International Journal of Construction Engineering and Management 2026, 15(2): 19-31
DOI: 10.5923/j.ijcem.20261502.01

Solar Energy Solutions for Off-Grid Residential Communities in Ikorodu, Lagos State, Nigeria: Determinants of Household Adoption and Their Implications for Sustainable Infrastructure Development

Elizabeth O. Abosede*, Joseph A. Oche, Micheal C. Okolo, Oreoluwa J. Ukah, Opeyemi A. Asaju, Obafemi A. Ibitoye

Department of Architecture, Caleb University, Lagos, Nigeria

Abstract Access to reliable electricity remains a major challenge in many off-grid communities in Nigeria, limiting residential development and sustainable infrastructure delivery. This study examined the determinants of household adoption of solar energy solutions and their implications for sustainable infrastructure development in the off-grid communities of Maya and Adamo, Ikorodu, Lagos State. A quantitative research design was adopted using a structured questionnaire administered to 200 households selected through purposive and convenience sampling techniques. Data were analysed using descriptive statistics, the Relative Importance Index (RII), Pearson correlation analysis, and regression analysis. The findings revealed that reliability (RII = 0.824), perceived benefits (RII = 0.808), and awareness (RII = 0.799) were the most influential determinants of solar energy adoption, whereas high installation cost (RII = 0.872) and limited access to financing (RII = 0.847) were identified as the principal barriers. The results further indicated that households perceived solar energy adoption as contributing positively to improved living standards, productivity, infrastructure quality, community development, and resilience. Correlation analysis showed a strong positive relationship between reliability and adoption intention ($r = 0.694$), while linear regression analysis established that adoption intention was a statistically significant positive predictor of sustainable infrastructure development ($\beta = 0.458$, $R^2 = 0.289$, $p < 0.001$). The study concludes that improving the affordability and accessibility of solar energy systems while enhancing their reliability can accelerate household adoption and support sustainable infrastructure development in off-grid residential communities. It recommends the integration of renewable energy solutions into residential planning, financing programmes, and infrastructure development strategies to promote resilient and sustainable settlements.

Keywords Solar energy adoption, Sustainable infrastructure development, Off-grid communities, Residential development, Renewable energy, Ikorodu, Nigeria

1. Introduction

Access to reliable, affordable, and sustainable energy remains one of the most important prerequisites for economic growth, social development, and improved living standards. Modern energy services support virtually every aspect of human activity, including industrial production, education, healthcare delivery, communication, transportation, and household welfare. Consequently, access to electricity has become a key indicator of development and an essential requirement for achieving sustainable economic and social progress. Despite considerable improvements in global electrification over recent decades, significant disparities in energy access persist, particularly across developing countries where millions of people continue to lack reliable electricity services. Recognizing the central role of energy in sustainable development, the United Nations incorporated energy access into Sustainable Development Goal 7 (SDG 7), which seeks to ensure universal access to affordable, reliable, sustainable, and modern energy for all by 2030. However, achieving this objective remains a major challenge in many parts of Sub-Saharan Africa where inadequate electricity infrastructure continues to constrain development outcomes. Nnaji et al. [1] observed that insufficient electricity supply remains one of the major obstacles to socio-economic development in many African countries, limiting opportunities for poverty reduction, industrial growth,

* Corresponding author:
elizabethabosede63@gmail.com (Elizabeth O. Abosede)
Received: Jun. 16, 2026; Accepted: Jun. 29, 2026; Published: Jul. 4, 2026
Published online at http://journal.sapub.org/ijcem

and improved quality of life.

The challenge of energy access is closely linked to the issues of energy poverty and energy security. Energy poverty occurs when households are unable to obtain adequate modern energy services required for basic living conditions, while energy security refers to the availability of sufficient energy resources at affordable and stable prices. In many developing countries, poor electricity infrastructure, inadequate investment, and increasing energy demand have contributed to persistent energy poverty among households and businesses. Monyei et al. [2] argued that improving access to reliable electricity is critical for reducing poverty, enhancing productivity, and promoting sustainable development. Consequently, governments and development organizations have increasingly prioritized energy access initiatives as part of broader efforts to achieve economic growth and social inclusion.

Nigeria presents one of the most significant examples of the energy access challenge in Sub-Saharan Africa. Although the country possesses abundant fossil fuel resources and considerable renewable energy potential, electricity supply remains inadequate for a large proportion of the population. Aliyu et al. [3] attributed this situation to longstanding challenges within the electricity sector, including insufficient generation capacity, transmission constraints, distribution inefficiencies, and poor infrastructure maintenance. These challenges have resulted in frequent power outages and unreliable electricity supply across both urban and rural areas. Oseni [4] noted that the persistent inability of the national grid to meet electricity demand has compelled many households and businesses to depend heavily on self-generation through diesel and petrol generators. While generators provide an alternative source of electricity, they are associated with high operating costs, environmental pollution, greenhouse gas emissions, and noise-related health concerns. According to Monyei et al. [2], the continued dependence on generators reflects the severity of Nigeria's electricity deficit and highlights the urgent need for alternative energy solutions capable of improving access to reliable power.

In response to these challenges, renewable energy technologies have increasingly attracted attention as viable alternatives for improving electricity access. Among the available renewable energy options, solar energy has emerged as one of the most promising due to its abundance, environmental sustainability, and suitability for decentralized electricity generation. Nigeria is located within a region of high solar irradiation and possesses substantial solar energy resources that can support widespread deployment of photovoltaic technologies. Ohunakin et al. [5] emphasized that Nigeria's geographical location provides favourable conditions for year-round solar energy generation. Similarly, Okoye et al. [6] identified solar photovoltaic systems as practical solutions for addressing electricity shortages, particularly in communities where grid extension is technically difficult or economically unviable. More recently, Chanchangi et al. [7] highlighted the strategic importance of solar energy in supporting Nigeria's energy transition objectives, improving energy security, and reducing dependence on conventional fossil-fuel-based energy systems.

The growing recognition of solar energy's potential has encouraged the deployment of Solar Home Systems (SHSs), rooftop photovoltaic systems, and solar mini-grids across many developing countries. These decentralized energy systems are particularly valuable because they can provide electricity to households and communities that are underserved by conventional grid infrastructure. Barrie and Cruickshank [8] demonstrated that decentralized solar technologies can significantly improve energy access and support socio-economic development in underserved communities. Pelizan et al. [9] further reported that solar-based electrification programmes have contributed positively to improved living standards, enhanced educational opportunities, and increased economic activities within off-grid settlements. Within Nigeria, Audu and Adamu [10] observed increasing interest in Solar Home Systems among households seeking reliable alternatives to erratic grid electricity and expensive generator use. These developments indicate that solar technologies have considerable potential to complement conventional electricity systems and contribute to improved energy access.

