

Determinants of Solar Photovoltaic Adoption in North-Central Nigeria: A Systematic Literature Review.

Daniel Tersoo Aule^{1*}

¹Research Officer at Genius Global Consulting Services, Kano-Nigeria

*Corresponding Author: Daniel T. Aule;

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ABSTRACT

The North-Central region of Nigeria has witnessed low adoption of solar photovoltaic (PV) despite the abundant resources and demand for decentralised electricity. This systematic literature review (SLR) examines the factors constraining the expansion of solar PV adoption, which has long been limited to basic lighting and phone-charging applications. This study adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 protocol to select studies published between 2015 and 2026 from four suitable databases: ScienceDirect, Web of Science, MDPI, and Google Scholar. The initial search identified 1190 records; after thorough screening using inclusion and exclusion procedures, we selected 12 studies for synthesis. We anchored the study in two theories: The Technology Adoption Model (TAM) and the Theory of Planned Behaviour (TPB), which are relevant to the research problem. The combination of these theories is to ensure that while TAM explains perceived usefulness and ease of use of solar PV in the region, the TPB provides insights into perceived behaviour, subjective norms, and attitudes that TAM overlooks. The results show that affordability is the most influential barrier, while income affects both the scale of acquired systems and the likelihood of adoption. It also indicates that the PAYGo financing model reduces the upfront payment burden and improves access. However, its capacity to support higher tiers is constrained by repayment ability, dispersed rural settlements, and high last-mile distribution costs. It further reveals that awareness and availability are essential determinants of adoption, while consumer trust depends on product quality, durability, and after-sales service. The study concludes that inconsistent energy policy, weak coordination among agencies, lack of access to finance, and delayed disbursement affect solar energy development. It recommends coordinated interventions that provide sustained affordable financing for higher tiers that support productive use.

Keywords: North-Central Nigeria; solar photovoltaic adoption; systematic literature review, solar irradiance; energy poverty; renewable energy financing.

INTRODUCTION

The tremendous increase in the global population, modern industrial development, and changing lifestyles have led to gaps between energy supply and demand (Aized et al., 2018; Tajudeen, 2015; Wang, 2014). This gap requires a substantial and sustainable energy supply of sufficient quantity and quality to meet demand. Meanwhile, many scholars have questioned the capacity and reliability of fossil energy sources to meet global electricity demand (Yang, Deshmukh & Suh, 2023; Kabeyi & Olanrewaju, 2022). They opined that matching energy demand with supply requires adopting clean, stable, and reliable sources. This is a target that most developed countries (such as the USA, China, and the UK, among others) have significantly achieved (Helm, 2023; Ameyaw et al., 2021), while its attainment in developing countries remains relatively low (Javed, Ashraf & Yong, 2025). In sub-Saharan African countries, access to reliable, stable electricity and its affordability are among the major developmental challenges (Agoundedemba, Kim, & Kim, 2023). Consequently, many scholars have advocated for greater investment in renewable sources like solar PV, alongside streamlining regulatory and payment systems to enhance widespread adoption and benefit from

social and economic returns (Darkwah et al., 2026; Detemple et al., 2024). Olanrele and Fuinhas (2024) stated that solar photovoltaic (PV) technology is widely and consistently promoted across the region as a remedy to the energy constraint. The aim is to leverage the high solar radiation across the region, decentralised systems, and to bypass the limited centralised grids for effective transmission and distribution (Osunmuyiwa & Kalfagianni (2017). In Nigeria, statistics have shown that over 40% of the population is not connected to the national grid, while millions who are connected neither have stable nor quality electricity (Emetere et al., 2022). This has triggered the adoption of off-grid and behind-the-meter solar systems, supported by their friendly financial models (such as pay-as-you-go (PAYGo)). These models enable users to spread energy costs across days or months through instalment payments, avoiding the upfront cost of renewable energy sources (Mergulhão et al., 2023).

However, scholars (such as Chueca et al., 2023) observed a stark divergence between the technology's promise and adoption. Audu, Adamu, and Oladipo (2023) added that solar uptake in rural and semi-urban Nigeria has skewed toward small solar lanterns and single-panel lighting kits, used primarily for lighting and phone charging. This suggests that acquiring a multi-panel battery-backed system that supports economic activities like cold storage, irrigation pumps, and powering of appliances largely remains a mirage among rural households. According to Dorsey and Wolfson (2024), the drastic drop in prices of solar components and instalment schemes is mostly beneficial to urban dwellers. They observed that the systems taken to rural communities remain small, as marketers prioritise affordability at the expense of transformation. This raises the question in the literature on why solar adoption remains relatively low in rural areas despite improvements in payment conditions.

North-Central region of Nigeria comprises Benue, Plateau, Nasarawa, Kogi, Niger, and the Federal Capital Territory (FCT). The region offers an instructive environment, as it receives some of the most favourable conditions in Nigeria. Studies have shown that the states have an estimated mean daily irradiance between 5.5 and 7.0 kWh/m² (Mbonu & Owosho, 2025; Tor et al., 2025). Edomah (2022) also described the region as predominantly agrarian and dispersed in settlement, where national grid electrification lags behind averages. The study attributed this to the higher cost of expanding transmission infrastructure in rural communities, which are widely spaced across the region. Arowolo et al. (2019) also concurred, as they found lower grid electrification costs in the South due to densely clustered settlements. In principle, it is anticipated that North-Central Nigeria should take the lead in solar PV given the low grid reliability and high solar potential. This should transcend beyond mere lighting to economic use. The inability of this to happen at large scale is the core motivation that is addressed in this review.

