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Towards Achieving Clean Energy in West Africa: The Role of Financial Inclusion

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ABSTRACT

Despite notable progress in expanding financial services across West Africa, the nexus between financial inclusion and access to clean energy remains insufficiently examined at the sub-regional level. This study investigates the effect of financial inclusion on access to clean energy across eight West African countries over the period 2010–2023. Employing panel data methodology, including fixed effects, random effects, and Hausman test procedures, the study uses the Access to Clean Energy Index (ACEI) as the dependent variable, with outstanding loans, ATM usage, and bank branches per thousand people as financial inclusion proxies, and inflation as a macroeconomic control. The Hausman test confirms the appropriateness of the random effects model ($\chi^2 = 5.324$, $p = 0.256$). Results reveal that outstanding loans ($\beta = 0.00000560$, $p = 0.020$) and ATM usage ($\beta = 1.123$, $p < 0.001$) exert positive and statistically significant effects on clean energy access, while bank branch density yields a negative but insignificant coefficient ($\beta = -1.188$, $p = 0.068$). These findings underscore the primacy of credit accessibility and digital financial infrastructure over physical banking presence in driving energy transitions. The study contributes novel sub-regional evidence to the financial inclusion–clean energy nexus literature and offers targeted policy recommendations for expanding green financing mechanisms and digital financial services to accelerate sustainable energy transitions in West Africa.

Keywords: financial inclusion; clean energy access; West Africa; ATM usage; sustainable development.

INTRODUCTION

The global transition toward sustainable energy systems has placed considerable emphasis on addressing energy poverty in Sub-Saharan Africa, where access to clean and reliable energy remains acutely limited. West Africa, in particular, presents a paradox of substantial renewable energy potential coupled with persistently low electrification rates and heavy reliance on traditional biomass fuels. According to the International Energy Agency (IEA, 2021, 2023), over 50% of the West African population lacks access to electricity, with rural communities disproportionately affected. The consequences extend beyond energy deprivation, encompassing public health hazards, constrained economic productivity, and environmental degradation.

A central but underexplored dimension of this challenge is the role of financial inclusion in enabling households and small enterprises to transition toward cleaner energy sources. Financial inclusion, defined as universal access to affordable, appropriate financial products and services provides the capital mobilization pathways necessary for clean energy investments. Where credit is accessible and digital financial infrastructure is developed, low-income households can participate in pay-as-you-go (PAYG) solar models, microfinance-backed energy purchases, and climate-linked lending schemes. Yet West Africa records some of the world's lowest financial inclusion metrics, with the World Bank (2023) estimating that a substantial proportion of adults across the sub-region remain unbanked or underserved by formal financial systems.

The scholarly literature increasingly recognizes the financial inclusion–clean energy nexus as a critical lever for sustainable development. Ofosu-Mensah et al. (2024) demonstrated, across 67 developing nations, that financial inclusion positively drives renewable energy consumption through improved access to financial resources. However, sub-regional studies focused specifically on West Africa are sparse, and most extant work conflates the sub-region with broader Sub-Saharan African samples or relies on single-country analysis. This aggregation obscures important heterogeneity in financial infrastructure and energy access conditions across West African economies.

This study addresses this gap by investigating the effect of three financial inclusion indicators outstanding loans, ATM usage, and bank branch density on access to clean energy across eight West African countries from 2010 to 2023. The selection of these proxies reflects distinct but complementary dimensions of financial inclusion: credit availability, digital financial service penetration, and physical banking infrastructure. By employing panel econometric techniques with formal model selection tests, the study provides empirically grounded evidence on the differential effects of these inclusion channels on clean energy access, with direct implications for regional policy design.

The study makes two principal contributions to literature. First, it provides sub-regional panel evidence from West Africa, a context that has received insufficient attention relative to broader African or global studies. Second, it disaggregates financial inclusion into distinct proxies, enabling differentiated policy conclusions about the relative efficacy of credit markets, digital finance, and physical infrastructure. The remainder of the paper proceeds as follows: Section 2 synthesizes the relevant literature; Section 3 outlines the methodology; Section 4 presents results; Section 5 discusses the findings; and Section 6 offers conclusions and policy recommendations.