Despite the increasing availability of solar technologies and their recognized benefits, adoption rates remain relatively low compared with the country's technical solar energy potential. The existence of abundant solar resources does not automatically translate into widespread adoption of solar energy systems. Existing studies suggest that adoption decisions are influenced by a combination of economic, social, technical, institutional, and behavioural factors. Ali et al. [11] argued that awareness, perceived usefulness, ease of use, economic considerations, and social influences play important roles in shaping renewable energy adoption behaviour. Audu and Adamu [10] identified affordability as a major determinant of Solar Home System adoption among households in Nigeria, while Barrie and Cruickshank [8] emphasized the importance of financing mechanisms in improving access to renewable energy technologies. Pelizan et al. [9] similarly demonstrated that flexible financing arrangements can enhance solar energy adoption among low-income households. Durodola et al. [12] further maintained that successful deployment of decentralized renewable energy technologies depends not only on technological availability but also on users' willingness and capacity to adopt and sustain such technologies over time.

Beyond addressing electricity access challenges, solar energy adoption has broader implications for sustainable infrastructure development. Energy is a critical component of infrastructure systems because it supports the operation of residential buildings, healthcare facilities, educational institutions, water supply systems, and commercial activities. Elusakin et al. [13] observed that renewable energy technologies can contribute significantly to rural and community development by improving access to essential services and reducing infrastructure deficits. Babalola et al. [14] further argued that investments in renewable energy infrastructure

contribute to sustainable development by enhancing economic productivity, environmental sustainability, and social inclusion. Consequently, the adoption of solar energy technologies has implications that extend beyond household electricity supply to encompass broader issues of community resilience, infrastructure performance, and sustainable development.

Although numerous studies have examined renewable energy adoption, off-grid electrification, affordability, financing mechanisms, and the socio-economic impacts of solar energy technologies, important knowledge gaps remain. Much of the existing literature has focused on rural communities, national-level energy policies, or the technical performance of renewable energy systems. Comparatively fewer studies have investigated the determinants of individual solar energy adoption within rapidly developing peri-urban communities experiencing persistent electricity supply challenges. Furthermore, limited empirical evidence exists regarding how household-level solar energy adoption contributes to sustainable infrastructure development within specific local contexts.

This gap is particularly evident in Ikorodu, Lagos State, where growing residential development continues to place increasing pressure on existing electricity infrastructure. Despite the area's strategic importance within Lagos State, many communities continue to experience varying levels of electricity supply inadequacy, creating interest in alternative energy solutions such as solar power systems. However, limited evidence exists regarding the factors that influence household adoption decisions within these communities and the implications of such adoption for sustainable infrastructure development.

This study therefore investigates the determinants of household adoption of solar energy solutions among residents of Maya and Adamo communities in Ikorodu, Lagos State, Nigeria. Specifically, the study examines household energy access characteristics, determines the level of solar energy adoption, identifies the key determinants and challenges influencing adoption decisions, and assesses the implications of solar energy adoption for sustainable infrastructure development. The findings are expected to contribute to the growing body of knowledge on renewable energy adoption while providing evidence-based insights for policymakers, renewable energy developers, infrastructure planners, and community stakeholders seeking to promote sustainable energy access and sustainable infrastructure development in Nigeria.

2. Literature Review

2.1. Solar Energy Solutions and Determinants of Adoption

Solar energy has emerged as one of the most viable renewable energy solutions for improving electricity access in communities affected by inadequate or unreliable grid supply. Common residential applications include Solar Home Systems (SHSs), rooftop photovoltaic systems, and solar mini-grids. These technologies provide households with alternative sources of electricity for lighting, communication, refrigeration, and other domestic activities while reducing dependence on conventional energy sources. Azimoh et al. [18] observed that solar technologies have contributed significantly to improved energy access in underserved communities, while also supporting broader socio-economic development objectives.

The increasing deployment of solar technologies has been driven by their environmental and economic benefits. Babajide and Brito [19] noted that solar photovoltaic systems provide cleaner and more sustainable alternatives to widespread generator dependence, particularly in countries experiencing persistent electricity supply challenges. In addition to reducing greenhouse gas emissions and fuel consumption, solar technologies offer opportunities for improved energy security and long-term cost savings.

Despite these advantages, adoption rates remain uneven across households and communities. Existing studies indicate that solar energy adoption is influenced by a combination of socio-economic, behavioural, and institutional factors. Ali et al. [11] emphasized that awareness, knowledge, and perceptions of technology play important roles in shaping adoption decisions. Households that understand the benefits and operation of solar technologies are generally more willing to invest in and utilize such systems.

Affordability remains one of the most significant determinants of adoption. Audu and Adamu [10] found that although households often demonstrate positive attitudes towards solar technologies, high acquisition costs can limit adoption, particularly among low-income groups. Similar concerns have been reported regarding installation expenses, maintenance costs, and the financial capacity of potential users to invest in renewable energy systems.

Access to financing has also been identified as a critical factor influencing solar energy uptake. Barrie and Cruickshank [8] demonstrated that innovative financing models can reduce upfront investment barriers and improve access to solar technologies among low-income households. Likewise, Pelizan et al. [9] showed that flexible payment arrangements can significantly enhance affordability and increase adoption rates where conventional financing options are limited.

Perceived benefits and system reliability further influence household decisions regarding solar energy adoption. Anagbakwu [20] reported that households are more likely to adopt solar technologies when they perceive improvements in electricity reliability, reduced energy expenditure, and enhanced quality of life. Durodola et al. [12] similarly argued that successful adoption depends not only on the availability of technology but also on users' confidence in its performance and long-term value.

Collectively, the literature suggests that awareness, affordability, financing opportunities, perceived benefits, and reliability are among the most important factors shaping solar energy adoption. Understanding the influence of these determinants is therefore essential for designing interventions

capable of increasing renewable energy uptake and improving energy access in electricity-deficient communities.

2.2. Sustainable Infrastructure Development

Sustainable infrastructure development refers to the planning, provision, and management of infrastructure systems in ways that support economic growth, social well-being, and environmental sustainability. It emphasizes the delivery of infrastructure that meets present needs while maintaining the capacity to support future development. Energy infrastructure is a critical component of this process because reliable energy services underpin the functioning of residential buildings, healthcare facilities, educational institutions, water systems, and commercial activities (Nnaji et al. [1]).

