EVALUATING THE SOCIOECONOMIC BENEFITS OF COMMUNITY-BASED GREEN ENERGY PROJECTS IN ZARIA METROPOLIS: IMPLICATIONS FOR SUSTAINABLE LIVELIHOODS FOR PUBLIC HEALTH EQUITY

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Abstract

This study evaluates the socioeconomic benefits of community-based green energy projects in Zaria Metropolis and their implications for sustainable livelihoods and public health equity. A correlational research design was adopted, targeting a population of 300 households across selected communities, from which 295 respondents were sampled using a stratified random technique. A structured questionnaire served as the main instrument, while data were analysed with descriptive statistics and Pearson Product-Moment Correlation. Findings revealed strong and significant positive relationships between green energy access ($r = 0.652$), socioeconomic participation and employment ($r = 0.490$), and infrastructure-driven health access ($r = 0.653$) with sustainable livelihoods, all at $p = 0.000$. These results confirm that community-based renewable energy projects enhance income generation, employment opportunities, and health service delivery. The study concludes that decentralised green energy promotes public health equity and sustainable development, recommending community engagement, policy support, vocational training, and strategic investment for maximum impact.

Keyword: Sustainable health equity, energy access, socioeconomic, Infrastructure- health access

Introduction

Globally, renewable energy deployment has shown significant socio-economic potential, especially in developed and emerging economies. Countries such as Germany, China, and Brazil have witnessed large-scale job creation, GDP growth, and improved environmental and health outcomes from transitioning to renewables (Okedele et al., 2024; Nazarov et al., 2024). IRENA (2017a) estimated that meeting global renewable targets under the Paris Agreement could yield a cumulative economic gain of USD 19 trillion by 2050, driven by strong policy frameworks, reliable infrastructure, and investments in energy efficiency and innovation. By contrast, many developing nations, particularly in sub-Saharan Africa, face barriers in realising similar outcomes (Agoundedemba et al., 2023; Zickafoose et al., 2024). In Zaria Metropolis, Nigeria, community-based renewable energy projects such as solar mini-grids and biogas systems are often underfunded and underutilised (Isma'il, 2016). While these initiatives could transform livelihoods, health, and education, weak infrastructure, low community participation, and limited fiscal incentives hinder progress. Unlike in high-income countries, renewable energy in Nigeria often substitutes unreliable grid electricity rather than driving economic diversification and job creation. Organizations like Renewables in Africa (RiA) illustrate how targeted renewable projects in Kenya and Nigeria improved household incomes and women's entrepreneurship through rural solar mini-grids (RiA, 2025). However, the scale and institutional support differ widely from Western contexts. Romero-Lankao et al. (2023) stress that renewable adoption requires not only technology but also equity, participation, and trust. Their findings show that inclusive, community-driven planning—common in Western transitions is often missing in Nigerian projects, which are largely top-down and donor-driven. Thus, while evidence confirms renewable energy's socio-economic benefits, achieving them in Zaria requires localised engagement, policy alignment, and community capacity building.

Sustainable livelihoods and public health equity refer to the long-term ability of individuals and communities to generate income, access essential services, and secure equitable health outcomes regardless of location or status. Chambers and Conway (1992) defined livelihoods as the capabilities, assets, and activities needed to sustain living while recovering from shocks. Later interpretations emphasised systems-thinking, considering dynamic interactions among economic, social, and ecological components that enable or constrain resilience (Serrat, 2017). Contemporary approaches also integrate participatory and rights-based perspectives, aligning with global sustainability and equity agendas. In Zaria, this includes reliable energy for income-generating activities, access to clean water, and health facilities powered by renewables. Public health equity focuses on fair distribution of health resources, reducing disparities linked to geography or wealth (Braveman et al., 2011). Together, these dimensions form a lens for assessing community well-being in both economic opportunity and health fairness. This study argues that green energy, if implemented through inclusive community-based models, can strengthen energy access, socioeconomic participation, and health infrastructure.