This study therefore has three specific objectives: first, to ascertain the determinants of solar PV adoption in North-Central Nigeria. Second, to explore the barriers to widespread solar PV adoption in North-Central Nigeria. Third, to examine the impact of instalment payment platforms on the cost of solar adoption in the region. Meanwhile, the remaining parts of this paper are structured as follows: Section 2 discusses the theoretical frameworks; Section 3 covers the systematic review methodology; Section 4 presents the thematic findings; Section 5 covers the discussion of findings; while Section 6 presents the policy and practice implications, 7 covers limitations, and 8 presents conclusion.

THEORETICAL FRAMEWORK

Rationale for the Framework

A good theoretical framework explaining household solar PV adoption must capture two basic issues. First, it must reflect the attitudinal and cognitive processes through which households decide before acquiring solar PV. Second, it must capture sensitive conditions such as distribution infrastructure, income, and financing, which are central to solar adoption. Addressing these suggests being sensitive to the region, households' characteristics, and the energy-related facilities available to them. For instance, a household in the region may hold a strong attitude toward solar PV and perceive it as more useful relative to fossil sources, but may still not adopt it because the financial model available is beyond their financial capacity. As a result, they may end up adopting a lighting-tier product based on affordability. This suggests the

careful selection of behavioural theories that explain resource and opportunity constraints, as assuming attitude alone would not be sufficient to explain adoption. In view of this, we adopt two relevant theories (Technology Acceptance Model and Theory of Planned Behaviour) in this study after a careful review of energy and technology-adoption theories. This is presented in section 3.2 below.

Review and Selection of Relevant Theories

A careful review of the literature shows the application of many theories to energy and technology adoption studies. However, four appear most often in the household technology adoption literature. They include the Technology Acceptance Model (TAM), the Theory of Planned Behaviour (TPB), Diffusion of Innovation (DOI) theory, and the Unified Theory of Acceptance and Use of Technology and its consumer-context extension (UTAUT/UTAUT2). The review described TAM as a function of perceived ease of use and usefulness (Davis, 1989), while the TPB explains intention to adopt through subjective norms, perceived behavioural control, and attitude (Ajzen, 1991). The DOI theory was considered in terms of adoption rate and pattern across the population relative to compatibility, trialability, complexity, advantage, and observability (Rogers, 2023), while the UTAUT/UTAUT2 synthesis models into facilitating conditions, performance expectancy, social influence, effort expectancy, and extended with price value, habit, and hedonic motivation (Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh, Thong, & Xu, 2012).

A thorough appraisal of these theories set two aside for mismatching with all the criteria. For instance, the DOI's primary tenet is to explain how newly produced products spread across a population over time. According to Memedovich et al. (2025), the new product is used first by a few customers or innovators, then other customers cautiously follow until almost everyone eventually follows suit. Scholars (Palm, 2022; Asongu, Biekpe, & Cassimon, 2021) adopted it to explain the penetration of some selected smartphone brands into the global market. However, Antonelli et al. (2022) criticise that studying this kind of spread requires collecting data over time and tracking market changes. Meanwhile, in this study, we review existing studies which each examine households at a particular point in time. Consequently, it is unrealistic to track the spread of solar adoption across the region, suggesting the non-suitability of DOI theory to this study. DOI theory also emphasises triability, which implies that users can try before adoption. This may work effectively in other technology products like a new phone's app, which can be tested without charge (Wolske, Stern, & Dietz, 2017). In the case of a solar panel system, it is permanent and expensive, suggesting the theory will not capture solar adoption in our context appropriately. UTAUT embodied the blend of old and new theories, including TAM and TPB. However, it was postulated and tested among the population of workers adopting a newly established technology (Venkatesh et al., 2016). Its advanced version (UTAUT2) was established to basically test users in more advanced and wealthier markets, which have easy access to loans, credit cards, and shops (Roy, 2025). In relation to our study area (the North-Central region of Nigeria), it is very contrasting, implying the theory may not adequately capture the aims of the study.

The Technology Acceptance Model (TAM)

The TAM builds on two beliefs most households form when confronting a new technology. The first belief is perceived usefulness, which explains the degree to which adopting a technology will improve outcomes (Rahmani et al., 2026). The second belief is perceived ease of use, which reflects the degree to which adopting it will require less effort (Davis, 1989). Heidenreich and Talke (2020) criticised the model for emphasising the voluntary adoption of information systems in the workplace with favourable resources to evaluate its potency. However, Karakaya and Sriwannawit (2015) used the model across low- and high-income economies and found the upfront cost as the core barrier to solar energy adoption. Moreover, the strengths of TAM in this study outweigh the perceived criticisms, given that North-Central Nigeria is situated within a zone of persistent high solar irradiation (Chanchangi et al., 2022). This is coupled with persistent collapses in Nigeria's national grid, reliance on petrol and gasoline generators as practical alternatives, and increased fuel costs following the fuel subsidy removal (Chanchangi et al., 2022). Bawonda and Adefarati (2023) also concurred that the technical case for adopting solar PV in the region is strong and visible due to its strategic position and contribution in economic growth. Households within the region do

not require specialised knowledge to observe that adopting solar will be useful and sustainable. The availability of sunshine and lack of electricity are enough evidence for people to adopt solar energy. Moreover, sunshine is similar, as is technology; what differs is users' perception of its usefulness and their decision to adopt it, which are the gaps this model is built to address (Cheam, Lau, & Wei, 2021). Consequently, TAM provides a precise instrument for isolating the cognitive and perceptual components of the decision to adopt, where the underlying resource is not the barrier (Chanchangi et al., 2022; Karakaya & Sriwannawit, 2015).