Access to reliable electricity contributes significantly to improved living standards and enhanced infrastructure performance. Elusakin et al. [13] observed that renewable energy technologies can address infrastructure deficits by improving access to essential services and supporting community development. By reducing dependence on unreliable conventional electricity sources, decentralized renewable energy systems can enhance the functionality and resilience of residential communities.

The contribution of renewable energy extends beyond electricity provision to broader socio-economic outcomes. Babalola et al. [14] argued that investments in renewable energy infrastructure promote economic productivity, environmental sustainability, and social inclusion while strengthening community resilience. Consequently, the adoption of solar energy technologies can support sustainable infrastructure development by improving energy access, enhancing residential welfare, and contributing to long-term community sustainability.

Given the important relationship between energy and infrastructure, understanding the factors that influence solar energy adoption is essential for developing strategies that promote both improved electricity access and sustainable infrastructure development in electricity-deficient communities.

2.3. Diffusion of Innovation Theory

This study is anchored on the Diffusion of Innovation (DOI) Theory developed by Rogers [21]. The theory explains how new ideas, technologies, and innovations spread within a social system over time and why some individuals adopt innovations more readily than others. According to the theory, the adoption process involves awareness, evaluation, trial, and eventual acceptance or rejection of an innovation. The theory has been widely applied in studies examining the adoption of technological innovations, including renewable energy technologies and solar energy systems.

The Diffusion of Innovation Theory identifies five major characteristics that influence adoption decisions. These include relative advantage, which refers to the extent to which an innovation is perceived as better than existing alternatives; compatibility, which describes how consistent the innovation is with users' needs, values, and experiences; complexity, which relates to the ease of understanding and using the innovation; trialability, which reflects the opportunity to test an innovation before full adoption; and observability, which concerns the visibility of the benefits derived from the innovation. Rogers [21] argued that innovations possessing favourable attributes across these dimensions are more likely to achieve widespread acceptance.

The theory is particularly relevant to solar energy adoption because household decisions are often influenced by perceptions of costs, benefits, reliability, and ease of use. Potential users are more likely to adopt solar technologies when they perceive clear advantages over conventional electricity sources, understand how the systems operate, and have confidence in their ability to provide reliable energy services. Conversely, limited awareness, affordability constraints, and uncertainty regarding system performance may discourage adoption. As a result, the theory provides a useful framework for understanding the behavioural and socio-economic factors that influence renewable energy adoption.

The relevance of the Diffusion of Innovation Theory to this study lies in its ability to explain the determinants of solar energy adoption among residents of electricity-deficient communities in Ikorodu, Lagos State. Variables examined in this study, including awareness, income, affordability, financing opportunities, perceived benefits, and reliability, influence how potential users perceive and evaluate solar energy technologies. The theory therefore provides an appropriate foundation for examining household adoption behaviour and understanding how increased adoption of solar energy solutions can contribute to sustainable infrastructure development.

2.4. Empirical Evidence on Solar Energy Adoption

Empirical studies on solar energy adoption have identified several factors that influence households' decisions to adopt renewable energy technologies. These factors generally include affordability, financing opportunities, awareness, perceived benefits, reliability, and broader socio-economic conditions. Existing studies also demonstrate that solar energy adoption contributes not only to improved electricity access but also to wider developmental outcomes such as economic productivity, household welfare, and community resilience.

A significant body of literature emphasizes the role of affordability in shaping solar energy adoption. Audu and Adamu [10] investigated the adoption of Solar Home Systems among households in off-grid communities in Kwara State, Nigeria, and found that although respondents expressed positive attitudes toward solar technologies, affordability remained a major constraint. The study revealed that many households were willing to adopt solar systems but lacked the financial capacity to meet prevailing market prices.

Similarly, Pelizan et al. [9] reported that affordability significantly influences the adoption of solar technologies among rural households, particularly in developing economies where income levels remain relatively low. These findings suggest that reducing the cost burden associated with solar technologies is critical for expanding adoption among underserved populations.

Closely related to affordability is the issue of financing. Barrie and Cruickshank [8] examined the role of Pay-As-You-Go financing models in promoting Solar Home System adoption and found that flexible payment arrangements can substantially improve access to renewable energy technologies. By reducing upfront investment requirements, such financing mechanisms enable households with limited financial resources to adopt solar energy systems. The study highlighted the importance of innovative financing strategies in accelerating renewable energy uptake, particularly in low-income communities where conventional credit facilities may be inaccessible.

Beyond economic considerations, behavioural factors have also been identified as important determinants of solar energy adoption. Ali et al. [11] found that awareness, perceived usefulness, and social influences significantly affect household decisions regarding renewable energy technologies. The study demonstrated that individuals are more likely to adopt solar technologies when they possess adequate knowledge of their benefits and operation. Durodola et al. [12] similarly argued that successful deployment of decentralized renewable energy systems depends not only on technological availability but also on users' willingness to embrace and sustain their use. These findings reinforce the importance of awareness creation and public education programmes in promoting renewable energy adoption.

Perceptions regarding the benefits and performance of solar technologies also influence adoption decisions. Anagbakwu [20] found that households were more inclined to adopt Solar Home Systems when they perceived improvements in electricity reliability, reduced energy expenditure, and enhanced living conditions. The study demonstrated that positive user experiences and confidence in system performance contribute significantly to increased adoption. Reliability therefore remains an important consideration, particularly in areas where households seek alternatives to unstable grid electricity and expensive generator use.

Several studies have further examined the developmental impacts associated with solar energy adoption. Babajide and Brito [19] assessed the potential of residential solar photovoltaic systems as alternatives to widespread generator dependence in Nigeria and concluded that solar technologies provide cleaner, more sustainable, and economically viable energy solutions. Their findings highlighted the role of solar energy in improving household energy security while reducing environmental impacts associated with fossil-fuel-based electricity generation.

At the community level, Babalola et al. [14] investigated the socio-economic impacts of off-grid energy systems in Southwest Nigeria and found that access to decentralized energy technologies contributes positively to business performance, income generation, local economic development, productivity, employment opportunities, and overall community welfare. These findings suggest that the benefits of solar energy adoption extend beyond individual households and contribute to broader socio-economic and development outcomes.