LITERATURE REVIEW

Conceptual Review

Financial Inclusion

Financial inclusion refers to the accessibility and usage of financial services by individuals and businesses, particularly those that are underserved or unbanked (World Bank, 2023). It is a crucial driver of economic development, poverty reduction, and financial stability, as it enables individuals to save, invest, and protect themselves from financial shocks (Demirgüç-Kunt et al., 2022). Financial inclusion is a critical component of economic development, as it ensures that individuals and businesses have access to useful and affordable financial products and services that meet their need.

Access to Clean Energy

Access to clean energy is defined as the ability of households, businesses, and industries to obtain and utilize modern, renewable, and environmentally sustainable energy sources, such as solar, wind, and hydroelectric power. Operationally, it includes the affordability, availability, and reliability of these energy sources to replace traditional fossil fuels and biomass.

West Africa faces significant energy challenges, with access to reliable and affordable clean energy remaining a major issue for millions. According to the International Energy Agency (IEA, 2023), over 50% of the population in West Africa lacks access to electricity, and many still rely on traditional biomass for cooking, contributing to environmental and health hazards (ECOWAS, 2023). Energy access varies significantly across the region. Countries like Ghana and Senegal have made progress in electrification, while others, such as Niger and Liberia, struggle with widespread energy poverty (IRENA, 2023). The reliance on fossil fuels and inefficient power grids exacerbates energy insecurity.

Access to Clean Energy Index

The Access to Clean Energy Index is a composite measure that quantifies the extent to which a country or region has access to renewable and sustainable energy sources. It includes indicators such as the percentage of the population with electricity access, renewable energy consumption, energy affordability, and government policies supporting clean energy adoption.

***Automated Teller Machines (ATMs)*:** Automated Teller Machines (ATMs) are self-service banking terminals that allow individuals to perform financial transactions, such as withdrawing cash, checking account balances, and transferring funds, without direct interaction with bank staff. In this study, the number of ATMs per 100,000 people is used as an indicator of financial accessibility and inclusion.

Bank Branches per thousand

Bank branches per thousand refer to the number of physical banking offices available for every 1,000 people in a given region or country. It serves as an indicator of financial service penetration and accessibility, particularly in rural areas where financial exclusion is high. A higher number of bank branches suggests better access to formal banking services, which can facilitate financing for clean energy projects

Deposit Money Banks Outstanding loans

Deposit Money Banks Outstanding Loans refer to the total amount of credit extended by commercial banks to individuals, businesses, and governments. In this study, it represents the availability of financial resources that can be channeled into clean energy investments, supporting households and businesses in adopting renewable energy solutions.

Inflation

Inflation is the rate at which the general level of prices for goods and services rises over time, eroding the purchasing power of money. In the context of this study, inflation affects the affordability of clean energy solutions and financial services, as higher inflation can increase borrowing costs and reduce disposable income for energy-related expenditures.

Theoretical Framework

The relationship between financial inclusion and clean energy access is anchored in Beck et al.'s (2007) Theory of Access to Finance, which posits that financial constraints constitute a fundamental barrier to productive investment, including investment in clean energy technologies. This theory is particularly germane to the West African context, where high transaction costs, limited credit histories, and inadequate collateral regimes systematically exclude low-income households and small enterprises from formal financial markets, thereby perpetuating energy poverty.

Complementing this framework, Gurley and Shaw's (1960) Financial Intermediation Theory explains how financial institutions bridge the gap between savers and borrowers, facilitating capital allocation toward productive assets. In the clean energy context, intermediaries such as microfinance institutions, commercial banks, and fintech platforms channel savings into solar installations, mini-grid projects, and energy-efficient appliances. The Energy Ladder Theory (Leach, 1992) further illuminates the pathway through which income growth and financial access enable households to transition from traditional biomass to modern energy sources, with financial innovations functioning as accelerators of this transition. Collectively, these frameworks support the hypothesis that expanding financial access through credit markets, digital platforms, and physical infrastructure should positively influence the adoption of clean energy solutions.

Empirical Evidence

Recent empirical scholarship has substantially advanced understanding of the financial inclusion–clean energy nexus, though the evidence base for West Africa specifically remains limited. Ofosu-Mensah et al. (2024) provide the most comprehensive multi-country analysis to date, employing GMM-PVAR, impulse response functions, and FMOLS/DOLS estimators across 67 developing nations. Their findings confirm that financial inclusion positively influences renewable energy consumption and environmental sustainability, primarily through improved access to credit that facilitates investment in green energy projects.