Community-based green energy access involves localised deployment and socially embedded management of systems such as solar mini-grids, solar-powered boreholes, and electrified health centres, tailored to underserved populations. Unlike

centralised utility models, these solutions are user-focused, affordable, and participatory (Adamu et al., 2020). In Zaria, where public power supply is unreliable, they are essential. Pearce (2020) notes that such systems stimulate local economies, reduce dependence on harmful fuels, and enhance resilience through community ownership. Examples from Toto and Petti demonstrate how integrating mini-grids with productive use of energy (PUE) activities improves rural mobility and economic outcomes (Golden et al., 2023). The IEA (2021) estimates that mini-grids may account for up to 40% of future electrification in sub-Saharan Africa. Initiatives by AECF and ENEA Consulting (2022) emphasise public-private partnerships, innovative financing, and enabling policies to sustain mini-grids. Beyond infrastructure, these systems foster inclusive development, gender empowerment, and decentralised governance. Socioeconomic participation and employment refer to opportunities for households to engage in income generation, vocational training, or jobs linked to renewable energy. As the sector grows, it demands technical and entrepreneurial skills, creating roles for technicians, installers, and entrepreneurs. In Nigeria, green energy projects have stimulated informal cooperatives and women-led enterprises in solar boreholes and clean cookstoves (Ikwuoma et al., 2024). These boost incomes while encouraging gender-inclusive participation.

Oyedepo and Babalola (2016) argue that decentralised renewable systems in rural areas reduce energy poverty, lower youth unemployment, and foster community stability. Capacity-building initiatives further enhance long-term resilience, reinforcing household investments in health and education. Thus, socioeconomic integration of renewables transforms livelihoods while promoting equity. Infrastructure-driven health **access** highlights how renewable energy enables continuous operation of healthcare systems, including vaccine cold chains, delivery room lighting, sterilisation, and digital platforms. Akorede et al. (2022) and Isma'il (2016) showed that solar-powered clinics improved maternal health outcomes in peri-urban Nigeria by ensuring lighting and refrigeration. In Zaria, many clinics use solar systems for electricity and water supply, reducing disease spread and easing burdens on women and children (Alfa & Ahmadu, 2021). Maccido (2014) emphasised that health underpins productivity, reinforcing the need for resilient systems. Supporting healthcare professionals with sustainable energy magnifies their community impact. Globally, solar energy is increasingly deployed for health services. Soto et al. (2024) found that solar infrastructure in developing nations addresses operational and economic barriers while improving care delivery. However, challenges such as limited technical expertise remain. International collaborations like UNICEF's Solar for Health, active in over 80 countries, demonstrate how partnerships can scale solutions (Sharma et al., 2024). While Nigeria often relies on community or NGO initiatives, global platforms can institutionalise solar health programs. From vaccine storage to safe deliveries, solar systems improve efficiency, equity, and reliability in healthcare.

Together, community-based energy access, socioeconomic participation, and infrastructure-driven health access interact to strengthen livelihoods and reduce disparities. Energy access provides foundational services; employment ensures economic empowerment; and health infrastructure delivers equitable well-being. Empowered communities managing renewable energy systems become more resilient, inclusive, and sustainable (UNDP, 2021). This study contributes to debates on energy justice and climate-resilient health systems by examining how decentralised renewable energy intersects with health and economic well-being in Zaria Metropolis.

Statement of the Problem

Zaria Metropolis, once known for its vibrant agricultural economy, educational institutions, and artisan livelihoods, thrived on a balanced ecosystem supported by stable environmental conditions and modest but functional infrastructure. Communities relied on traditional energy sources and limited grid electricity to sustain households, businesses, and public services like health and education. This fragile balance enabled predictable livelihoods, low energy dependency, and shared access to services. Over the past two decades, however, Zaria has faced severe environmental and infrastructural decline. Rapid urbanisation, population growth, and unreliable electricity have strained energy and health systems. Many households now depend on diesel generators and wood fuels, worsening pollution and health risks. Healthcare centres struggle with erratic power, undermining vaccine storage, emergency services, and general care. At the same time, lack of energy access and technological empowerment has deepened unemployment and inequality, particularly for women, youth, and rural dwellers. Despite Zaria's vast solar potential, community-based renewable energy initiatives remain limited. Projects such as solar mini-grids and biogas systems are underfunded, poorly integrated into local development, and hindered by weak socioeconomic participation, minimal employment links to green sectors, and inadequate energy infrastructure for health services. Consequently, the transformative potential of green energy for livelihoods and health equity remains untapped. This study addresses these overlapping challenges by examining how renewable energy initiatives can promote sustainable livelihoods and public health equity. It emphasises the need for inclusive, climate-resilient strategies that extend beyond power provision to empower communities economically, improve health outcomes, and provide replicable models for Northern Nigeria and beyond.

