curated mix of international, national, and industry datasets to examine the evolution of financial inclusion, digital financial access, and user perceptions in Nigeria over the study period. The World Bank Global Findex Database provides internationally comparable indicators of financial inclusion, including account ownership, saving behaviour, digital payments, borrowing, and the use of formal financial services. The analysis draws on the available Global Findex waves for 2011, 2014, 2017, and 2021, enabling the study to capture changes in digital financial access and usage over time.

The Global Findex data are complemented by Nigeria-specific evidence from the Enhancing Financial Innovation & Access (EFInA) Access to Financial Services (A2F) Surveys. The A2F Surveys provide nationally representative information on financial access and use in Nigeria, including indicators of mobile and digital financial services, formal and informal financial channels, and consumer experiences with financial institutions. Where applicable, indicators of trust and customer satisfaction are included to capture the user-perception dimension of digital financial services.

Additional indicators are drawn from the World Bank’s World Development Indicators (WDI) and from relevant national and industry sources, including the Central Bank of Nigeria (CBN), Nigerian Communications Commission (NCC), International Telecommunication

Union (ITU), and GSMA. These sources provide complementary measures of internet and mobile connectivity, digital payment infrastructure, mobile money development, and the broader enabling environment for digital financial services. Sustainable-investment indicators are drawn from internationally recognised sources covering green and sustainability-related financial activity, including green and sustainability bond issuance, clean-energy investment, sustainability-themed assets, and relevant policy or regulatory measures.

Using multiple data sources enables the study to triangulate measures of digital financial access, actual usage, user perceptions, and the broader sustainable-investment environment. Importantly, the Sustainable Investment Index should be interpreted as a system-level proxy for the availability and development of sustainable-investment opportunities, rather than as a direct measure of individual purchases of sustainable financial products. Consequently, the empirical analysis evaluates the association between digital banking development and the sustainable-investment environment in Nigeria, rather than whether access to digital banking necessarily translates into individual sustainable-investment behaviour.

Variable Measurement and Construction of the Sustainable Investment Index

The empirical analysis distinguishes between the sustainable-investment environment, measured by the Sustainable Investment Index, and indicators of digital financial access and usage, which serve as the explanatory variables. This distinction is important because the availability or use of digital banking services does not necessarily imply that individuals directly purchase sustainable or green investment products. The explanatory variables therefore capture the digital-financial infrastructure and user characteristics that may facilitate broader access to sustainable investment opportunities.

The dependent variable is the Sustainable Investment Index (SII). The principal explanatory variables are internet use, mobile banking use, trust and customer satisfaction, digital payment account ownership, and mobile money account ownership. These variables capture complementary dimensions of digital financial development, including digital connectivity, banking-channel utilisation, consumer confidence, electronic payments, and mobile-based financial access. The Global Findex framework similarly distinguishes between financial account ownership and the actual use of accounts for digital payments and other financial activities, reinforcing the importance of separating access from usage in empirical analysis.

Table 1:
Variable Definition and Measurements

Variable	Measurement	Expected role
Sustainable Investment Index (SII)	Composite index of sustainable-investment market and institutional indicators	Dependent variable
Internet Usage (INT)	Percentage/share of the relevant population using the internet	Digital connectivity
Mobile Banking Usage (MB)	Measure of mobile/digital banking utilisation	Digital banking access and usage
Trust/Customer Satisfaction (TRUST)	Composite/standardised measure of reported trust and satisfaction with financial services	User-perception dimension
Digital Payment Account (DPA)	Share/proportion of adults using or holding digital payment facilities	Digital payment access
Mobile Money Account (MMA)	Share/proportion of adults with/use of mobile money services	Mobile-based financial access

Source: Authors' Compilation, 2026.

The variables are harmonised to the annual study period using available observations from the World Bank Global Findex, EFInA A2F surveys, WDI, ITU, NCC, CBN, GSMA, and other relevant national and industry sources. Where survey-based indicators are available

only for specific survey years, the study uses the corresponding harmonised series in the dataset rather than treating interpolated or aligned observations as additional survey observations. This approach preserves consistency between the source data and the econometric sample.

Internet Usage

Internet usage (INT) captures the extent of population access to and use of the internet and reflects the underlying digital infrastructure that enables individuals to access online financial services. The indicator draws on internationally comparable digital-connectivity statistics, primarily from the World Bank and the ITU. Internet connectivity is treated as an enabling condition for digital financial participation rather than as direct evidence of financial-service utilisation. This distinction is important because internet access can facilitate digital banking without necessarily leading to the use of financial or sustainable-investment products.