At the sub-regional level, Adebayo and Yusuf (2021) examined mobile banking and microfinance services across 15 West African countries, finding that increased mobile money access significantly boosted off-grid solar adoption, particularly in rural areas. Aminu et al. (2021) used data from ten West African countries (2005–2020) to demonstrate a positive correlation between bank branch penetration and clean energy financing, suggesting that physical banking infrastructure also plays a role, albeit potentially a diminishing one as digital alternatives expand.

Studies in specific West African economies further substantiate these relationships. In Nigeria, Adebayo et al. (2023) found, through household survey data, that financial inclusion increased solar energy adoption by approximately 25%, attributing this effect to mobile banking expansion and microfinance institution coverage. In Ghana, Opoku and Adomako (2023) demonstrated that mobile money penetration drove a 30% increase in PAYG solar energy adoption. Kouadio et al. (2023) provided time-series evidence from Côte d'Ivoire confirming a positive correlation between financial deepening and solar and wind energy investments.

Beyond Africa, comparable dynamics are documented in South Asia and Latin America. Banerjee et al. (2022) found in India that micro-loan access increased clean cooking technology adoption by 15%, while Chowdhury et al. (2022) in Bangladesh documented a 20% electrification rate improvement attributable to microfinance-backed solar home system programs. Castillo et al. (2022) demonstrated in Brazil and Mexico that credit availability and government-backed financial programs were central to renewable energy infrastructure expansion. Zhou, et. al (2026) examined the impact of green technology innovation, renewable energy usage and financial development on carbon emissions in 21 European countries with human capital and gross domestic product (GDP) as control variables. Their empirical results from cross - sectional autoregressive distributed lags model (CS - ARDL) revealed that green technology innovation, human capital and renewable energy usage mitigate carbon emissions. Their findings indicated that a decrease in carbon emissions will be greatly aided by green technology innovation, usage of renewable energy and human capital, whereas financial development and GDP will show higher variation carbon emissions in the next decade.

Rabie and Acheampong (2024) scrutinized the relationship between financial inclusion, renewable energy and carbon emissions using data from 11 Middle East and North Africa (MENA) countries from 2004 to 2019. Their study revealed that financial inclusion contributes significantly to decarbonization using fixed effects - ordinary least squares (FE-OLS), dynamic ordinary least squares (DOLS), fully modified ordinary least squares (FMOLS) and canonical correlation regression (CRR) and they also recommended that policies promoting financial inclusion and renewable energy usage would add to the attainment of carbon neutrality goal by MENA countries.

Muhammad, et al (2025) explored the role of inclusive finance in achieving carbon neutrality, with a particular emphasis on the impact of lifelong learning which covered 16 African countries and examined data from 2000 to 2020. Their empirical results indicated that both inclusive finance and lifelong learning positively contributed to carbon neutrality using MMQR and Driscoll - Kraay estimator. They suggested that creating policies that increase financial inclusion, encouraging renewable energy investments and aligning economic development goals with carbon neutrality goals should be prioritized to support sustainable growth in Africa.

Despite this growing evidence base, several gaps persist. First, most West Africa-focused studies are either limited to single countries or rely on broader Sub-Saharan samples that mask sub-regional heterogeneity. Second, few studies systematically disaggregate financial inclusion into distinct proxies to assess their differential effects. Third, the comparative analysis of credit-based, digital, and physical inclusion channels within a unified panel framework using formal model selection has not been applied to the West African context. This study is designed to address these gaps directly.

METHODOLOGY

Research Design and Data

This study adopts a quantitative, longitudinal research design using secondary panel data from eight West African countries Nigeria, Ghana, Côte d'Ivoire, The Gambia, Guinea, Guinea-Bissau, Mali, and Benin over the period 2010–2023, yielding a panel of 112 country-year observations. Country and period selection were determined by the availability of complete data for all study variables. Data were sourced from the World Bank Financial Development Databank and the World Development Indicators database.

Variable Measurement

The dependent variable, Access to Clean Energy Index (ACEI), measures the proportion of renewable and sustainable energy in total energy consumption for each country-year observation. Three financial inclusion proxies constitute the primary independent variables: (1) Outstanding Loans (OUTL), representing total deposit money bank credit outstanding in domestic currency units; (2) ATM Usage (ATMU), measured as the number of ATMs per 100,000 adults; and (3) Bank Branches per Thousand (BBRT), representing the number of deposit money bank branches per 1,000 people. Inflation (INFL), measured as the annual percentage change in the consumer price index, is included as a macroeconomic control variable given its potential to affect both borrowing costs and energy affordability.