Research Questions

The study is guided by the following research questions:

i. What is the relationship between Community-based green energy access on sustainable livelihoods and public health equity in Zaria Metropolis?
ii. What is the relationship between socioeconomic participation and employment, sustainable livelihoods, and public health equity in Zaria Metropolis?
iii. What is the relationship between Infrastructure-driven health access and sustainable livelihoods and public health equity in Zaria Metropolis?

Objectives of the Study

The main objective of this study is to evaluate the Socioeconomic Benefits of Community-Based Green Energy Projects in Zaria Metropolis: Implications for Sustainable Livelihoods and Public Health Equity. While **t**he specific objectives are:

i. To examine the relationship between Community-based green energy access and sustainable livelihoods and public health equity in Zaria Metropolis.
ii. To investigate the relationship between socioeconomic participation and employment and sustainable livelihoods, and public health equity in Zaria Metropolis.
iii. To determine the relationship between Infrastructure-driven health access and sustainable livelihoods and public health equity in Zaria Metropolis.

Research Hypotheses

The following null hypotheses were formulated to guide the study:

i. There is no significant relationship between Community-based green energy access and sustainable livelihoods and public health equity in Zaria Metropolis.
ii. There is no significant relationship between socioeconomic participation and employment and sustainable livelihoods, and public health equity in Zaria Metropolis.
iii. There is no significant relationship between Infrastructure-driven health access and sustainable livelihoods and public health equity in Zaria Metropolis.

Methodology

This study adopted a descriptive survey research design to examine the socioeconomic benefits of community-based green energy projects in Zaria Metropolis and their implications for sustainable livelihoods and public health equity. The design enabled the collection of quantitative data on community access to green energy, participation in renewable energy-related activities, and access to health-supporting infrastructure powered by renewables. The target population comprised 300 households and stakeholders, including household heads, small business owners, health workers, and energy beneficiaries across wards where solar mini-grids, solar-powered boreholes, and health facility electrification had been implemented or proposed. A multi-stage stratified random sampling technique was employed to ensure fair representation across zones. From each of the 10 stratified wards, 30 respondents were randomly selected, giving a total of 300 participants. Of the questionnaires administered, 294 were properly filled out and returned, yielding a 98% response rate. The main instrument was a researcher-designed questionnaire titled *Evaluating the Socioeconomic Impact of Community-Based Renewable Energy Projects on Livelihoods and Health Equity in Zaria Metropolis*. It consisted of four sections—Green Energy Access, Socioeconomic Participation and Employment, Infrastructure-Driven Health Access, and Sustainable Livelihoods and Health Equity—each with five items measured on a 4-point Likert scale. Validity was ensured through expert review by professionals in Environmental Economics, Public Health, and Renewable Energy Policy from the Federal University of Education, Zaria. A pilot test with 30 respondents outside the sample frame produced a Cronbach's Alpha reliability coefficient of 0.872, confirming strong internal consistency. Ethical compliance was observed through consultations with community leaders, informed consent, and respondent anonymity, with a research assistant supporting completion where necessary. Data were analysed using descriptive and inferential statistics: frequencies and percentages for demographics, means and standard deviations for research questions, and Pearson's correlation to test hypotheses at the 0.05 significance level.

Results

Research Question One

Table 1: What is the relationship between Community-based green energy access on sustainable livelihoods and public health equity in Zaria Metropolis?