Mobile Banking Usage

Mobile banking usage (MB) measures the extent to which financial services are accessed via mobile or digital banking channels. The indicator is derived primarily from Nigeria-specific financial-access information and internationally comparable financial-inclusion data. The variable reflects actual use of digital banking channels, rather than merely the availability of mobile banking infrastructure. This distinction aligns with the Global Findex approach, which separately reports account ownership and the use of accounts for digital payments and other financial activities.

Trust and Customer Satisfaction

Trust/customer satisfaction (TRUST) captures the user-perception dimension of digital financial services. It reflects consumers' confidence in financial-service providers and their reported satisfaction with the services they receive. The measure is constructed from relevant EFInA A2F indicators and, where necessary, transformed into a harmonised index for inclusion in the annual dataset.

Trust is included because digital financial participation depends not only on technological availability but also on users' willingness to engage with digital financial channels. Concerns about security, reliability, fraud, privacy, service quality, and provider credibility may influence how much consumers use digital financial services. Accordingly, TRUST is interpreted as an enabling or constraining user-perception factor rather than a direct measure of sustainable-investment behaviour.

Digital Payment Account

The digital payment account variable (DPA) measures the extent of access to or use of digital payment facilities. It captures the development of electronic payment channels through which individuals can make or receive payments using financial accounts, cards, mobile phones, or internet-based services. The Global Findex distinguishes account ownership from actual use of digital payments, with digital payments including those made through mobile phones, the internet, cards, and other formal digital channels.

DPA therefore represents a broader measure of digital financial engagement than simple account ownership. It is expected to capture the extent to which the digital-payment ecosystem has developed sufficiently to enable participation in other formal financial activities.

Mobile Money Account

Mobile money account ownership and use (MMA) measures participation in mobile-money-based financial services. The indicator is derived primarily from the Global Findex and

complementary Nigerian financial-access sources. The Global Findex defines mobile-money account ownership based on respondents' personal use of a mobile-money service and recognises mobile money as an important component of financial inclusion, particularly in Sub-Saharan Africa.MMA is included separately from DPA because mobile money represents a distinct delivery channel with potentially different patterns of adoption and usage from conventional bank-based digital payments.

Construction of the Sustainable Investment Index

The Sustainable Investment Index (SII) is constructed as a composite measure of the development of the sustainable-investment environment in Nigeria. The index is designed to capture the extent to which sustainable and green investment opportunities are developing within the financial and investment system. It does not represent the number or value of sustainable-investment products personally purchased by individual consumers.

The index combines four dimensions:

i. Green and sustainability-related bond issuance: the value of green, sustainability, or sustainability-linked bond financing associated with Nigeria;
ii. Clean-energy investment: investment flows directed toward renewable and other clean-energy activities;
iii. Sustainability-themed assets: assets associated with sustainability- or environmentally oriented investment funds and financial instruments; and
iv. Policy and regulatory environment: an indicator capturing the extent to which national policies and regulatory frameworks support sustainable or green finance.

Because these components are expressed in different units, the individual indicators are first transformed into comparable standardised measures.

To capture the multidimensional nature of sustainable investment development, a composite Sustainable Investment Index (SII) is constructed from the selected sustainable investment dimensions. Because the component indicators are measured on different scales, each component is first standardised using the z-score transformation:

$$\boldsymbol{Z_{jt} = \frac{X_{jt} - \overline{X}_j}{s_j}} \qquad \textbf{(1)}$$

Where X_{jt} represents the value of component j in year t, $\overline{X}_j$ is the sample mean of component j over the study period, and s_j is its sample standard deviation. Standardisation transforms the component variables to a common scale with a mean of zero and a standard deviation of one, thereby allowing indicators measured in different units to be combined.

The composite Sustainable Investment Index is subsequently calculated as the equally weighted arithmetic mean of the standardised components:

$$\boldsymbol{SII_t = \frac{1}{J}\sum_{j=1}^{J} Z_{jt}} \qquad \textbf{(2)}$$

Where J denotes the number of sustainable-investment dimensions included in the index. Equal weighting ensures that no single dimension dominates the index solely because of its measurement scale or statistical variance. Consequently, higher values of SII_t indicate a relatively stronger sustainable-investment environment in year t, while lower values indicate a relatively weaker environment.

The composite index is justified by the multidimensional nature of sustainable investment, which a single financial-market indicator cannot adequately capture. By combining selected dimensions, the SII captures both market-related activity and the broader institutional and

digital-financial environment that supports sustainable finance. Nevertheless, the index should be interpreted as a system-level proxy for sustainable-investment development and access, rather than as a direct measure of the investment behaviour of individual households, firms, or investors.