The Theory of Planned Behavior (TPB)

The TPB explains three components of behavioural intention: subjective norms, perceived social pressure, and perceived behavioural control. For subjective norms, it depends on attitude towards the behaviour (Vu, Nguyen, & Nguyen, 2023), while perceived social pressure explains the influence other groups have on an individual in relation to adoption of a new technology (Opiyo, 2019). Meanwhile, perceived behavioural control explains the individual's self-assessment of their capability to adopt a new technology given the resources at their disposal (Ajzen, 1991). Scholars (such as Armitage & Conner, 2001) challenge the efficacy of the theory in two ways: First, the inability to consistently measure subjective norms, as different people compare themselves to different people or groups. As a result, identifying the reference group or person becomes challenging due to different social dynamics; a challenge which the founder of the theory also acknowledged (Ajzen, 1991). Sheeran (2002) also criticise the theory as being intention-based in nature. They argue that intention only captures willingness, which is different from adoption. Suggesting a household may nurture the intention to adopt solar energy but may not, given that intention does not necessarily translate into actions. Nevertheless, TPB captures the perceived behavioural construct where both resources and opportunities are considered before making the decision to adopt a technology (Rana et al., 2025). Huansuriya & Ariyabuddhiphongs (2023) stated that the theory is developed to capture access to finance, access to distributors, and affordability. These factors were outlined by Chanchangi et al. (2022) as persistent challenges affecting the adoption of solar PV, while Chanchangi et al. (2022) describe them as core barriers to solar adoption in Nigeria. We therefore used the theory to argue that technical grounds for PV favour North-Central Nigeria, but what remains is the perceived behavioural discretion between households' conviction and ability to adopt. According to Chanchangi et al. (2022), households make decisions to adopt visible capital goods (like solar PV) based on reference to what relatives or friends have used, especially in a setting where fuel generators are competing alternatives to power supply.

METHODOLOGY

Review Design

In this study, we follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) protocol. This method enhances transparency, synthesises the process, and provides replicability (Panic et al., 2013). We carefully selected this protocol given that the underlying question is to ascertain the barriers limiting solar PV adoption to scale beyond the lighting tier across states in North-Central Nigeria. Using a narrative approach would not enhance a comprehensive and replicable process. Moreover, empirical studies diverge across a fragmented literature, requiring a careful and systematic review to analyse the perceived research problem.

Search Strategy and Sources

Given that this study is specifically targeted to North-Central Nigeria and solar energy adoption in the region is relatively new, we conducted searches across many sources. They include ScienceDirect, Google Scholar, the MDPI journal platform, and Web of Science. According to Gusenbauer and Haddaway (2020), ScienceDirect hosts leading renewable-energy and energy-economics journals that provide relevant literature on solar adoption research. Google Scholar, on the other hand, provides wider coverage and curated databases that capture region-specific literature (including Nigerian energy journals) and grey literature (Martín-Martín et al., 2018). In addition, Web of Science provides rigorous, peer-reviewed, high-

impact journals that enhance the methodological credibility of an SLR (Falagas et al., 2008). Likewise, including MDPI ensures access to rapidly published, more recent, fully open-access literature on technology adoption, specifically in renewable energy (Csomós & Farkas, 2023).

The searches were done using search terms like “solar photovoltaic”, “solar energy”, “solar energy adoption”, “determinants”, “rural electrification”, “North-Central Nigeria”, “pay-as-you-go”, and “adoption barriers”. The breakdown is presented in Table 3.1 below:

Table 3.1 Search Terms and Databases

Database	Search Terms	Combined Hits	Date
ScienceDirect	“Solar energy adoption in rural communities of North-Central Nigeria”	1044	1 Aug., 2026
Google Scholar	“Tier-systems of solar energy adopted in rural communities of Nigeria”	78	1 Au., 2026
MDPI	“Solar PV in Nigeria”	27	2 Aug., 2026
Web of Science	“Determinants of solar adoption in Northern Nigeria”	41	2 Aug., 2026
Total		1190	

Source: Author’s Compilation, 2026

Table 3.1 provides a clear explanation of the search strategies and syntax used across the four selected databases. The search identified 1190 hits across all databases, which were further sifted using the PIOS (Population, Issue, Outcome, Study) framework. The PIOS is adopted because it enhances structured and reproducible search logic without forcing an artificial comparison between groups, as in other frameworks such as PICO (Amir-Behghadami & Janati, 2020; Eriksen & Frandsen, 2018). This is presented in Table 3.2 below.

Table 3.2 The PIOS Framework

Element	Meaning	Applied Criterion
P	Population	Households (both in SMES and not), communities in Nigeria, especially in North-Central Nigeria
I	Intervention/Issue	Solar PV adoption, solar system tier and intensity, and barriers to solar PV adoption.
O	Outcome	Studies on barriers, adoption intensity, and theoretically or empirically measured adoption. Those without a socioeconomic outcome were screened out.
S	Study Design	High-ranking peer-reviewed studies published between 2015 and 2026 in English.

Source: Author’s Compilation, 2026.

Inclusion and Exclusion Criteria

In this section, we explain the inclusion and exclusion criteria used to select the articles reviewed. For inclusion, studies that meet the following criteria were selected: i, studies that are strictly written in English; ii, studies that are published from 2015 and above; iii, studies that are on Nigeria, especially North-Central Nigeria; iv, empirical studies. We excluded studies that have the following: i, studies that are published before 2015; ii, studies that are practically engineering and technical analysis of solar PV without any socioeconomic dimension; iii, non-peer-reviewed studies; iv, studies that are published in languages other

than English. Meanwhile, a considerable number of references were used outside the reviewed papers, including multilateral reports and non-academic materials for statistics.