Items	Strongly Disagree	Disagree	Agree	Strongly Agree
My community has access to at least one form of green energy (e.g., solar).	33.9% 100	27.1% 80	16.9% 50	22.0% 65
Green energy systems (solar mini-grids, boreholes) meet our local needs.	16.9% 50	13.6% 40	35.6% 105	33.9% 100
I was involved in decision-making on renewable energy projects.	23.7% 70	30.5% 90	32.2% 95	13.6% 40
The community energy system is affordable and user-friendly.	30.5% 90	20.3% 60	25.4% 75	23.7% 70
Green energy access has reduced our dependence on generators.	16.9% 50	20.3% 60	32.2% 95	30.5% 90

Field survey 2025

Table 1 results represent the views of respondents on the relationship between community-based green energy access and sustainable livelihoods and public health equity in Zaria Metropolis. On the first item, 33.9% (100) of respondents strongly disagreed and 27.1% (80) disagreed that their communities had access to at least one form of green energy, while 16.9% (50) agreed and 22.0% (65) strongly agreed, indicating that although some communities benefit, access is still uneven. Building on this, responses to the second item show a more positive trend, as 35.6% (105) agreed and 33.9% (100) strongly agreed that green energy systems such as solar mini-grids and boreholes meet their local needs, compared to 16.9% (50) who strongly disagreed and 13.6% (40) who disagreed, suggesting these systems have a tangible impact on livelihoods. However, when asked about involvement in decision-making, 23.7% (70) strongly disagreed and 30.5% (90) disagreed, while 32.2% (95) agreed and only 13.6% (40) strongly agreed, showing limited participation of community members in project planning. In terms of affordability and usability, 30.5% (90) strongly disagreed and 20.3% (60) disagreed that the energy systems are affordable and user-friendly, while 25.4% (75) agreed and 23.7% (70) strongly agreed, reflecting mixed experiences across

households. Finally, responses to the fifth item revealed that 32.2% (95) agreed and 30.5% (90) strongly agreed that green energy access has reduced their dependence on generators, whereas 16.9% (50) strongly disagreed and 20.3% (60) disagreed, emphasising noticeable though not universal improvements. The results demonstrate that community-based green energy initiatives in Zaria Metropolis positively contribute to sustainable livelihoods and public health equity, particularly through meeting local needs and reducing reliance on generators; however, challenges of equitable access, affordability, and community involvement in decision-making remain critical areas requiring policy and implementation attention.

Research Question Two

Table 2: What is the relationship between socioeconomic participation and employment, and sustainable livelihoods and public health equity in Zaria Metropolis?

Items	Strongly Disagree	Disagree	Agree	Strongly Agree
Green energy projects have created job opportunities in my community.	50 16.9%	70 23.7%	80 27.1%	95 32.2%
I or someone I know is earning income through solar energy-related work.	70 23.7%	95 32.2%	75 25.4%	55 18.6%
Access to green energy has enhanced my ability to run a business.	60 20.3%	70 23.7%	85 28.8%	80 27.1%
Youth and women are involved in green energy jobs in this area.	50 16.9%	55 18.6%	90 30.5%	100 33.9%
Skills training related to renewable energy is available in my area.	45 15.0%	65 21.7%	85 28.3%	105 35.0%

Field survey 2025

Table 2 results represent respondents' views on the relationship between socio-economic participation, employment, and sustainable livelihoods and public health equity in Zaria Metropolis. On the first item, 16.9% (50) strongly disagreed and 23.7% (70) disagreed that green energy projects had created job opportunities, while 27.1% (80) agreed and 32.2% (95) strongly agreed, suggesting that such projects are already providing noticeable employment opportunities in some communities. Item two shows weaker outcomes in direct income generation, as 23.7% (70) strongly disagreed and 32.2% (95) disagreed that they or someone they knew earned income through solar-related work, compared with 25.4% (75) who agreed and only 18.6% (55) who strongly agreed, pointing to limited but emerging economic benefits. Furthermore, on whether green energy access has enhanced respondents' ability to run a business, 20.3% (60) strongly disagreed and 23.7% (70) disagreed, while 28.8% (85) agreed and 27.1% (80) strongly agreed, reflecting that access contributes to business operations, though benefits are not evenly spread. Turning to inclusiveness, 16.9% (50) strongly disagreed and 18.6% (55) disagreed that youth and women were involved in green energy jobs, whereas 30.5% (90) agreed and 33.9% (100) strongly agreed, indicating growing but not universal participation of marginalised groups. Finally, skills training availability showed more positive responses, with 28.3% (85) agreeing and 35.0% (105) strongly agreeing, compared with 15.0% (45) strongly disagreeing and 21.7% (65) disagreeing, highlighting expanding but still uneven training opportunities. Green energy projects in Zaria Metropolis are generating employment, supporting business growth, and increasingly involving youth and women, gaps remain in income generation and equitable access to skills training. Strengthening training programs and broadening participation could enhance the long-term contribution of green energy to sustainable livelihoods and public health equity.