Econometric Specification

This study examines the relationship between digital banking development and the sustainable-investment environment using an ordinary least squares (OLS) regression model. Following Burton (2021), it is specified as:

$$\boldsymbol{SII_t = \beta_0 + \beta_1 INT_t + \beta_2 MB_t + \beta_3 TRUST_t + \beta_4 DPA_t + \beta_5 MMA_t + \varepsilon_t} \quad \textbf{(3)}$$

Where;

SII_t= Sustainable Investment Index in year t;

INT_t= internet usage;

MB_t= mobile banking usage;

$TRUST_t$= trust/customer satisfaction with digital financial services;

DPA_t= digital payment account indicator;

MMA_t= mobile money account indicator;

β_0= intercept term;

$\beta_1, \ldots, \beta_5$=regression coefficients associated with the respective digital-financial indicators; and

ε_t= error term.

The coefficients $\beta_1 - \beta_5$represent the conditional associations between the respective digital-financial indicators and the Sustainable Investment Index, holding the other explanatory variables constant. A positive coefficient indicates that higher levels of the corresponding digital-financial indicator are associated with a higher SII, whereas a negative coefficient indicates an inverse association.

Given the time-series nature of the data, the OLS estimates should be interpreted cautiously. Before estimation, examine the variables for stationarity and potential multicollinearity, and run diagnostic tests for serial correlation and heteroskedasticity. Where necessary, robust or heteroskedasticity-and-autocorrelation-consistent standard errors should be employed. Importantly, the OLS framework identifies conditional associations and should not, by itself, be interpreted as establishing a causal relationship of digital banking development on sustainable investment.

Study Limitations and Directions for Future Research

This study has several limitations to consider when interpreting its findings. First, the analysis focuses on Nigeria and uses an annual time-series dataset spanning 34 years. Consequently, the findings reflect country-level relationships and may not generalise to other emerging economies with different financial, technological, regulatory, and institutional environments. Second, the study relies primarily on secondary, aggregated data, limiting its ability to examine household- or individual-level differences in digital banking adoption, financial literacy, trust, risk preferences, and sustainable investment decisions.

Third, the OLS framework identifies conditional associations rather than causal relationships and may be subject to endogeneity and reverse causality. For example, individuals and financial markets with greater financial sophistication may be more likely to adopt digital banking while also having greater access to investment opportunities. Conversely, improvements in the sustainable-investment environment may stimulate demand for digital financial services. Omitted factors, including financial literacy, income, regulatory quality, digital infrastructure, and macroeconomic conditions, may also influence both digital banking

development and access to sustainable investment. Although the study incorporates diagnostic tests and controls for the principal digital-finance dimensions available in the dataset, the design cannot eliminate these sources of endogeneity.

The relatively small number of annual observations also constrains the complexity of the econometric specification and the statistical power of alternative estimators. The results should therefore be interpreted as evidence of a national-level empirical association between digital banking development and the sustainable-investment environment, rather than as evidence that digital banking causally increases individual investment in sustainable financial products.

Future research could address these limitations by combining household-level survey data with financial-market and institutional indicators, thereby distinguishing digital banking access and usage from participation in sustainable investment. Multi-country panel datasets would also allow fixed-effects, dynamic-panel, instrumental-variable, or System-GMM approaches where the data structure and instrument validity permit. Future studies could also investigate specific sustainable-finance outcomes including green bonds, sustainability-linked bonds, renewable-energy funds, and other green financial products and examine whether digital banking affects their adoption or utilisation. Such research would provide a more direct assessment of the mechanisms through which digital financial technologies may contribute to sustainable investment.

4.0 Results and Discussion

Digital Transformation and Sustainable Investment in Nigeria

Figure 1 illustrates the evolution of Nigeria's digital and financial landscape between 1990 and 2024. The time-series patterns show broad expansion in digital connectivity and financial-service participation over the study period, though the pace of change differs across indicators. Internet access and related digital infrastructure expanded progressively, while indicators of formal financial participation and digital financial-service use became more prominent in the later years. Mobile money adoption increased substantially during the more recent period, reflecting the growing importance of mobile-based financial channels in Nigeria's financial ecosystem. The observed trends suggest a broad temporal association between improvements in digital connectivity and the expansion of digital financial services. However, the figure provides only descriptive evidence and should not be interpreted as showing that internet access, public trust, or financial inclusion directly caused the subsequent growth in mobile money or other digital financial services. The concurrent movements may also reflect changes in regulation, telecommunications infrastructure, financial-service innovation, income, financial literacy, and broader macroeconomic conditions. Thus, Figure 1 primarily establishes the evolution and co-movement of the indicators examined in the econometric analysis.