Study Selection and Synthesis

The initial search produced 1190 hits across the four databases. We therefore removed duplicates, trimming the list to 736. We further screened the studies using abstracts and obtained 195 hits. Furthermore, we applied the inclusion criteria by screening out low-quality articles. Consequently, we retained 58 hits, of which 46 failed the PIOS screening. We therefore have 12 studies retained for review. The PRISMA flow diagram below (Figure 3.1) summarises the process for better understanding. In addition, we synthesised the themes using an integrated framework extracted from data on author(s), year, country/zone, methodology, theoretical framework (where applicable), and barriers or determinants, as presented in section 2.

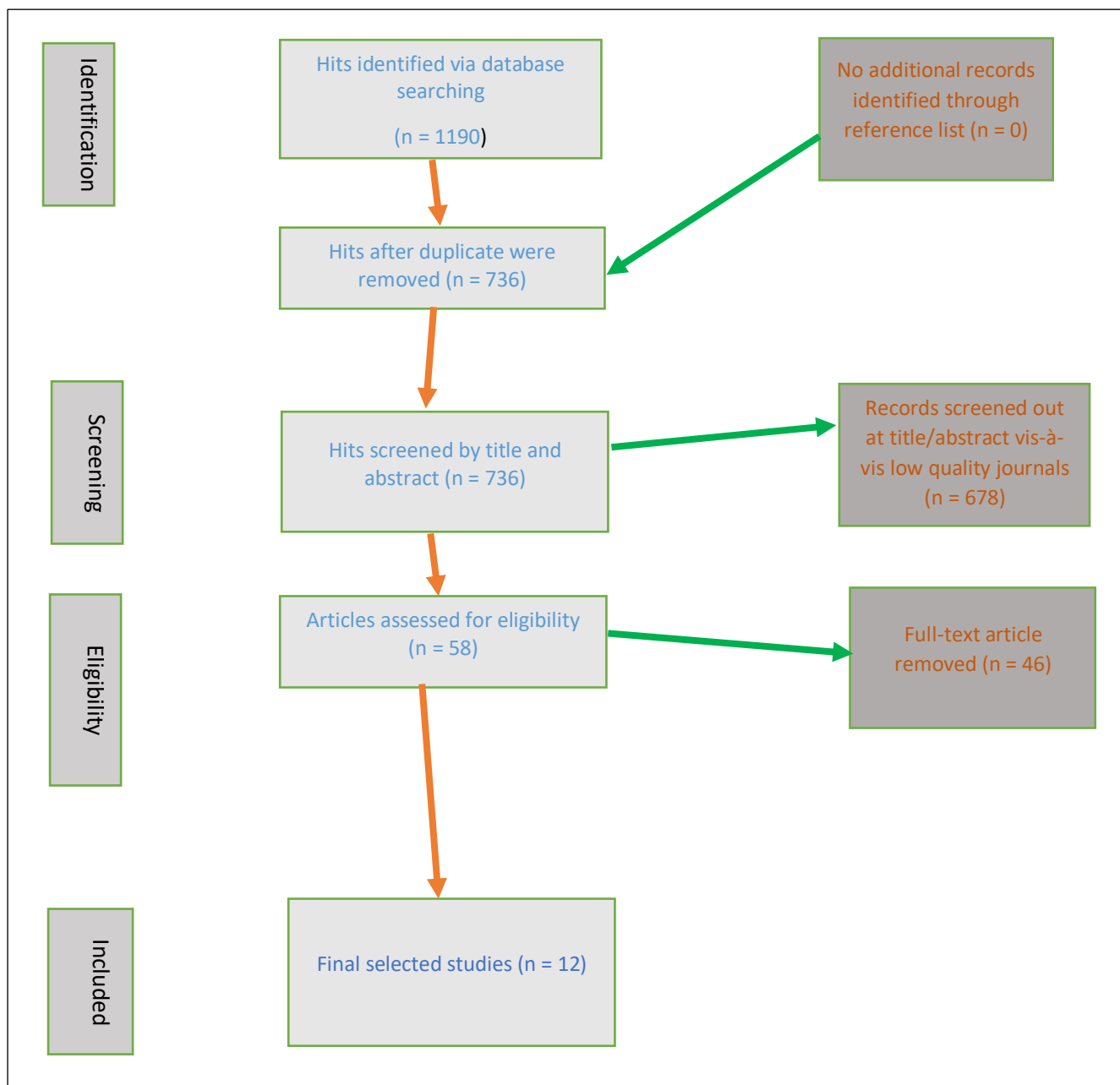


Figure 3.1. PRISMA 2020 flow diagram showing the selection process.

Figure 3.1 above shows the detailed selection of papers for synthesis. The hits totalled 1190 records: 1044 from ScienceDirect, 78 from Google Scholar, 41 from Web of Science, and 27 from WDPI. Meanwhile, 46 papers were screened out of the 58 due to the following exclusion criteria. A total of 12 papers were excluded for not having any socioeconomic dimension, 10 papers did not meet the quality threshold, 11 were outside the geographic scope, 13 were not indexed. These fair and transparent methods reduced the reviewed papers to 12.

THEMATIC FINDINGS

The findings from the 12 reviewed studies are classified into five interrelated themes as follows: solar resource abundance and adoption mismatch; cost and affordability of solar PV; the potential and challenges of financing models; other factors like awareness, socioculture, and trust; weaknesses in institutions and policy; and evidence from the comparator review. All the aforementioned themes are discussed in detail, while the summary subset of the reviewed studies is presented in Table 1 below.