Model Specification

The empirical model is specified as a panel data regression:

$$ACEIit = \alpha + \beta_1 LOGOUTLit + \beta_2 ATMUit + \beta_3 BBRTit + \beta_4 INFLit + \varepsilon it \quad (1)$$

where i indexes countries, t indexes years, α is the intercept, β_1–β_4 are slope coefficients, and εit is the idiosyncratic error term. The model was estimated under both fixed effects (FE) and random effects (RE) specifications. The FE model allows for country-specific time-invariant heterogeneity by assigning each country its own intercept. The RE model treats country-specific effects as random components incorporated into a composite error term. Model selection between FE and RE was determined by the Hausman (1978) specification test, which evaluates the statistical correlation between country-specific effects and the regressors.

Method of Data Analysis

The analytical strategy proceeds in three sequential stages. In the first stage, descriptive statistics including measures of central tendency, dispersion, skewness, and kurtosis are computed for all variables to characterise the distributional properties of the panel dataset. Jarque-Bera normality tests are applied to assess whether variables conform to a normal distribution. While non-normality in macroeconomic panel data is common and does not invalidate large-sample regression inference, awareness of distributional properties informs interpretation of results.

In the second stage, a bivariate Pearson correlation matrix is constructed to examine pairwise linear associations between ACEI and each regressor. This pre-estimation diagnostic serves two purposes: it provides preliminary evidence on the direction and magnitude of relationships between financial inclusion proxies and clean energy access, and it enables an initial assessment of potential multicollinearity among independent variables. A correlation threshold of $|r| > 0.80$ between regressors is used as an indicative benchmark for problematic multicollinearity (Gujarati & Porter, 2009).

In the third and principal analytical stage, panel data regression is conducted. Panel methodology is preferred over cross-sectional or pure time-series approaches because it exploits both cross-country and temporal variation simultaneously, controls for unobserved country-specific heterogeneity, and produces more efficient parameter estimates with greater degrees of freedom (Baltagi, 2021). The general panel regression model takes the form:

$$yit = \alpha + x'it\ \beta + \mu i + \varepsilon it \quad (2)$$

where yit is the dependent variable for country i at time t, x'it is a vector of regressors, μi captures country-specific effects, and εit is the idiosyncratic disturbance. Two competing estimators are applied: the Fixed Effects (FE) estimator, which demeans within-country data to eliminate time-invariant unobserved heterogeneity, and the Random Effects (GLS) estimator, which treats μi as a random component assumed

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orthogonal to the regressors. The Swamy-Arora method is used to estimate variance components in the RE model.

The Hausman (1978) specification test is then applied to adjudicate between FE and RE estimators. The test statistic is:

$$H = (\hat{\beta}FE - \hat{\beta}RE)' [Var(\hat{\beta}FE) - Var(\hat{\beta}RE)]^{-1} (\hat{\beta}FE - \hat{\beta}RE) \sim \chi^2(k) \quad (3)$$

where k is the number of time-varying regressors. Under the null hypothesis that country-specific effects are uncorrelated with the regressors, both FE and RE are consistent but RE is more efficient. Rejection of the null ($p < 0.05$) favours the FE estimator; failure to reject favours RE. Statistical significance of individual coefficients is assessed using two-tailed t-tests at the 1%, 5%, and 10% significance levels. All estimations are performed in EViews 12, and the panel is unbalanced with 112 observations across eight countries over 14 years (2010–2023).

RESULTS

Descriptive Statistics

Table 1 presents the descriptive statistics for all study variables. The mean ACEI of 9.79 (SD = 11.92) with a range of 0.70 to 46.22 reflects substantial cross-national variation in clean energy access across the sample. Nigeria records the highest ACEI values (reaching 46.22 by 2023), driven primarily by increasing renewable electricity capacity, while Guinea, Guinea-Bissau, and Mali consistently record values below 2.0 throughout the study period. ATM usage exhibits the widest relative variation, ranging from 0.74 to 17.00 ATMs per 100,000 adults, with a mean of 6.53. Outstanding loans display a heavily right-skewed distribution (skewness = 2.21, kurtosis = 7.72), reflecting Nigeria's dominant share of total banking system credit in the sample. The Jarque-Bera statistics confirm non-normality across all variables, which is expected in cross-sectional macroeconomic data and does not invalidate the panel regression approach.