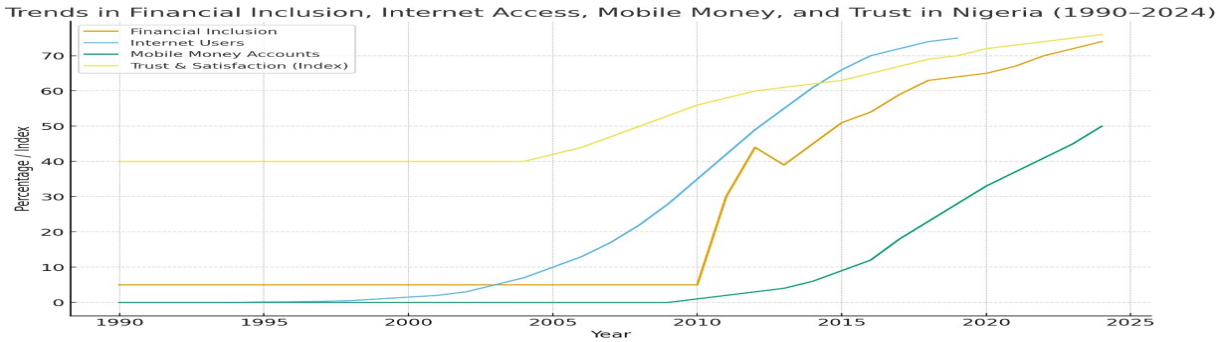


Figure 1: Trends in Financial Inclusion, Internet Access, Mobile Money, and Trust in Nigeria (1990-2024).

Figure 2 provides a complementary view of the evolution of digital connectivity and mobile financial services in Nigeria. Internet penetration increased substantially from a very low base in 2000 to approximately 40% of the population by 2023, indicating a considerable expansion in the digital infrastructure available to households and businesses. Over the same period, registered mobile money accounts increased markedly, with particularly rapid growth observed between 2021 and 2023, reaching nearly 40 million accounts.

The concurrent expansion of internet connectivity and mobile money suggests a positive temporal association between digital infrastructure development and the growth of mobile-based financial services. However, the descriptive trends do not establish that increased internet penetration directly caused the expansion of mobile money accounts or that a specific "critical mass" of internet users was reached. The observed growth may also reflect regulatory changes, increased smartphone availability, improved mobile-network coverage, fintech innovation, shifts in consumer preferences, and broader financial-inclusion initiatives. Figure 2 therefore provides descriptive evidence of Nigeria's accelerating digital-financial transformation, while the econometric analysis examines the direction and strength of the relationship between digital-finance indicators and sustainable-investment outcomes.

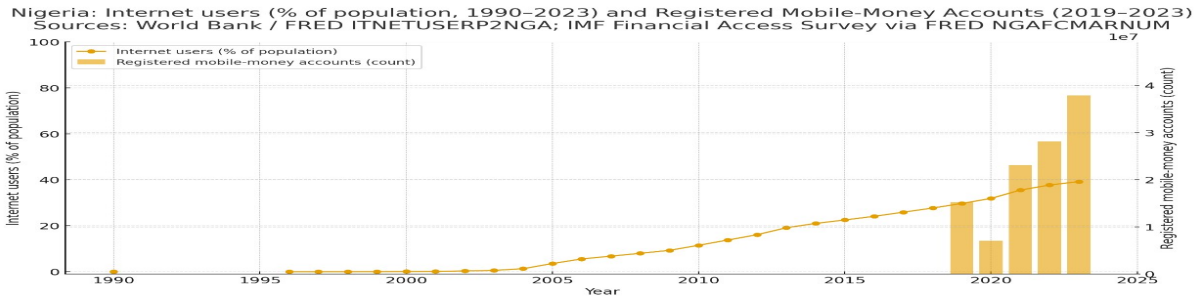


Figure 2: Internet Users (% of Population) and Registered Mobile Money Accounts in Nigeria. Source: World Bank / FRED ITNETUSER2NGA.