Solar Resource Abundance and Low Adoption Mismatch

Nigeria is richly endowed with solar resources. Studies have shown irradiance between 3.5 and 7.5 kWh/m²/day across the country, with some northern states experiencing the highest levels due to their proximity to the Sahel (Ozoegwu & Akpan, 2021). Mbonu and Owosho (2025) compiled a NiMet report and found that the mean daily solar radiation ranged from 5.5–7.0 kWh/m² across the North-Central states. Further evidence suggests that the FCT, Nasarawa, and Plateau states ranked top accordingly in the region (Tor et al., 2025; Ozoegwu & Akpan, 2021). Moreover, the average of 4.8 kWh/m²/day places Nigeria in the solar-favourable zone. The World Bank (2020) has classified regions or countries with 4.5 kWh/m²/day and above as being in a favourable zone for solar adoption. Unfortunately, the abundance of solar potential does not translate proportionally into effective adoption. Okwanya et al. (2021) reiterated that adoption drastically falls short of resource endowments, even in the most resource-endowed states in North-Central Nigeria (Nasarawa, the FCT, and Plateau). They further argued that solar energy use across the states is constrained to small-scale applications. This suggests that the region's solar potential has not been converted into meaningful use.

Cost and Affordability of Solar PV Barriers

Among the barriers affecting the adoption of solar PV, affordability appears more frequently in the literature and is considered one of the most influential factors. For instance, Mbonu and Owosho (2025), in a study on SMEs in North-Central Nigeria, found income and education levels to be major factors increasing the odds of adoption. They further revealed that the decision and the intensity of adoption were more sensitive to income than adoption itself. This implies that average-income earners in rural communities across North-Central Nigeria are partially priced out. Their income constraints limit their ability to afford larger solar systems, as they can only afford lower-tier options. Lower-tier systems are carefully built to provide lighting and improve charging for smaller devices like phones. Ajah and Pathranarakul (2024) adopted a structural equation modelling approach using a nationally representative sample of Nigerian households, merging awareness and affordability into a joint latent construct and finding that these factors shape solar adoption outcomes. Meanwhile, Karakaya and Sriwannawit (2015) found that economic, policy, management, and sociotechnical barriers significantly affected the diffusion of solar PV across income contexts.

Studies have shown that this affordability barrier is influenced by the levels of currency instability and macroeconomic instability in a country (Yazdanie et al., 2024). According to Javed, Ashraf, & Yong (2025), persistent changes in the Nigerian currency and an unstable macroeconomic performance have had a significant and devastating impact on solar adoption among rural dwellers. This is evident in the depreciation of the Naira, which has been manifested by the cost of imported solar components and lanterns, thereby exacerbating the existing affordability challenge faced by low-income households. Dinneya-Onuoha (2025) concurred, stating that the majority of the solar PV hardware used in Nigeria is imported. The persistent change in the exchange rate periodically served as an unhedged cost shock, usually pushing up the

affordability threshold. This case is peculiar to Nigeria and at odds with the changes in global component prices. Adesanya and Pearce (2019) argued that this development has reached a stage where the economic and technical costs of generating electricity are almost the same as diesel generation. As a result, many have advocated expanding the pay-as-you-go solar framework to reduce affordability burdens and increase upper-tier system adoption among households (Yadav, Heynen, & Palit, 2019).’

Opportunities and Challenges of Financing Models

To address the cost and affordability constraints of solar adoption, many have seen PAYGo as a gateway to helping households overcome the upfront cost of adoption (Mergulhão et al., 2023; Montoya-Duque, Arango-Aramburo, & Arias-Gaviria, 2022). The PAYGo financial model entails that payment for solar systems is spread across daily or monthly payments by the household or users. Mukisa et al. (2022) observed that effective implementation of PAYGo without leakages will enhance affordability for households and improve sales for producers. The positive multiplier effect is to invest more in research and development (R&D) and expand innovative technologies in the sector. Arowolo et al. (2019) also added that PAYGo can expand solar access to households if it is well regulated. Ogundari et al. (2021) also examined national PAYGo adoption patterns and argued that the scheme is mostly concentrated in urban and peri-urban areas.

A review of literature has shown a structural limitation to the achievement of PAYGo financing as a policy. Solar companies concentrate in urban and semi-urban centres because of the logistics challenges of distributing solar PV across rural communities. Yaguma et al. (2026) added that even if they consider distributing solar energy to remote areas using the PAYGo financing model, prices become relatively higher than in urban areas. This makes the model more useful for households with higher incomes than for rural households with low incomes. This issue is more complicated and pronounced in North Central Nigeria, where houses are widely dispersed, and low-income earners dominate the population (Hassan et al., 2020). Some scholars (Perros et al., 2024; Barry & Creti, 2020) have recently described this as a poverty premium. They explained that low-income households are expected to pay the highest unit cost of off-grid electricity compared with high-income earners living in cities. This undermines the essence of the payment system, which is meant to reduce the payment burden and enhance affordability for households. The financing gap helps explain the discouraging growth in subscriptions to the PAYGo model among the general public, especially in rural communities. According to Cross and Neumark (2021), many have viewed it as an exploitative means of selling solar systems to people at hidden costs higher than those incurred from the existing national grid. Others have also argued that the PAYGo model has done little to eradicate the affordability barrier that affects adoption of solar energy, as most rural dwellers are still purchasing the same lower-tier systems for phone charging and lighting.