Table 1 Descriptive Statistics of Study Variables (2010–2023, N = 112)

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
ACEI	9.789	3.800	46.220	0.700	11.918	1.229	3.431
OUTL	2,211,042	688,243	18,000,000	4,171	3,576,634	2.210	7.719
ATMU	6.526	5.123	17.003	0.737	4.153	1.005	3.205
BBRT	4.737	4.461	11.169	1.422	1.906	0.723	3.189
INFL	6.290	5.551	21.317	−1.800	5.465	0.556	2.438

Note. ACEI = Access to Clean Energy Index (%); OUTL = Outstanding Loans (domestic currency units); ATMU = ATMs per 100,000 adults; BBRT = Bank branches per 1,000 people; INFL = Inflation rate (%). Source: World Bank Financial Development Databank and World Development Indicators.

Correlation Analysis

Table 2 presents the Pearson correlation coefficients between all variables. ATM usage exhibits the strongest positive correlation with ACEI ($r = 0.602$), suggesting that digital financial service penetration has the most direct association with clean energy access in the sample. Bank branch density ($r = 0.214$) and inflation ($r = 0.307$) also display positive but weaker correlations with ACEI, while outstanding loans yield a weak positive correlation of 0.103. Notably, OUTL is negatively correlated with ATMU ($r = -0.310$) and BBRT ($r = -0.332$), reflecting the concentration of outstanding loan volumes in Nigeria a country with relatively lower physical banking density than some smaller economies in the sample. No correlation coefficient among the regressors exceeds 0.47 in absolute value, suggesting the absence of severe multicollinearity.

Table 2 Pearson Correlation Matrix

Variable	ACEI	OUTL	ATMU	BBRT	INFL
ACEI	1.000				
OUTL	0.103	1.000			
ATMU	0.602	−0.310	1.000		
BBRT	0.214	−0.332	0.465	1.000	
INFL	0.307	−0.072	0.440	0.126	1.000

Note. All correlations are pairwise. Source: Author's computation (2026).

Panel Regression Results and Model Selection

Panel least square

Dependent Variable: ACEI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
OUTL	0.0000106	0.00000258	4.094995	0.0001
ATMU	1.985584	0.262664	7.559409	0.0000
BBRT	-0.036607	0.520804	-0.070290	0.9441
INFL	0.057314	0.175063	0.327394	0.7440
C	-5.690723	2.763088	-2.059552	0.0419
R-squared	0.456157			
Adjusted R-squared	0.435635			
F-statistic	22.22731			
Prob(F-statistic)	0.000000			

Table 3 presents the comparative results of the fixed effects and random effects models, alongside the Hausman test statistic. The Hausman test yields a chi-square statistic of 5.324 (df = 4, p = 0.256), which fails to reject the null hypothesis of no systematic difference between FE and RE coefficient estimates. This result confirms that country-specific effects are uncorrelated with the regressors, rendering the random effects model efficient and the preferred basis for inference.

Table 4.5: Hausman Test

Correlated Random Effects - Hausman Test			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	5.324129	4	0.2556

Table 3 Fixed Effects and Random Effects Panel Regression Results (Dependent Variable: ACEI)

Variable	FE Coefficient	FE Std. Error	FE p-value	RE Coefficient	RE Std. Error	RE p-value
OUTL	5.92×10^{-7}	2.46×10^{-7}	0.018**	5.60×10^{-7}	2.37×10^{-7}	0.020**
ATMU	1.001	0.317	0.002***	1.123	0.297	0.000***
BBRT	−1.432	0.693	0.041**	−1.188	0.644	0.068
INFL	0.558	0.199	0.006***	0.553	0.189	0.004***
Constant	5.216	4.068	0.203	3.259	4.668	0.487
R-squared	0.811			0.247		
F-statistic	38.597		0.000***	8.700		0.000***
Hausman χ^2				5.324 (df = 4)		p = 0.256

Note. *** $p < 0.01$; ** $p < 0.05$. FE = Fixed Effects; RE = Random Effects. The preferred model for inference is RE based on the Hausman test. Source: Author's computation (2026).