Collectively, the empirical literature demonstrates that solar energy adoption is influenced by a combination of affordability, financing opportunities, awareness, perceived benefits, and reliability considerations. The literature also establishes that renewable energy technologies contribute significantly to improved energy access, household welfare, economic productivity, and community development. However, despite these contributions, limited empirical evidence exists regarding how these determinants interact to influence household adoption decisions within electricity-deficient communities in Ikorodu, Lagos State. This gap underscores the need for context-specific investigations capable of informing policies and strategies for expanding solar energy adoption and promoting sustainable infrastructure development.

2.5. Research Gap

Existing studies have established the potential of solar energy technologies to improve electricity access, reduce energy poverty, and support socio-economic development through decentralized electrification systems. Previous research has examined issues such as affordability, financing mechanisms, behavioural determinants, renewable energy policy, and the developmental impacts of off-grid electrification. Audu and Adamu [10] highlighted affordability constraints in Solar Home System adoption, while Babajide and Brito [19] emphasized the role of solar technologies as alternatives to generator dependence. Ali et al. [11] examined behavioural factors influencing adoption decisions, and Babalola et al. [14] demonstrated the contribution of decentralized energy systems to community development. Collectively, these studies confirm the importance of solar energy in improving household welfare and expanding energy access.

Despite these contributions, important gaps remain. Much of the existing literature focuses on rural communities, national-level assessments, or individual adoption determinants such as affordability, financing, awareness, and technical feasibility, with limited attention given to how these factors interact to influence household adoption decisions. In addition, although previous studies have reported positive socio-economic outcomes associated with renewable energy systems, limited empirical evidence exists on the relationship between household solar energy adoption and sustainable infrastructure development, particularly within electricity-deficient residential communities in Ikorodu, Lagos State. This study addresses this geographical and thematic gap by examining the determinants of individual solar energy adoption and their implications for sustainable infrastructure development in Maya and Adamo communities,

thereby providing context-specific evidence for policy and planning.

3. Methodology

This study adopted a quantitative cross-sectional survey design to investigate the determinants of household solar energy adoption and their implications for sustainable infrastructure development in selected off-grid communities in Ikorodu, Lagos State, Nigeria. The study was conducted in Maya and Adamo communities, which were purposively selected due to persistent electricity supply challenges and the growing need for alternative energy solutions.

The target population comprised adult residents who were knowledgeable about household energy use and electricity supply conditions. The sample size was determined using Cochran's [22] formula for large populations, yielding approximately 196 respondents. To improve representation and facilitate data collection, the sample size was rounded up to 200 respondents, consisting of 100 respondents each from Maya and Adamo communities. A purposive sampling technique was first employed to select the Maya and Adamo communities due to their persistent electricity supply challenges and relevance to the study objectives. Thereafter, convenience sampling was used to select eligible households and respondents who were available and willing to participate in the survey, with one adult respondent selected from each household.

Primary data were collected using a structured questionnaire designed to obtain information on respondents' socio-economic characteristics, household energy access conditions, determinants of solar energy adoption, adoption intention, perceived challenges, and perceptions of sustainable infrastructure development. The questionnaire was subjected to expert review to ensure content validity, while a pilot survey was conducted to evaluate its reliability. In addition, the internal consistency of the study constructs was assessed using Cronbach's Alpha coefficient.

The study measured key constructs including awareness, affordability, financing, perceived benefits, reliability, adoption intention, and sustainable infrastructure development, while respondents' socio-economic characteristics such as education and income were also captured. Data were analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages, mean scores, and standard deviations, were used to summarise respondents' characteristics and perceptions. The Relative Importance Index (RII) was employed to rank the determinants and challenges of solar energy adoption. Cronbach's Alpha was used to assess the reliability of the measurement scales, while Pearson correlation analysis examined the relationships among the principal study constructs. Finally, linear regression analysis was performed to evaluate the influence of adoption intention on sustainable infrastructure development, thereby providing empirical evidence on the implications of household solar energy adoption for infrastructure sustainability in the study area.

Participation was voluntary, respondents provided informed consent, and all responses were treated confidentially and used solely for academic research purposes.

4. Results and Discussion

4.1. Socio-Economic Characteristics of Respondents

The socio-economic characteristics of the respondents were examined to provide an understanding of the demographic and economic profile of households participating in the study. The variables considered include gender, age, educational attainment, occupation, monthly household income, and community of residence. The results are presented in Table 1.

Table 1. Socio-Economic Characteristics of Respondents

Variable	Category	Frequency (n=200)	Percentage (%)
Community	Maya	100	50
	Adamo	100	50
Gender	Male	126	63
	Female	74	37
Age Group	18–25 years	64	32
	26–35 years	67	33.5
	36–45 years	50	25
	46–55 years	18	9
	Above 55 years	1	0.5
Marital Status	Married	102	51
	Single	86	43
	Divorced	8	4
	Widowed	4	2
Educational Qualification	Primary School	3	1.5
	Secondary School	11	5.5
	OND/NCE	20	10
	HND/B.Sc.	116	58
	Postgraduate Degree	50	25
Occupation	Private Sector Employee	71	35.5
	Self-Employed	47	23.5
	Student	33	16.5
	Civil Servant	19	9.5
	Trader	17	8.5
	Artisan	13	6.5
Monthly Income	Below ₦50,000	10	5
	₦50,000–₦100,000	29	14.5
	₦100,001–₦200,000	65	32.5
	₦200,001–₦500,000	52	26
	Above ₦500,000	43	21.5

The results indicate that the respondents comprised a diverse cross-section of households from the Maya and Adamo communities, representing different age groups, educational backgrounds, occupations, and income categories. This diversity enhances the representativeness of the survey and provides a suitable basis for examining the determinants of solar energy adoption and its implications for sustainable infrastructure development.

The distribution of respondents across educational and income categories suggests that household decisions regarding energy technologies are influenced by varying socio-economic conditions. Similarly, the occupational profile reflects the presence of both formally and informally employed individuals whose financial capacity and energy needs may differ. The balanced representation of respondents from the two study communities further strengthens the comparative validity of the findings.

These observations are consistent with previous studies that identified socio-economic characteristics as important contextual factors influencing household energy choices and access to modern energy services. Oseni [4] emphasised that income and demographic disparities significantly affect energy access patterns in Nigeria, while Mohammed et al. [23] reported that household characteristics play an important role in shaping energy consumption behaviour. Likewise, Ohunakin et al. [5] highlighted the influence of socio-economic variables on renewable energy utilisation and energy transition decisions among Nigerian households.