Figure 3: Evolution of Nigeria's Sustainable Investment Proxy Index

Figure 3 presents the evolution of Nigeria's Sustainable Investment Proxy Index (SII) between 1991 and 2024. The index shows relatively little variation in the early part of the study period, followed by a gradual increase from the mid-2000s. The series was then normalised to a base value of 100 in 2010 to facilitate comparison of changes over time. A more pronounced increase is observed from approximately 2015 onwards, indicating a substantial expansion in the composite indicators underlying the sustainable-investment proxy. The later period also shows greater year-to-year variation, including a decline and subsequent recovery around 2019, a peak around 2021, and a subsequent correction. These movements indicate that the sustainable-investment environment represented by the index became more dynamic over the latter part of the study period.

However, because the SII combines indicators of green and sustainability-related financial activity, clean-energy investment, sustainability-themed assets, and the policy and regulatory environment, changes in the index do not necessarily reflect individual investors' actual purchases or utilisation of sustainable financial products. Rather, the figure indicates changes in the broader national sustainable-investment environment. The increasing variability in later years may reflect shifts in investment flows, financial-market conditions, policy developments, and other factors affecting the index's underlying components. These

descriptive trends provide the temporal context for subsequently examining the association between digital banking development and the sustainable-investment environment using the econometric
model.

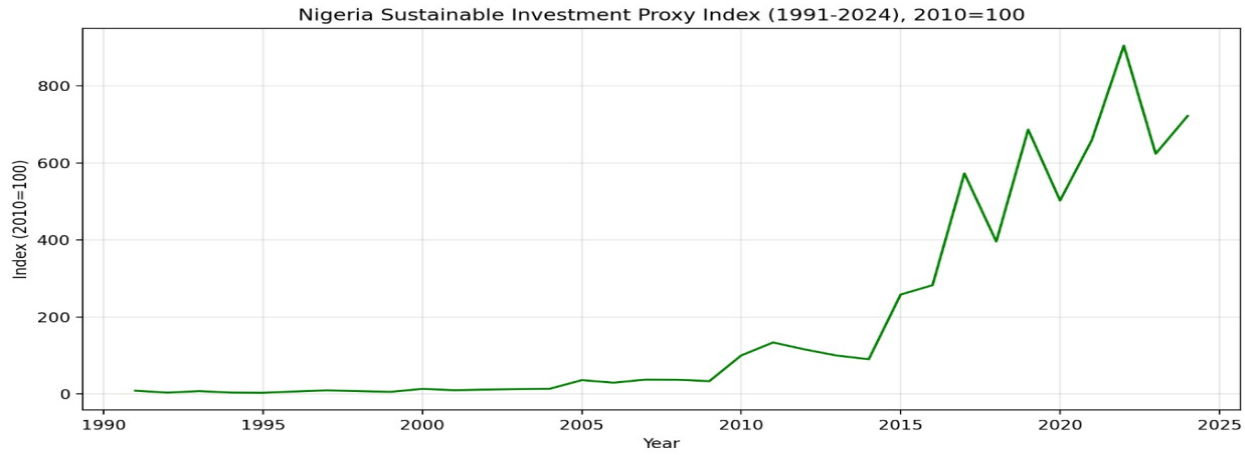


Figure 3: Nigeria Sustainable Investment Proxy Index (1991–2024).

Patterns of Digital Finance Adoption and Sustainable Investment Access

Table 2 presents descriptive statistics for the study variables and highlights substantial variation in digital-finance indicators over the study period. The Sustainable Investment Index (SII) has a mean of 1.807 and a standard deviation of 0.776, indicating considerable temporal variation in Nigeria's sustainable-investment environment. Internet usage (mean = 0.520; SD = 1.156) and mobile banking usage (mean = 0.812; SD = 1.466) show greater dispersion, suggesting substantial changes in digital connectivity and mobile banking utilisation over the study period. Digital payment accounts show comparatively little variation (mean = 1.264; SD = 0.144), indicating greater stability than the other digital-finance measures. Trust and customer satisfaction have a mean of 1.335 and a standard deviation of 0.630, reflecting moderate variation in reported perceptions of digital financial services.

Similarly, mobile money accounts have a mean of 0.839 and a standard deviation of 0.247, indicating noticeable but comparatively lower variation over time. Overall, the descriptive statistics indicate that digital-finance indicators did not evolve uniformly during the study period, with internet usage and mobile banking showing greater variability than digital payment accounts and mobile money. These patterns provide useful descriptive context for the subsequent regression analysis, although the statistics alone do not establish whether variation in digital-finance indicators is associated with changes in the Sustainable Investment Index.