Based on the RE model results, outstanding loans exert a positive and statistically significant effect on ACEI ($\beta = 5.60 \times 10^{-7}$, $p = 0.020$), indicating that greater commercial bank credit availability is associated with improved clean energy access. ATM usage yields the largest positive and statistically significant coefficient ($\beta = 1.123$, $p < 0.001$), suggesting that each unit increase in ATM density is associated with a 1.123 percentage-point increase in ACEI. Bank branch density yields a negative and statistically insignificant coefficient ($\beta = -1.188$, $p = 0.068$), indicating that physical banking infrastructure does not significantly drive clean energy access in this sample. The control variable, inflation, is positive and significant ($\beta = 0.553$, $p = 0.004$), a finding that warrants further interpretation in the discussion.

S/N	Hypothesis	t-Statistics	P-value	Decision
1	Outstanding loans have no significant positive effect on access to clean energy in West Africa.	2.360900	0.0201<0.05	Reject H_0 Accept H_1
2	ATM use has no significant positive effect on access to clean energy in West Africa.	3.779795	0.0003<0.05	Reject H_0 Accept H_1
3	Bank branches per thousand have significant positive effect on access to clean energy in West Africa.	-1.84398	0.0680>0.05	Accept H_0 Reject H_1

DISCUSSION

Outstanding Loans and Clean Energy Access

The significant positive effect of outstanding loans on clean energy access is consistent with Beck et al.'s (2007) theory that financial constraints impede productive investment, and with the empirical findings of Ofosu-Mensah et al. (2024) and Sharma et al. (2023). When deposit money banks extend credit, households and enterprises gain the capital required to overcome the high upfront costs associated with solar home systems, mini-grid connections, and clean cooking technologies   costs that are prohibitive in the absence of financing. This finding aligns with evidence from Adebayo et al. (2023), who documented that financial inclusion increased solar adoption by 25% in Nigeria, and with the trajectory of green financing schemes in Nigeria and Ghana, which have sought to channel private sector credit toward renewable energy investments (IRENA, 2020, 2023).

The relatively small magnitude of the coefficient reflects the scalar disparity between loan volumes (in domestic currency units) and the ACEI metric, rather than a substantively weak effect. It also reflects the fact that not all outstanding credit is directed toward energy investments; a more refined proxy such as energy-sector-specific credit would likely produce a larger estimated effect. Nonetheless, the statistical significance confirms that aggregate credit expansion in the banking system creates enabling conditions for clean energy uptake, supporting the broader thesis that financial sector development and energy transition are complementary policy objectives.

ATM Usage and Digital Financial Infrastructure

The strongest result in this study   the highly significant positive effect of ATM usage on ACEI   speaks to the role of digital financial infrastructure as a key enabler of clean energy transitions in West Africa. ATM density serves as a proxy for the broader ecosystem of digital financial services, including mobile banking, agent banking, and electronic payments (Demirgüç-Kunt et al., 2018), which together reduce transaction costs and enable flexible payment mechanisms for energy products. In the PAYG solar model, for instance, users make small, regular payments via mobile money platforms; the convenience and accessibility of ATMs and allied digital channels make formal financial participation more feasible for low-income and rural households.

This finding is consistent with Opoku and Adomako (2023), who reported a 30% increase in PAYG solar adoption alongside mobile money penetration growth in Ghana, and with Ogunleye and Omowumi (2023), who documented that digital payment platforms significantly increased decentralized renewable energy investment across West African countries. The result also aligns with Jack and Suri (2023), whose review of mobile money literature across Africa demonstrates that digital financial services have been transformative not only for financial inclusion but for enabling productive expenditure, including energy-related investment. The implication is that investments in digital financial infrastructure beyond physical bank branches yield significant dividends for energy access, making the digitalization of financial services a dual-purpose development priority.

Bank Branch Density and Physical Infrastructure Limitations

The negative but statistically insignificant effect of bank branch density on ACEI constitutes an important finding that challenges assumptions about the universally positive role of physical banking infrastructure in driving clean energy transitions. Several plausible mechanisms explain this result. First, commercial bank branches in West Africa are heavily concentrated in urban centers, where energy access is already comparatively higher (Odell & Clements, 2018). The marginal contribution of additional urban branches to national ACEI levels is therefore limited, particularly when rural energy poverty the largest contributor to low ACEI scores is determined by factors beyond urban banking reach.