Overall, the socio-economic profile of the respondents provides an appropriate context for interpreting the subsequent analyses and supports the study objective of examining the determinants of solar energy adoption in off-grid residential communities in Ikorodu, Lagos State.

4.2. Household Energy Access Characteristics

Household energy access characteristics were examined to provide insight into the electricity supply conditions and energy-use patterns of respondents in the study area. The results are presented in Table 2.

The findings reveal that many households in Maya and Adamo continue to experience unreliable electricity supply and therefore rely on alternative energy sources to satisfy their daily energy needs. Frequent power interruptions and dependence on supplementary energy options underscore the inadequacy of existing electricity services within the study communities.

These conditions suggest that energy insecurity remains a significant concern and create a practical need for decentralized energy solutions capable of providing more reliable and sustainable electricity. The existing energy access gap also provides a plausible explanation for the growing interest in solar energy technologies observed among residents.

Table 2. Household Energy Access Characteristics (N = 200)

Variable	Category	Frequency	Percentage (%)
Primary Source of Electricity	National Grid	104	52
	Combination of Sources	56	28
	Generator	17	8.5
	Solar Energy System	15	7.5
	Inverter System	8	4
Rating of Electricity Supply	Very Poor	52	26
	Poor	79	39.5
	Fair	47	23.5
	Good	19	9.5
	Excellent	3	1.5

Table 3. Household Solar Energy Adoption Status

Adoption Status	Frequency	Percentage (%)
Yes	79	39.5
No	121	60.5
Total	**200**	**100**

Table 4. Type of Solar Energy System Adopted

Solar Energy System	Frequency	Percentage of Solar Users (%)
Solar Inverter System	36	46.2
Rooftop Solar PV	19	24.4
Solar Home System (SHS)	16	20.5
Solar Mini-grid	8	9
Total	**79**	**100**

Table 5. Determinants of Solar Energy Adoption

Determinant	Mean	Standard Deviation	RII	Rank
Reliability	4.118	0.612	0.824	1
Perceived Benefits	4.038	0.615	0.808	2
Awareness	3.995	0.609	0.799	3
Financing	3.68	0.891	0.736	4
Affordability	2.322	0.713	0.464	5

This pattern is consistent with the observations of Mohammed et al. [16], who reported that persistent deficiencies in electricity supply influence household energy choices and encourage the use of alternative power sources. Similarly, Durodola et al. [12] emphasised that improving access to sustainable energy technologies is essential for enhancing residential energy security and supporting long-term infrastructure development.

Overall, the household energy access profile establishes the contextual basis for understanding subsequent analyses on solar energy adoption and its implications for sustainable infrastructure development in the study area.

4.3. Level of Solar Energy Adoption

The level of solar energy adoption among households was assessed to determine the extent to which respondents have embraced solar technologies as part of their residential energy supply. The results are presented in Table 3.

The findings indicate varying levels of solar energy adoption across the study communities, with some households already utilising solar systems while others continue to depend primarily on conventional electricity sources and backup alternatives. This pattern suggests that although solar technology has gained acceptance, its adoption remains at a transitional stage rather than being widespread.

The presence of existing adopters nevertheless demonstrates increasing confidence in solar energy as a practical response to persistent electricity challenges. It also reflects the growing recognition of renewable energy as a viable means of improving household energy security and reducing dependence on unreliable grid supply.

These findings are broadly consistent with Haruna [24], who observed that the adoption of solar energy systems is gradually increasing in remote and underserved communities in Nigeria as households seek reliable alternatives to conventional electricity supply. They also align with Nkado and Nkado [25], whose study demonstrated the technical suitability of off-grid residential photovoltaic systems for improving household electricity access.

Overall, the observed level of adoption indicates positive progress towards renewable energy utilisation while highlighting the continued opportunity to expand solar deployment in off-grid residential communities.

4.4. Determinants of Solar Energy Adoption

Table 5 presents the composite mean scores, standard deviations, Relative Importance Index (RII), and rankings of the major determinants influencing household adoption of solar energy solutions in the off-grid residential communities of Maya and Adamo, Ikorodu, Lagos State.

The prominence of reliability recording the highest composite mean score of 4.118 (SD = 0.612) and an RII of 0.824 suggests that households in the study area place considerable importance on the ability of solar energy systems to provide stable and uninterrupted electricity, particularly in the face of persistent grid unreliability. The high ranking of perceived benefits with a mean score of 4.038 (SD = 0.615; RII = 0.808) further indicates that respondents recognise the economic, environmental, and social advantages associated with solar energy adoption, while the strong performance of awareness reflects a relatively good understanding of solar technology and its potential applications. Financing also plays a notable role, implying that access to financial support mechanisms remains important in facilitating household investment in solar systems. In contrast, the low affordability score recorded with the lowest mean score of 2.322 (SD = 0.713) and the lowest RII of 0.464 demonstrates that many respondents perceive the acquisition and maintenance of solar energy systems as financially challenging, thereby constituting a significant barrier to wider adoption.

These findings are generally consistent with previous studies on renewable energy adoption in developing countries. Azimoh et al. [18] reported that reliability and improved energy access are key motivations for the adoption of off-grid solar technologies in rural communities. Similarly, Babajide and Brito [19] observed that households are more inclined to adopt solar energy when they perceive substantial economic and service delivery benefits. The importance of awareness aligns with the findings of Audu and Adamu [10] and Anagbakwu [20], who identified knowledge and public understanding as critical drivers of renewable energy acceptance. Furthermore, the relatively low affordability score supports the observations of Pelizan et al. [9] and Barrie and Cruickshank [8], who argued that high capital costs remain one of the most significant constraints to household adoption of solar technologies despite growing recognition of their long-term benefits.

Overall, the results demonstrate that the decision to adopt solar energy solutions in the study area is shaped by a combination of technical, socio-economic, and perceptual factors. While households are motivated by the reliability and perceived advantages of solar energy systems, financial limitations continue to constrain adoption. These findings

directly address the first objective of the study by identifying and ranking the key determinants influencing individual adoption of solar energy solutions in off-grid residential communities in Ikorodu, Lagos State, and provide empirical evidence to inform interventions aimed at accelerating the transition towards sustainable energy infrastructure.

4.5. Challenges of Solar Energy Adoption

Table 6 presents the major challenges affecting household adoption of solar energy solutions in the study area based on the composite mean scores and Relative Importance Index (RII).