Awareness, Sociocultural, and Trust Factors

Beyond cost and affordability, awareness has been identified as an important factor influencing solar PV adoption in rural communities in Nigeria. Scholars have argued that solar adoption could have expanded if the public were well aware of the product, financing schemes, and realistic performance expectations (Yadav et al., 2020). Mbonu and Owosho (2025) discovered that awareness campaigns created a larger effect on solar adoption than most individual demographic factors among SMEs. They further stated that although adoption is demand-driven, it is constrained by awareness, affordability, and weak policy support. Okwanya et al. (2021) found similar evidence in the region, where awareness and availability were significant and directly related to renewable energy use. Others (Duque Oliva & Atehortua Santamaria, 2025; Ajah & Pathranarakul, 2024) found similar results, indicating that awareness operates alongside affordability to significantly influence solar PV adoption. They also argue against using awareness as a proxy for affordability in the solar adoption model. This shows a similar pattern of challenges affecting solar adoption among developing countries, especially in rural communities. Meanwhile, Li et al. (2025) identified trust as an important variable in the solar adoption model. The study stated that trust addresses issues of credibility, product durability, and after-sales service, as well as customers' willingness to subscribe to an instalment-payment financial model. Others have also acknowledged efficiency as an

important variable affecting adoption in rural areas. For instance, in North Central Nigeria, extreme heat and dust may reduce solar panel efficiency. This occurs mostly in rural communities with little or no after sales technical services, the effectiveness of solar PV will drop especially during December to April due to heat and dust (Adesanya & Pearce, 2019). They opined that lack of maintenance may reduce effectiveness which unknown to household may attribute it low quality and would drastically affect adoption by other community members.

Policy and Institutional Barriers

The provision of stable and reliable electricity in Nigeria has long received attention as it is considered the lifewire of any economy. Consequently, successive administrations have designed many policy measures to address the country's epileptic power supply. One policy that has received more attention in recent decades is the use of renewable sources to generate a stable power supply and preserve the environment (Attanayake et al., 2024). According to Ozoegwu and Akpan (2021), policy measures set up to address energy issues in Nigeria are robust on paper but thin in implementation. A literature review identifies several policies, including the National Renewable Energy and Energy Efficiency Policy, the Rural Electrification Strategy and Implementation Plan, and the National Energy Transition Plan. Ozoegwu and Akpan (2021) observed that each policy was set up with a target and intervention funds appropriated to enhance effective implementation. However, our literature review identifies implementation gaps ranging from bureaucratic delays and mismanagement of funds to inconsistency in implementation, among others (Ajia, 2025).

Adelaja et al. (2020) conducted a national-level case analysis to examine the mechanisms (institutional and regulatory) through which the gaps occurred. Their study identifies delays in fund disbursement and fragmented coordination as the core constraints affecting the effective implementation of energy policies in Nigeria. Ojo (2012) earlier identified disbursement delay as one of the bureaucratic inefficiencies that leads to fund misappropriation, especially in environments where regulatory institutions are weak. Osunmuyiwa and Kalfagianni (2017) go further to examine how Nigeria could accelerate the adoption of renewable energy, given the persistent fall in technology costs. They found that financial and infrastructural challenges affect the full realisation of the policies. This suggests that resource availability and policy announcements are not sufficient to increase household adoption of solar energy, especially in rural communities.

Table 4.1 Appraisal criteria

Group	Criterion	#
The screening questions	What does the paper report: actual research or opinion-based idea?	Q1
	Are the goals of the research stated in a clear context?	Q2
	Is the context of the study explicitly described?	Q3
Study design	Was the design appropriate and able to help achieve the aim of the study?	Q4
	Was the population and sample appropriate for the study?	Q5
Data collection and analysis	Was the data collected in an appropriate manner	Q6
	Was the analysis of data carried out with the right rigour?	Q7
Findings	Are the findings stated correctly and clearly?	Q8
	Was the researcher-respondents relationship correctly accounted for?	Q9
	Is the study relevant and valuable to research or practice?	Q10

Source: Author's Compilation from the literature.

Table 4.1 shows the criteria used for scoring the reviewed papers. The aim is to appraise the quality of papers and determine whether they qualify for review in this study. Bin Alis and Usman (2019) confirmed that quality appraisal is essential in an SLR because it distinguishes weak studies from trustworthy evidence

and helps avoid conclusions based on biased or low-quality sources. The scoring is set up so that if a paper fully meets each criterion, it gets 1 point; if it partially meets it, it gets 0.5; if it does not meet it at all, it gets 0 points, with a maximum of 10 points. Berg et al. (2018) classified the rigour of papers as 0-3.5 (low), 4-6.5 (medium), and 7-10 (high). We therefore follow the same pattern to assess the reviewed papers and rate them accordingly.

Table 4.2 Features of the Reviewed Studies

S/N	Author	Title	Study Design	Outcome	Rating
1.	Mbonu & Owosho (2025)	An investigation of the economic, institutional, technical and firm-specific determinants of solar energy adoption among SMEs in the North-Central region of Nigeria	Quantitative	Solar adoption and system scale are jointly driven by awareness, income, incentives, and education, with awareness alone roughly doubling the likelihood of adoption.	Medium
2.	Tor et al. (2025)	Statistical modelling of solar energy potential in Abuja and Nasarawa State, Nigeria	Quantitative	Adoption intensity fails to match the high, stable solar potential across North-Central sites.	Medium
3.	Okwanya et al. (2021)	Evaluating renewable energy choices among rural communities in Nigeria: An insight for energy policy	Quantitative	Renewable energy use is directly influenced by availability, awareness, and income, with households in rural areas guided by reliability and the cost of installation and maintenance.	High
4.	Wali et al. (2025)	Socioeconomic Determinants of Solar Energy Adoption and Installed Capacity in Urban Areas of Kano State, Nigeria.	Quantitative	A significant number (31.25%) of households in urban areas of Kano adopted and installed solar energy, positively influenced by income, education, household expenditure, and market access. At the same time, age and family size negatively influenced adoption and installation.	High
5.	Kaze et al. (2026)	Evaluating determinants of community renewable energy adoption in Nigeria: insights for sustainable energy transitions in Sub-Saharan Africa	Quantitative	Renewable energy adoption across states in Northern Nigeria is influenced by awareness, education, and income, while awareness itself is influenced by income and educational levels of households in the region.	High
6.	Adelaja A. O. (2020)	Barriers to national renewable energy policy adoption: Insights from a case study of Nigeria	Qualitative	The adoption of renewable energy is affected by both conventional barriers (such as policy uncertainty, inadequate finance, and technical capacity) and institutional barriers	Medium