Second, the expansion of digital and alternative financial channels including mobile money, agent banking, and microfinance has progressively substituted for physical branch access, especially in rural and peri-urban areas. As Beck et al. (2011) observed in developing economy contexts, branch-based banking is increasingly less determinative of actual financial access as non-branch delivery models proliferate. Third, even where bank branches exist, bureaucratic loan requirements, stringent collateral conditions, and high interest rates deter energy-related borrowing by households and small enterprises (Ayyagari et al., 2013). This finding is consistent with Aminu et al. (2021), who found that while branch penetration was positively correlated with clean energy financing at the aggregate level, its effect was secondary to digital channels in determining actual investment activity.

The negative direction of the coefficient, though not significant, may reflect a compositional effect: countries with higher branch density tend to have larger urban banking sectors with risk-averse lending practices that favor commercial over household or energy-sector lending. This warrants further investigation using more granular branch-level or loan-purpose data.

Inflation and the Macroeconomic Environment

The positive and significant effect of inflation on ACEI ($\beta = 0.553$, $p = 0.004$) is counterintuitive at first glance, since inflation typically erodes household purchasing power and increases borrowing costs. However, this result may reflect a compositional dynamic in the panel: countries with higher inflation rates in this sample notably Nigeria and Ghana are also the countries that have made the greatest strides in clean energy access during the study period. In both cases, nominal credit expansion and rising energy investment have coincided with elevated inflation, making inflation a statistical marker of economic dynamism rather than a direct driver of clean energy adoption. This interpretation suggests that controlling for per capita income or economic growth in future specifications would help disentangle this relationship.

CONCLUSIONS AND POLICY IMPLICATIONS

This study investigated the effect of financial inclusion on access to clean energy across eight West African countries from 2010 to 2023. Using panel data methodology and a random effects model validated by the Hausman test, three principal findings emerge. First, outstanding loans in the deposit money banking system exert a positive and significant effect on the Access to Clean Energy Index, confirming that credit availability is a meaningful driver of energy transitions. Second, ATM usage as a proxy for digital financial infrastructure has the strongest and most statistically robust positive effect on clean energy access, underscoring the primacy of digital finance as an enabler of PAYG and other flexible energy financing models. Third, bank branch density exerts a negative but statistically insignificant effect, suggesting that physical banking infrastructure alone is insufficient to catalyse clean energy adoption in the sub-region.

These findings carry important implications for policy and practice across the West African sub-region.

Expansion of green and energy-specific credit facilities. Governments and regional development finance institutions should establish dedicated green lending windows within commercial banks, offering concessional interest rates and alternative collateral arrangements for households and small enterprises investing in clean energy technologies. Nigeria's National Financial Inclusion Strategy provides a model that could be adapted sub-regionally with an explicit clean energy mandate.

Acceleration of digital financial service penetration. Given the dominant effect of ATM usage and the broader digital financial ecosystem it proxies, central banks and financial regulators across West Africa should prioritize the expansion of agent banking networks, mobile money interoperability, and digital payment infrastructure   particularly in rural and off-grid communities where energy poverty is most acute. Integrating energy service providers with mobile money platforms can directly facilitate PAYG solar uptake.

Re-evaluation of bank branching strategies. The insignificant effect of bank branch density signals that strategies relying on traditional brick-and-mortar expansion to drive financial and energy inclusion are insufficient. Regulators should encourage banks to transition toward digital-first, low-cost service delivery models, and should evaluate branching policies in terms of their reach into underserved energy-poor communities rather than aggregate branch counts.

Regional harmonization of financial and energy policies. ECOWAS should advance the integration of its Renewable Energy Policy (EREP) with national financial inclusion strategies, establishing a cross-border green financing framework that allows capital to flow efficiently toward renewable energy projects across member states. International development partners can support this through technical assistance and co-financing mechanisms linked to clean energy and financial inclusion benchmarks.

Future research should extend this analysis by incorporating additional financial inclusion proxies such as mobile money account penetration, microfinance credit volumes, and fintech adoption rates. Disaggregating the ACEI into specific clean energy sub-components   electricity access, renewable energy consumption, and cooking fuel transition   could further refine understanding of which financial channels most effectively address each dimension of energy poverty. Incorporating supply-side variables such as energy infrastructure investment and regulatory quality would also strengthen the empirical framework.

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