Research Question Three

Table 3: What is the relationship between Infrastructure-driven health access and sustainable livelihoods and public health equity in Zaria Metropolis?

Items	Strongly Disagree	Disagree	Agree	Strongly Agree
Solar power is used in our local health centre or clinic..	95 32.2%	100 33.9%	35 11.9%	65 22.0%
Healthcare delivery has improved due to a consistent power supply.	55 18.6%	40 13.3%	90 30.5%	110 37.3%
There is solar-powered water or sanitation infrastructure in use.	100 33.9%	90 30.5%	45 15.3%	60 20.3%
Health workers can now store vaccines reliably due to solar power.	90 30.5%	105 35.6%	20 6.8%	80 27.1%
Access to renewable-powered health services has reduced travel time.	70 23.5%	95 32.2%	80 27.1%	50 16.9%

Field survey 2025

Table 3 results represent respondents' perceptions of the relationship between infrastructure-driven health access and sustainable livelihoods and public health equity in Zaria Metropolis. On the first item, 32.2% (95) strongly disagreed and 33.9% (100) disagreed that solar power is used in their local health centres or clinics, while only 11.9% (35) agreed and 22.0% (65) strongly agreed, indicating that solar power adoption in healthcare facilities is still limited across the metropolis. Item two, 18.6% (55) strongly disagreed and 13.6% (40) disagreed that healthcare delivery had improved due to consistent power supply, whereas 30.5% (90) agreed and 37.3% (110) strongly agreed, reflecting that in locations where solar power is operational, healthcare delivery has indeed improved, item three reveal that 33.9% (100) strongly disagreed and 30.5% (90) disagreed that solar-powered water or sanitation infrastructure is in use, while 15.3% (45) agreed and 20.3% (60) strongly

agreed, suggesting a shortage of renewable-powered sanitation facilities in many communities. Similarly, 30.5% (90) strongly disagreed and 35.6% (105) disagreed that health workers could now store vaccines reliably due to solar power, with only 6.8% (20) agreeing and 27.1% (80) strongly agreeing, indicating inconsistent access to reliable solar-powered cold chain facilities. Finally, on the fifth item, 23.7% (70) strongly disagreed and 32.2% (95) disagreed that renewable-powered health services reduced travel time, compared with 27.1% (80) agreeing and 16.9% (50) strongly agreeing, reflecting uneven distribution of such services across communities. The findings highlight that while renewable energy infrastructure has improved healthcare delivery in some areas of Zaria Metropolis, its adoption in clinics, sanitation systems, and vaccine storage remains inconsistent, thereby limiting its full potential to reduce travel time and advance public health equity. Strengthening investment and expanding equitable deployment of solar-powered health infrastructure could significantly enhance sustainable livelihoods and health outcomes.

Hypotheses Testing

Hypothesis One

H_{01}: There is no significant relationship between Community-based green energy access and sustainable livelihoods for public health equity in Zaria Metropolis.