				(such as conflicting agency mandates, weak coordination, fragmented government responsibilities, and a lack of clear national vision, coordination, and communication).	
7.	Adesanya & Pearce (2019)	Economic viability of captive off-grid solar photovoltaic and diesel hybrid energy systems for the Nigerian private sector	Quantitative	Solar PV-diesel hybrid systems are economically viable across the examined subsectors (real estate, banking, education, automobile, production, and hospitality) in the private sector.	High
8.	Abdullahi et al. (2022)	Barriers for implementing solar energy initiatives in Nigeria: An empirical study.	Qualitative	Social, financial, technological, and political barriers affect solar energy adoption in Nigeria.	Medium
9.	Audu, Adamu & Oladipo (2023)	A mixed-methods study on the determinants of solar home systems utilization in rural, off-grid Nigeria	Mixed Method	Factors such as distance from the electricity grid, education, and income influence adoption, while satisfaction with the current hydro reduces the likelihood of adopting solar energy.	High
10.	Ajah, & Pathranarakul, (2024)	Roles of Managers and Stakeholders Perception on Solar Technology Adoption Intention: A Case of Micro, Small and Medium Enterprises (MSMEs) in Lagos State, Nigeria.	Quantitative	Factors such as perceived opportunities, managers' attitudes, and disruptive innovation significantly influence SMEs' intention to adopt solar energy.	High
11.	Osunmuyiwa & Kalfagianni (2017)	Transitions in unlikely places: Exploring the conditions for renewable energy adoption in Nigeria	Qualitative	Solar energy adoption in Nigeria varies substantially across states, depending on household income, political conditions, and supportive institutions.	High
12.	Arowolo et al. (2019)	Seeking workable solutions to the electrification challenge in Nigeria: Minigrid, reverse auctions and institutional adaptation	Quantitative and GIS Analysis	Financial, institutional, and regulatory factors limit private investment in solar-PV-plus-battery minigrids that could provide stable electricity to underserved communities in Nigeria.	Medium

Source: Author's Compilation from the Literature

DISCUSSION

In the literature review, we found evidence that solar irradiance supports effective solar adoption in North-Central Nigeria, but is not an active variable. This suggests that the region's abundant sunshine has not been effectively used, despite an epileptic power supply that affects people, particularly in rural areas. Global standards clearly show that daily irradiance of 5.5–7.0 kWh/m², as found in North-Central Nigeria, would support the adoption of solar energy in reasonable quantities. However, in rural communities in North-Central Nigeria, which comprise mostly low- and average-income households, adoption is constrained to device-charging and lighting applications. This is attributable to the technology-realised footprint for rural households, given their adoption capacity. This is captured in the study's theoretical framework, which suggests that low adoption despite ample resources is not due to a lack of perceived usefulness, ease of use, or deficits in attitudes. Rather, it is primarily due to policy implementation, financing design, and the structural layer of affordability that limits the tier of solar technology a household can access given their income level. This holds regardless of how favourable such a household is disposed to solar PV resources. As a result, fully capturing solar energy adoption in poor and low-income regions, as covered in this study, requires incorporating both individual and structural factors for a more comprehensive elaboration. Consequently, although this study does not incorporate them, UTAUT2 provides support across different income levels (low- and middle-income) and explains how these income levels shape adoption decisions among households. Some empirical evidence suggests a positive but not very strong effect, indicating that households with higher incomes are more likely to adopt solar PV than those with lower incomes (Best & Chareunsky, 2022). Likewise, solar adoption in the region is also driven by socioeconomic factors and relative advantage. Households with relative advantage and better socioeconomic status adopt solar PV earlier, which the DOI explains as complementing the TAM-TPB framework used in this study.

Evidence across regions in North-Central and Nigeria at large consistently points to affordability, financing, and adoption policies as factors constraining solar energy uptake, despite utilising different respondent types and methodologies. Given that many studies have reached this conclusion, it suggests that the Nigerian economy lacks the capacity to support solar adoption, particularly among rural households in sparsely populated areas in North-Central Nigeria. Other studies also provided evidence supporting this, citing installation and maintenance costs as factors limiting renewable energy uptake even when solar PV systems are abundant and the demand is high (Okwanya et al., 2021). Mbonu and Owosho (2025) also concurred, stating that income levels and policy incentives significantly predict the intensity of solar adoption among SMEs in Nigeria.

The review also identifies three distinct and compounding features specific to the North-Central Nigeria region and related to the affordability-financing-policy structure. First, the dispersed settlement pattern and last-mile effects. Rural settlement in North-Central Nigeria is predominantly dispersed and, as a result, imposes structural deficiencies on PAYGo providers that conventional adoption models do not capture. Scholars (Peng & Zhang, 2026; Babayomi et al., 2023) found that high-density populations reduce the distance between end-users and service hubs, lowering per-connection installation and maintenance costs embedded in instalment contracts. Yaguma et al. (2026) provided empirical evidence indicating that PAYGo providers in low-density markets suffer from last-mile logistics costs, which, in addition to consumer-side affordability constraints, compound the challenges. Guajardo (2021) earlier identified repayment time for an asset by the household as the most influential constraint encountered by the last-mile companies. It is pertinent that expansion in service radius is associated with deterioration in economic units, thereby pushing providers toward smaller, lower-wattage product lines that guarantee quicker repayment cycles and minimise exposure in the field. This makes PAYGo providers more visible and skewed toward peri-urban segments with high density and repayment capacity (Daggash, 2025). This therefore suggests that in North-Central Nigeria, product design is shaped more by distributional geography than by household income levels.