The results show that high installation cost is the most significant barrier to solar energy adoption, recording the highest mean score (4.360) and RII (0.872). Limited access to financing ranked second with a mean score of 4.235 (RII = 0.847), indicating that financial constraints remain a major obstacle to household investment in solar technologies. Other challenges, including lack of awareness, maintenance concerns, uncertainty about system reliability, and inadequate technical support, recorded relatively lower rankings but were still perceived as important barriers.

The dominance of cost-related challenges suggests that although households recognise the potential benefits of solar energy, high upfront investment costs and limited access to financing significantly constrain adoption. This observation is consistent with Haruna [24], who identified financial limitations and affordability concerns as important obstacles to the wider adoption of solar energy systems in remote and rural communities in Nigeria. Similarly, Chanchangi et al. [7] observed that inadequate financing mechanisms continue to hinder the expansion of solar energy technologies across sub-Saharan Africa. Babalola et al. [14] also emphasised that economic constraints remain critical barriers to sustainable energy deployment, while Monyei et al. [2] highlighted the influence of institutional and market-related limitations on renewable energy adoption.

These findings reinforce the first objective of the study by demonstrating that the principal barriers to solar energy adoption in off-grid residential communities are predominantly financial rather than technical. Addressing installation costs and improving access to affordable financing schemes could substantially increase household adoption and accelerate the transition towards sustainable energy infrastructure in the study area.

4.6. Sustainable Infrastructure Development

The perceived contribution of solar energy adoption to sustainable infrastructure development was assessed using five indicators: improved living standards, enhanced productivity, improved infrastructure quality, community development, and resilience against electricity outages. The composite results are presented in Table 7.

The results indicate a high level of agreement among respondents that solar energy adoption contributes positively to sustainable infrastructure development in the study area. The composite mean score of 4.244 (SD = 0.511) suggests that households generally perceive solar energy systems as improving living standards, increasing productivity, enhancing the quality of residential infrastructure, promoting community development, and strengthening resilience against frequent electricity interruptions.

Table 6. Challenges of Solar Energy Adoption

Challenge	Mean	RII	Rank
High installation cost	4.36	0.872	1
Limited access to financing	4.235	0.847	2
Lack of awareness	3.645	0.729	3
Maintenance concerns	3.605	0.721	4
Uncertainty about system reliability	3.563	0.713	5
Lack of technical support	3.518	0.704	6

Table 7. Sustainable Infrastructure Development Indicators

Construct	Mean	Standard Deviation
Sustainable Infrastructure Development	4.244	0.511

Table 8. Reliability Statistics of the Study Constructs

Construct	Number of Items	Cronbach's Alpha	Interpretation
Awareness	3	0.581	Moderate
Affordability	3	0.905	Excellent
Financing	3	0.765	Good
Perceived Benefits	3	0.645	Acceptable
Reliability	3	0.687	Acceptable
Adoption Intention	3	0.696	Acceptable
Sustainable Infrastructure Development	5	0.717	Good

This finding implies that the benefits of solar energy adoption extend beyond the provision of electricity to broader socio-economic and infrastructure outcomes. Improved access to reliable power enables households to undertake productive activities, enhances comfort and quality of life, and reduces dependence on unstable grid supply and fossil-fuel-powered alternatives. Consequently, the adoption of solar energy has the potential to support more sustainable and resilient residential communities.

The findings are consistent with Nnaji et al. [1], who reported that renewable energy technologies can significantly improve socio-economic conditions and expand access to basic infrastructure in underserved communities. Likewise, Elusakin et al. [13] argued that decentralised renewable energy systems contribute to sustainable community development by improving energy security and supporting local development initiatives. Babalola et al. [14] also found that increased deployment of solar energy technologies enhances household welfare, promotes economic activities, and strengthens community resilience through improved access to reliable electricity.

These results directly address the second objective of the study by demonstrating that household adoption of solar energy solutions has positive implications for sustainable infrastructure development in off-grid residential communities in Ikorodu, Lagos State. The findings provide empirical support for policies and investments aimed at expanding solar energy deployment as a strategy for promoting sustainable urban and community development.

4.7. Reliability Assessment

The internal consistency of the study constructs was assessed using Cronbach's Alpha, and the results are presented in Table 8.

The reliability assessment indicates that the measurement instrument demonstrates satisfactory internal consistency across the principal study constructs. Overall, the Cronbach's Alpha coefficients suggest that the questionnaire items consistently measure their respective latent variables and are therefore suitable for subsequent statistical analyses.

Notably, the affordability construct exhibited particularly strong internal consistency, reflecting a high degree of agreement among the items used to measure respondents' perceptions of the cost-related aspects of solar energy adoption. The remaining constructs also demonstrated acceptable levels of reliability, indicating that the scales adequately captured the concepts of interest despite minor variations in their internal consistency.

Overall, the reliability results provide confidence in the quality of the measurement instrument and support the validity of the subsequent correlation and regression analyses undertaken in this study.

4.8. Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships among the principal constructs included in the study.

The results indicate several noteworthy relationships among the study variables. In particular, reliability exhibited the strongest positive correlation with Adoption Intention ($r = 0.694$), suggesting that respondents who perceive solar energy systems as dependable are more likely to express a willingness to adopt them. Perceived Benefits also demonstrated a moderate positive association with Adoption Intention ($r = 0.409$), indicating that favourable perceptions of the economic and social advantages of solar energy are associated with increased adoption intentions.

Furthermore, Adoption Intention showed a moderate positive correlation with Sustainable Infrastructure Development ($r = 0.538$), implying that stronger intentions to adopt solar energy are associated with more positive perceptions of improvements in infrastructure resilience, productivity, and living standards. By contrast, Affordability exhibited only a weak negative correlation with Adoption Intention ($r = –0.030$), indicating a limited linear association between the two variables within the study sample.

Table 9. Pearson Correlation Matrix of Study Constructs

Variable	AW	AF	FI	PB	RE	AI	SID
AW	1						
AF	0.059	1					
FI	0.503	0.198	1				
PB	0.273	0.037	0.113	1			
RE	0.139	0.012	0.084	0.341	1		
AI	-0.05	-0.03	0.137	0.409	0.694	1	
SID	-0.2	-0.07	-0.02	0.206	0.348	0.538	1

Note: AW = Awareness; AF = Affordability; FI = Financing; PB = Perceived Benefits; RE = Reliability; AI = Adoption Intention; SID = Sustainable Infrastructure Development.

Table 10. Regression Results

Variable	Coefficient (β)	R^2	p-value
Adoption Intention	0.458	0.289	< 0.001

Overall, the correlation analysis demonstrates meaningful associations among the principal constructs and provides preliminary evidence supporting the subsequent regression analysis used to examine the influence of adoption intention on sustainable infrastructure development.