Table 2:
Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Index of Sustainable Investment	30	1.807	0.776	0.484	2.957
Internet usage	30	0.52	1.156	−2.054	1.593
Mobile banking usage	30	0.812	1.466	−1.92	1.998
Trust and customer satisfaction	30	1.335	0.63	−0.213	2.327

Variable	Obs	Mean	Std. Dev.	Min	Max
Digital payments account	30	1.264	0.144	1.146	1.473
Mobile money account	30	0.839	0.247	0.125	1.00

Source: Authors' Compilation, 2025.

Relationship between Digital Banking and Sustainable Investment Access

Table 3 presents the correlation matrix for all study variables, and Table 3 reports the OLS regression results. Together, they provide a comprehensive picture of how digital financial services shape sustainable investment. The Sustainable Investment Index exhibits strong positive correlations with internet usage (r = 0.795), mobile banking usage (r = 0.822), and digital payment accounts (r = 0.891), suggesting that advances in digital financial infrastructure are closely associated with higher levels of sustainable investment. Internet usage is, in turn, strongly correlated with mobile banking usage (r = 0.893) and digital payment accounts (r = 0.650), indicating that internet penetration facilitates the use of digital financial platforms. Trust and customer satisfaction display weak correlations with most variables slightly positive with sustainable investment (r = 0.124) but marginally negative with internet usage (r = -0.071) and mobile banking (r = -0.125). Mobile money accounts show negative correlations with sustainable investment (r = -0.469), internet usage (r = -0.479), mobile banking (r = -0.476), and digital payments (r = -0.522).

Table 3:
Correlation Analysis of Digital Finance and Sustainable Investment

Variable	1	2	3	4	5	6
Index of Sustainable Investment	1.000					
Internet usage	0.795	1.000				
Mobile banking usage	0.822	0.893	1.000			
Trust and customer satisfaction	0.124	−0.071	−0.125	1.000		
Digital payments account	0.891	0.650	0.593	0.327	1.000	
Mobile money account	−0.469	−0.479	−0.476	0.370	−0.522	1.000

Source: Authors' Compilation, 2025.

Relationship between Digital Banking and Sustainable Investment Access

The OLS regression results indicate a strong in-sample relationship between the explanatory variables and the Sustainable Investment Index, with the model explaining 94.8% of the observed variation in SII ($R^2 = 0.948$; $F = 87.584$; $p < 0.001$). This high explanatory power, however, should be interpreted as a measure of model fit rather than as evidence of causality, particularly given the small annual sample and the potential for endogeneity among digital-finance indicators. Previous research similarly emphasises that digital financial inclusion encompasses multiple dimensions of access and use and can vary substantially across countries and regions (Khera et al., 2021).

Mobile banking usage is positively and significantly associated with the Sustainable Investment Index ($\beta = 0.263$; $p < 0.001$), indicating that higher mobile banking use coincides with a stronger sustainable-investment environment. This finding aligns with the broader literature linking digital financial inclusion and FinTech development to sustainable-

development outcomes. For example, evidence from 25 African countries shows a positive association between FinTech, financial inclusion, and measures of sustainable development, although the interaction between FinTech and financial inclusion varies across specifications (Tidjani & Madouri, 2024). Similarly, recent evidence from 46 sub-Saharan African countries suggests that FinTech can support green growth by facilitating access to sustainable finance, clean energy, and environmentally friendly technologies, although the magnitude and direction of the relationship vary with countries' environmental conditions (Abdalla et al., 2025).

Digital payment accounts also show a positive and statistically significant association with SII ($\beta = 0.456$; $p < 0.001$). This result aligns with evidence that digital financial inclusion can expand participation in formal financial systems and create channels for mobilising financial resources for productive and sustainability-oriented activities. Studies of digital financial inclusion emphasise that both access and actual use are important dimensions of digital financial development (Khera et al., 2021), while empirical research in African countries has reported positive relationships between financial inclusion, FinTech development, and broader sustainable-development indicators (Tidjani & Madouri, 2024). Evidence from low- and middle-income Asian countries has likewise examined mobile-payment-based financial inclusion as a potential channel for supporting green recovery, illustrating the growing empirical interest in the connection between digital payment systems and environmental sustainability (2023).

Mobile money accounts are also positively associated with SII ($\beta = 0.688$; $p = 0.007$). Notably, this coefficient contrasts with the negative bivariate correlation between mobile money and SII. This discrepancy indicates that the conditional relationship shifts after controlling for other digital-finance variables. Such a pattern can arise when predictors share substantial variance, although the coefficient should not automatically be labelled a formal "suppression effect" without additional diagnostic testing. The result is nevertheless consistent with recent evidence that digital financial inclusion and mobile-based financial services can have important sustainability-related associations, although these relationships are not necessarily uniform across contexts. For example, evidence from Africa reports heterogeneous relationships between financial inclusion and green sustainability, with effects varying across countries and levels of financial development (Eshun & Kočenda, 2025).