Second, volatility in Naira value and the cost of importing hardware. Solar hardware (such as panels, batteries, and balance-of-system components) is imported at dollar-denominated rates. Consequently, naira depreciation translates directly and largely without a hedge into retail prices, decoupling affordability from any decline in global costs of solar technology. Evidence from Olowu et al. (2024) revealed that devaluations and currency shocks in Nigeria, especially during 2023 and 2024, raised the price of solar

lanterns by over 200 per cent. A tremendous increase that is sufficient to push households from access to exclusion, irrespective of their previous purchasing behaviour and the pricing strategy adopted by providers. Others (Abdullahi et al., 2022) corroborate that costs remain a persistent constraint due to the solar market's volatility in Nigeria. They further explain that even with improvements in enabling policy and technology, costs remain a major challenge. This implies that household affordability is significantly influenced by exogenous macroeconomic factors that differ from provider efficiency and household income capacity. Consequently, this limits the extent to which innovative financing models alone can enhance demand stability.

Third, localised insecurity and infrastructural challenges. Financing models such as PAYGo rely on instalment-based payments, which depend on a functional distribution and after-sales link to ensure payment collection, technical services, and repossession. This suggests that providers would have a baseline level of physical access to rural communities. However, North-Central Nigeria in recent years has been overwhelmed by armed violence such as herder-farmer crises, militia attacks, banditry, and kidnapping that impose restrictions on access to some rural communities (George & Adelaja, 2022; Akov, 2017). Madueke (2026) also found evidence that economic activities across regions in Nigeria (including North-Central) are deeply affected by insecurity issues such as armed conflict, kidnapping, and banditry. Therefore, service providers' inability to access communities for after-sales services affects the efficacy of the PAYGo model. Consequently, this makes it non-viable or non-existent, or limits it to non-commercial solar PV required for lighting and phone charging.

POLICY AND PRACTICE IMPLICATIONS

First, enhance financial interventions to ensure system-tier upgrades rather than relying only on accessibility. Currently, most PAYGo models prioritise payment systems where customers pay in instalments. However, this does not reduce solar PV prices, as customers are compelled to pay the same high costs spread into smaller amounts over time. This implies that most households will not be able to afford the higher system tier that supports economic activities. Therefore, policy measures that prioritise reducing the prices of higher system tiers would be more beneficial to households, especially in rural communities.

Second, creating awareness about solar energy should be treated as a distinct program. Government or energy-market stakeholders should not assume that improving financial models will automatically increase adoption. Evidence from Mbonu and Owosho (2025) shows that awareness campaigns alone doubled households' chances of adoption, regardless of income level. Okwanya et al. (2021) also argued that, regardless of household income, awareness and access remain the most influential factors in solar PV adoption. Therefore, there should be sustained funding for awareness programs, and they should cut across rural communities in North-Central Nigeria.

Third, poor policy implementation, driven by corruption and bureaucracy, has negatively affected institutions in Nigeria. This has cut across sectors and sub-sectors, including the energy market. Over the years, the Nigerian government has introduced numerous energy policies that could have transformed the entire energy sector. Policies (such as the Renewable Energy Master Plan (REMP), 2005/2006; the National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015; the Energy Transition Plan (ETP), 2022; and the Rural Electrification Fund, among others) have already articulated the right objectives for renewable energy adoption. However, a lack of coordination among regulatory institutions (the Rural Electrification Agency and the Central Bank of Nigeria) and private developers, as well as regulatory inconsistency and delayed disbursement of funds, have crippled implementation of these programs (Ajia, 2025; Adelaja, 2020). Properly revisiting, refunding, and de-risking instruments would provide more benefits at minimal cost compared with introducing new policies.

LIMITATIONS OF THE REVIEW

This study has three notable limitations. First, the limited literature on North-Central Nigeria remains a major challenge, as most studies cover either all of northern Nigeria, other regions, or Nigeria as a whole.

Second, we narrowed the search to ScienceDirect, Web of Science, the MDPI platform, and Google Scholar, which limited the number of papers included.

Third, limiting the review to only 12 papers limit the generalisability of the outcomes, as including more studies would yield more robust results.

CONCLUSION

North-Central Nigeria has a viable and favourable site for solar adoption due to high solar irradiance. This, in conjunction with declining prices of solar energy equipment due to technological advances and subsidies, and flexible payment models, has made solar adoption more visible in the region. However, the adoption remains extremely low and concentrated in low-tier systems for lighting and phone charging, especially among rural communities. This has not remedied the region's epileptic electricity supply, caused by limited access and the persistent collapse of the national grid. Solar PV adoption has not reached wider communities or scaled up to support productive capacity or irrigation, as farming is a major source of income for rural households in the region. This study systematically reviewed 12 studies drawn from recognised journals across four websites. We found that affordability constraints, financing models that scale rather than dismantle cost barriers, limited awareness programs, and implementation gaps have delayed the adoption of solar PV in the region. These structural challenges are considered persistent and follow similar patterns across the states in the region and Nigeria at large.

The study therefore suggests that further studies should explore these areas. First, a survey study in the region should examine system-tier effects on financing approaches and last-mile distribution, particularly in rural communities. Second, conduct a comparative analysis with countries with similar financing models or with high-irradiance developing countries with similar market features.

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