4.9. Regression Analysis

To further examine the relationship between solar energy adoption and sustainable infrastructure development, a simple linear regression analysis was performed using Adoption Intention as the independent variable and Sustainable Infrastructure Development as the dependent variable. The results are presented in Table 10.

The regression results indicate that Adoption Intention has a positive and statistically significant association on Sustainable Infrastructure Development ($\beta = 0.458$, $p < 0.001$). The model explains approximately 28.9% of the variation in sustainable infrastructure development ($R^2 = 0.289$), suggesting that households with stronger intentions to adopt solar energy are more likely to perceive improvements in infrastructure resilience, productivity, and overall living conditions. While the explanatory power of the model is moderate, it also suggests that additional social, economic, institutional, and environmental factors not examined in this study may contribute to sustainable infrastructure development within the study area.

The positive association observed in this study supports the argument of Aliyu et al. [3] that wider deployment of renewable energy technologies can contribute meaningfully to sustainable development by improving energy access and supporting socio-economic progress. Prior to estimating the regression model, multicollinearity diagnostics were examined and all predictor variables recorded Variance Inflation Factor (VIF) values below the commonly accepted threshold of 5, indicating that multicollinearity was not a significant concern. Overall, the regression findings reinforce the study objective by demonstrating that increased household willingness to adopt solar energy is associated with more favourable perceptions of sustainable infrastructure development in the off-grid communities of Maya and Adamo, Ikorodu, Lagos State.

4.10. Implications for Construction and Infrastructure Management

The findings of this study have important implications for construction engineering, residential development, and infrastructure management in off-grid communities. The identification of reliability and perceived benefits as the strongest drivers of solar energy adoption, alongside high installation costs and financing constraints as the major barriers, indicates that sustainable energy planning should be integrated into residential infrastructure development rather than treated as a separate intervention.

For residential development, developers and housing providers should incorporate solar photovoltaic systems into project planning and design to improve energy security and reduce dependence on unreliable grid electricity. Early integration of renewable energy infrastructure can enhance the long-term functionality and resilience of housing developments.

For infrastructure planning, the positive relationship between adoption intention and sustainable infrastructure development suggests that decentralised energy systems should be considered an essential component of community infrastructure. Integrating renewable energy into planning frameworks can improve service delivery and strengthen the resilience of rapidly growing settlements.

The findings also have implications for community development and sustainable housing. Improved access to reliable solar energy can support household productivity, enhance living standards, and reduce reliance on costly alternative energy sources. Consequently, housing policies should promote renewable energy integration as part of broader sustainability objectives rather than as an optional feature.

Finally, the study supports the concept of energy-integrated settlements, where energy infrastructure is planned alongside residential and community facilities. Such an approach can contribute to more resilient neighbourhoods, improve infrastructure performance, and support the transition towards sustainable urban development in off-grid communities.

5. Conclusions

This study examined the determinants of household adoption of solar energy solutions and their implications for sustainable infrastructure development in the off-grid communities of Maya and Adamo, Ikorodu, Lagos State. The findings revealed that reliability, perceived benefits, and awareness are the principal factors influencing adoption, while high installation costs and limited access to financing remain the most significant barriers. The study also established that households generally perceive solar energy as contributing positively to improved living standards, productivity, infrastructure quality, community development, and resilience.

Furthermore, the regression analysis demonstrated a positive and statistically significant relationship between adoption intention and sustainable infrastructure development, indicating that greater willingness to adopt solar energy is associated with more favourable infrastructure outcomes. These findings highlight the potential importance of integrating renewable energy solutions into residential development and infrastructure planning as a strategy for enhancing energy security and supporting sustainable community development in off-grid settlements.

The study contributes to existing knowledge by providing empirical evidence on the determinants of household solar energy adoption within the context of off-grid residential communities in Ikorodu, Lagos State. Unlike many previous studies that examined affordability, financing, or awareness as separate determinants, this research integrates household

adoption determinants with sustainable infrastructure development outcomes and presents a ranked assessment of the key drivers and barriers to adoption using the Relative Importance Index. It further demonstrates a positive and statistically significant relationship between adoption intention and sustainable infrastructure development, thereby extending the understanding of the association between household renewable energy adoption and infrastructure resilience and community well-being.

Although this study provides valuable insights into the determinants of household solar energy adoption in the Maya and Adamo communities, its findings should be interpreted in light of certain limitations. The use of convenience sampling may introduce selection bias and limit the generalisability of the findings beyond the study area, as respondents were selected based on their availability and willingness to participate. In addition, the study was confined to two off-grid communities in Ikorodu, Lagos State, and employed a cross-sectional research design, which captures respondents' perceptions at a single point in time and does not account for changes in adoption behaviour over time. Consequently, the findings should be interpreted within the context of the study area and research design. Future research should consider probability-based sampling techniques, adopt longitudinal approaches where feasible, and include a wider range of communities to improve the representativeness and generalisability of the findings.

Based on these findings, it is recommended that government agencies introduce targeted financing mechanisms, including low-interest loans and subsidies, to reduce the financial burden associated with residential solar energy systems. Financial institutions and renewable energy providers should expand flexible payment models, such as pay-as-you-go schemes, to improve household access to solar technologies. Policymakers and infrastructure planners should integrate renewable energy systems into residential development policies and community infrastructure planning, particularly in underserved and off-grid areas. In addition, public awareness campaigns should be strengthened to improve understanding of the long-term economic and environmental benefits of solar energy adoption, while technical training programmes and local maintenance support services should be expanded to improve user confidence and ensure the long-term sustainability of installed solar energy systems.

REFERENCES

[1] C. E. Nnaji, C. C. Uzoma, and J. O. Chukwu, "The role of renewable energy resources in poverty alleviation and sustainable development in Nigeria," *Continental Journal of Social Sciences*, vol. 3, pp. 31–37, 2010.

[2] C. G. Monyei, A. O. Adewumia, M. O. Obolo, and B. Sajou, "Nigeria's energy poverty: Insights and implications for smart policies and framework towards a smart Nigeria electricity network," *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 1582–1601, 2018. https://doi.org/10.1016/j.rser.2017.05.237.

[3] A. S. Aliyu, A. T. Ramli, and M. A. Saleh, "Nigeria electricity crisis: Power generation capacity expansion and environmental ramifications," *Energy*, vol. 61, pp. 354–367, 2013. https://doi.org/10.1016/j.energy.2013.09.011.