Internet use shows a strong positive bivariate correlation with SII ($r = 0.795$), yet its conditional OLS coefficient is negative and statistically insignificant ($\beta = -0.063$; $p = 0.404$). This divergence suggests that the simple correlation between internet use and sustainable investment is partly shared with other digital-finance variables in the model, particularly mobile banking and digital payment accounts. Therefore, the result does not provide sufficient evidence that internet penetration independently influences the sustainable-investment environment. Rather, internet connectivity may be an enabling component of the broader digital-financial ecosystem through which other financial technologies operate. This interpretation aligns with research emphasising the multidimensional nature of digital financial inclusion, in which infrastructure, access, and actual usage represent related but analytically distinct dimensions (Khera et al., 2021).

Trust and customer satisfaction are negatively and significantly associated with SII ($\beta = -0.213$; $p = 0.024$). This finding warrants cautious interpretation. The negative coefficient should not be taken as evidence that higher trust or satisfaction causally reduces sustainable investment. Instead, it reflects a negative conditional association after accounting for the other digital-finance variables. One possible explanation is that trust and satisfaction may

capture established patterns of engagement with existing financial institutions that are not necessarily directed towards sustainability-oriented financial products; however, this mechanism is not directly tested in the present analysis and should therefore be treated as a possible explanation rather than an established causal channel. This caution is important because recent literature emphasises that trust, security, consumer protection, and emerging risks are central to the development of sustainable digital-finance ecosystems (Mamun & Várallyai, 2025).

More broadly, the mixed coefficient patterns across digital-finance indicators reinforce the importance of distinguishing between digital financial access, digital financial usage, and participation in sustainable investment. Recent African evidence does not show a uniformly positive relationship between digital inclusion and sustainability. Abdulkareem et al. (2025), for example, report positive effects for some dimensions of financial inclusion but negative associations for selected digital-inclusion measures in sub-Saharan Africa. Similarly, Eshun and Kočenda (2025) find that the relationship between financial inclusion and green sustainability in Africa is nonlinear and heterogeneous across regional and income groups. These findings support interpreting the present estimates as conditional associations within Nigeria rather than as evidence that digital banking necessarily causes greater participation in sustainable investment. Given the time-series nature of the data, the results may also reflect common trends, omitted factors, reverse causality, and multicollinearity among rapidly expanding digital-finance indicators. Consequently, view the estimated coefficients as evidence of statistical association that motivates further investigation using identification strategies that address endogeneity.

Table 4:
OLS regression on the effect of Digital Banking on Sustainable Investment Access

Variable	Coef.	Std. Err.	t-value	p-value
Internet usage	−0.063	0.074	−0.85	0.404
Mobile banking usage	0.263***	0.056	4.73	0.000
Trust and customer satisfaction	−0.213**	0.088	−2.42	0.024
Digital payments account	0.456***	0.488	9.13	0.000
Mobile money account	0.688***	0.232	2.97	0.007
Constant	−4.297	0.660	−6.51	0.000
Mean dependent var.	1.807	R-squared	0.948	
SD dependent var.	0.776	F-statistic	87.584	
Number of observations	30	Prob > F	0.000	
AIC	−7.827	BIC	0.580	

Source: Authors' Compilation, 2025. **** p<0.01, ** p<0.05, * p<0.1.*

To address potential multicollinearity flagged by strong intercorrelations among digital finance variables, we conducted VIF diagnostics, reported in Table 5.

Table 5:
Variance Inflation Factor (VIF) Diagnostics

Variable	VIF	1/VIF
Internet usage	5.580	0.179
Mobile banking usage	5.090	0.197
Trust and customer satisfaction	3.800	0.263
Digital payments account	2.510	0.399
Mobile money account	2.350	0.425
Mean VIF	**3.870**	

Source: Authors' Compilation, 2025.

The mean VIF of 3.870 falls below the widely accepted threshold of 10 (Hair et al., 2018; Akinwande et al., 2015), confirming that multicollinearity does not materially distort the regression estimates. Although internet usage (VIF = 5.580) and mobile banking usage (VIF = 5.090) slightly exceed this threshold individually, the mean VIF and the high model R^2 (0.948) collectively support confidence in the robustness of the regression findings.