[4] M. O. Oseni, "Analysis of the power sector performance in Nigeria," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 9, pp. 4765–4774, 2011. https://doi.org/10.1016/j.rser.2011.07.075.

[5] O. S. Ohunakin, M. S. Adaramola, O. M. Oyewola, and R. O. Fagbenle, "Solar energy applications and development in Nigeria: Drivers and barriers," *Renewable and Sustainable Energy Reviews*, vol. 32, pp. 294–301, 2014. https://doi.org/10.1016/j.rser.2014.01.014.

[6] C. O. Okoye, O. Taylan, and D. K. Baker, "Solar energy potentials in strategically located cities in Nigeria: Review, resource assessment and PV system design," *Renewable and Sustainable Energy Reviews*, vol. 55, pp. 550–566, 2016. https://doi.org/10.1016/j.rser.2015.10.154.

[7] Y. N. Chanchangi, F. Adu, A. Ghosh, S. Sundaram, and T. K. Mallick, "Nigeria's energy review: Focusing on solar energy potential and penetration," *Environment, Development and Sustainability*, vol. 25, pp. 5755–5796, 2023. https://doi.org/10.1007/s10668-022-02308-4.

[8] J. Barrie and H. J. Cruickshank, "Shedding light on the last mile: A study on the diffusion of pay-as-you-go solar home systems in Central East Africa," *Energy Policy*, vol. 107, pp. 425–436, 2017. https://doi.org/10.1016/j.enpol.2017.05.016.

[9] L. Pelizan, A. Rahnema Alavi, and L. Lickteig, *Solar Home Solutions Using a Pay-as-You-Go Model in Ghana: Exploring the Opportunity*, IESE Business School, OP-319-E, 2019. https://doi.org/10.15581/018.OP-319-E.

[10] [H. Audu and A. Adamu, "Expanding energy access in rural off-grid communities: A study on household adoption and affordability of solar home systems in Kwara State, Nigeria," *Journal of Global Economics and Business*, vol. 3, no. 11, pp. 182–197, 2022. https://doi.org/10.58934/jgeb.v3i11.166.

[11] S. Ali, P. Poulova, A. Akbar, H. M. U. Javed, and M. Danish, "Determining the influencing factors in the adoption of solar photovoltaic technology in Pakistan: A decomposed technology acceptance model approach," *Economies*, vol. 8, no. 4, p. 108, 2020. https://doi.org/10.3390/economies8040108.

[12] A. N. Durodola, J. B. Oyebade, and A. A. Lawal, "Awareness and perceived benefits of solar photovoltaic technology adoption in Nigeria: A review," *African Research Reports*, vol. 2, no. 4, pp. 419–433, 2026. https://doi.org/10.65221/0214.

[13] J. E. Elusakin, O. O. Ajide, and D. J. Chuks, "Challenges of sustaining off-grid power generation in Nigeria rural communities," *African Journal of Engineering Research*, vol. 2, no. 2, pp. 52–56, 2014. http://large.stanford.edu/courses/2017/ph240/akerele1/docs/elusakin.pdf.

[14] S. O. Babalola, M. O. Daramola, and S. A. Iwarere, "Socio-economic impacts of energy access through off-grid systems in rural communities: A case study of southwest Nigeria," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, vol. 380, no. 2221, 2022. https://doi.org/10.1098/rsta.2021.0140.

[15] A. Iwayemi, "Investment in electricity generation and transmission in Nigeria: Issues and options," *IAEE Energy Forum*, First Quarter, pp. 37–42, 2008. https://www.semanticscholar.org/paper/Investment-in-Electricity-Generation-and-in-Nigeria-Iwayemi/a42c3cc2e6b7341db6a4d8393b0592bd76140047.

[16] Y. S. Mohammed, M. W. Mustafa, N. Bashir, and I. S. Ibrahem, "Existing and recommended renewable and sustainable energy development in Nigeria based on autonomous energy and micro-grid technologies," *Renewable and Sustainable Energy Reviews*, vol. 75, pp. 820–838, 2017. https://doi.org/10.1016/j.rser.2016.11.062.

[17] M. Juanpera, L. Ferrer-Mart í R. Pastor, and J. Chiroque, "Planning and optimization of rural electrification systems: A decentralized renewable energy approach for underserved communities," *Renewable and Sustainable Energy Reviews*, vol. 133, 2020. https://doi.org/10.1016/j.rser.2020.110243.

[18] C. L. Azimoh, P. Klintenberg, F. Wallin, and B. Karlsson, "Illuminated but not electrified: An assessment of the impact of solar home system on rural households in South Africa," *Applied Energy*, vol. 155, pp. 354–364, 2015. https://doi.org/10.1016/j.apenergy.2015.05.120.

[19] A. Babajide and M. C. Brito, "Solar PV systems to eliminate or reduce the use of diesel generators at no additional cost: A case study of Lagos, Nigeria," *Renewable Energy*, vol. 172, pp. 209–218, 2021. https://doi.org/10.1016/j.renene.2021.02.088.

[20] O. J. Anagbakwu, "Impact of off-grid solar home systems on energy spending in Oyo State, Nigeria," *Green and Low-Carbon Economy*, 2025. https://doi.org/10.47852/bonviewGLCE52024242.

[21] E. M. Rogers, *Diffusion of Innovations*, 5th ed. New York: Free Press, 2003.

[22] W. G. Cochran, *Sampling Techniques*, 3rd ed. New York: John Wiley & Sons, 1977.

[23] Y. S. Mohammed, M. W. Mustafa, N. Bashir, and A. S. Mokhtar, "Renewable energy resources for distributed power generation in Nigeria: A review of the potential," *Renewable and Sustainable Energy Reviews*, vol. 22, pp. 257–268, 2013. https://doi.org/10.1016/j.rser.2013.01.020.

[24] M. M. Haruna, "Adoption of solar energy systems in remote and rural communities of Nigeria (A review)," *The International Journal of Science & Technoledge*, vol. 4, no. 1, pp. 23–28, 2023. https://www.researchgate.net/publication/374781804_Adoption_of_Solar_Energy_Systems_in_Remote_and_Rural_Communities_of_Nigeria_A_Review.

[25] F. Nkado and F. Nkado, "Design of an off-grid residential photovoltaic system," *International Journal of Engineering Research & Technology (IJERT)*, vol. 10, no. 9, pp. 733–738, 2021. https://www.ijert.org/design-of-an-off-grid-residential-photovoltaic-system.