5.0. Conclusion

Conclusion and Policy Recommendations

This study examined the relationship between digital banking development and the sustainable-investment environment in Nigeria using annual data and an OLS regression framework. The findings indicate significant positive associations between mobile banking usage, digital payment accounts, mobile money accounts, and the Sustainable Investment Index, whereas internet usage is statistically insignificant after controlling for the other digital-finance indicators. These results are broadly consistent with recent evidence that digital financial inclusion and FinTech development can be associated with sustainable-development outcomes through improved financial connectivity and broader participation in formal financial systems (Khera et al., 2021; Tidjani & Madouri, 2024; Abdalla et al., 2025). However, because the Sustainable Investment Index is a system-level measure of the sustainable-investment environment rather than individual-level purchases of sustainable financial products, the findings should not be interpreted as evidence that digital banking directly increases individual access to or adoption of sustainable investments.

The positive coefficients on mobile banking, digital payment accounts, and mobile money suggest that the expansion and utilisation of digital financial channels have occurred alongside improvements in Nigeria's sustainable-investment environment. The contrasting result for internet usage indicates that general connectivity alone may not explain variation in sustainable investment once more specific digital-finance channels are considered. The negative coefficient on trust and customer satisfaction also requires cautious interpretation. Rather than concluding that confidence in conventional banking discourages sustainable investment, the result indicates a negative conditional association within the estimated model. The available data cannot establish the underlying mechanism and may reflect differences in the types of financial services captured by the trust measure, overlapping trends among the explanatory variables, or omitted institutional and socioeconomic factors.

The findings nevertheless highlight the potential importance of an enabling digital-financial ecosystem for developing sustainable finance. Digital financial infrastructure can reduce geographical and transaction barriers and facilitate participation in formal financial services, while FinTech development may create additional channels for mobilising and allocating

capital (Khera et al., 2021; Tidjani & Madouri, 2024). Recent evidence also suggests that the relationship between financial inclusion and green sustainability is context-dependent and may vary according to institutional quality, financial development, and country-specific conditions (Eshun & Kočenda, 2025; Abdulkareem et al., 2025). Consequently, digital banking should be viewed as one component of a broader sustainable-finance ecosystem rather than as a standalone mechanism for achieving sustainable investment.

Recommendations

These findings carry several policy implications. First, policymakers and telecommunications regulators should continue to strengthen digital infrastructure, particularly reliable internet and mobile-network coverage in underserved and geographically remote areas. Improved connectivity can lay the foundation for wider participation in digital financial services, but connectivity improvements should be paired with affordability and service-quality measures.

Second, financial regulators should strengthen the institutional framework governing digital financial services and sustainable-finance products. This includes effective consumer protection, transparent disclosure of product characteristics and risks, data protection, cybersecurity safeguards, and appropriate oversight of digital investment platforms. These measures matter because greater digital access can also expose consumers to fraud, cyber risks, and information asymmetries if regulatory and consumer-protection mechanisms do not keep pace with technological adoption (Mamun & Várallyai, 2025).

Third, financial institutions, FinTech providers, and development organisations should expand financial and digital-financial literacy initiatives. Such programmes should help users understand digital financial services, investment risks, product characteristics, and the meaning of environmental, social, and governance (ESG) claims. Improving financial literacy should be paired with clear, accessible disclosure so consumers can distinguish ordinary digital financial services from genuinely sustainability-oriented investment products.

Fourth, policymakers should strengthen the availability and visibility of credible sustainable-finance instruments within digital financial ecosystems. The study does not establish that digital banking platforms currently provide sustainable-investment products uniformly across Nigeria. Therefore, policies should focus not only on expanding digital banking access but also on developing appropriate digital channels to distribute verified green bonds, sustainability-linked instruments, renewable-energy investment products, and other sustainable-finance opportunities where such products are available. This distinction is important because digital financial access does not automatically translate into sustainable-investment participation.

Finally, interpret the results in light of the study's methodological limitations. The OLS estimates identify conditional associations rather than causal effects, and the relatively small annual sample limits the ability to address complex dynamic relationships. Reverse causality, omitted-variable bias, common time trends, and correlations among digital-finance indicators may influence the estimated coefficients. Future research should therefore employ household- or firm-level data to distinguish digital financial access, actual usage, and sustainable-investment participation. Multi-country panel datasets, fixed-effects models, instrumental-variable approaches, or dynamic panel estimators could further strengthen causal identification where appropriate. Future studies should also examine specific sustainable-finance outcomes, such as green-bond participation, renewable-energy investment, sustainability-linked instruments, and ESG fund holdings. Such research would provide a more direct assessment of whether and through which mechanisms digital finance contributes to the mobilisation of capital for sustainable development.

Declarations

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