Table 4*:* Descriptive analysis and Pearson Correlation between Green Energy Access and Sustainable Livelihoods

Variables	N	Mean	SD	r	p-value	Remark
Green Energy Access	295	2.86	1.65			
				.652	0.000	Significant
Sustainable Livelihoods	295	2.44	1.02			

Table 4 results represent the relationship between community-based green energy access and sustainable livelihoods for public health equity in Zaria Metropolis. The mean scores for green energy access (M = 2.86, SD = 1.65) and sustainable livelihoods (M = 2.44, SD = 1.02) indicate moderate levels of both variables among respondents. The Pearson correlation coefficient (r = .652, p = 0.000) shows a strong, positive, and statistically significant relationship between the two variables at the 0.05 level. This implies that improved community-based access to green energy significantly enhances sustainable livelihoods and supports public health equity in Zaria Metropolis. Thus, the null hypothesis is rejected.

Hypothesis Two

There is no significant relationship between socioeconomic participation and employment for sustainable livelihoods for public health equity in Zaria Metropolis.

Table 5: Descriptive analysis and Pearson Correlation between Socio-economic participation and employment and sustainable livelihoods for public health equity in Zaria Metropolis.

Variables	N	Mean	SD	r	p-value	Remark
Socio-Economic Participation	294	3.0475	1.46			
				.490	0.00	Significant
Sustainable Livelihoods	294	2.44	1.02			

Table 5 results represent the relationship between socio-economic participation and employment and sustainable livelihoods for public health equity in Zaria Metropolis. The mean score for socio-economic participation (M = 3.05, SD = 1.46) indicates a relatively high level of involvement, while sustainable livelihoods recorded a moderate mean (M = 2.44, SD = 1.02). The Pearson correlation coefficient (r = .490, p = 0.00) reveals a moderate, positive, and statistically significant relationship between the two variables at the 0.05 level. This suggests that increased socio-economic participation and employment through green energy initiatives contribute meaningfully to sustainable livelihoods and public health equity. Therefore, the null hypothesis is rejected.

Hypothesis three

There is no significant relationship between Infrastructure-driven health access and sustainable livelihoods for public health equity in Zaria Metropolis.

Table 6*:* Descriptive analysis and Pearson Correlation between Infrastructure-driven health access and sustainable livelihoods for public health equity in Zaria Metropolis.

Variables	N	Mean	SD	r	p-value	Remark
Infrastructure-driven health access	295	3.7581	1.216			
				.653	0.000	Significant
Sustainable Livelihoods	295	3.76	1.23			

Table 6 results represent the relationship between infrastructure-driven health access and sustainable livelihoods for public health equity in Zaria Metropolis. The mean score for infrastructure-driven health access (M = 3.76, SD = 1.22) and sustainable livelihoods (M = 3.76, SD = 1.23) both reflect a high level of agreement among respondents on the positive impact of renewable-powered health services. The Pearson correlation coefficient (r = .653, p = 0.000) shows a strong, positive, and statistically significant relationship between the two variables at the 0.05 level. This indicates that improved renewable-powered health infrastructure enhances sustainable livelihoods and health equity. Thus, the null hypothesis is rejected.

Discussion

The findings from the three hypotheses collectively underscore the critical role of community-based renewable energy systems in enhancing sustainable livelihoods and promoting public health equity in Zaria Metropolis. The first hypothesis revealed a strong and statistically significant positive relationship between green energy access and sustainable livelihoods (**r =** 0.652, p = 0.000, df = 294), supporting the view that decentralised energy systems such as solar mini-grids and boreholes empower communities economically and socially (Adamu et al., 2020; Pearce, 2020). The second hypothesis confirmed a moderate but significant correlation between socioeconomic participation and employment and sustainable livelihoods (r = 0.490, p = 0.000, df = 245), aligning with research showing that renewable energy projects facilitate local job creation, entrepreneurship, and vocational training, especially among marginalised groups (Ikwuoma et al., 2024; Oyedepo & Babalola, 2016). The third hypothesis showed the strongest relationship, with a significant correlation between infrastructure-driven health access and sustainable livelihoods (r = 0.653, p = 0.000, df = 294), affirming the role of solar-powered healthcare infrastructure in improving health service delivery, reducing health disparities, and strengthening the resilience of public health systems (Alfa & Ahmadu, 2021; Sharma et al., 2024). Together, these findings validate the central argument that renewable energy, when implemented through inclusive, community-driven models, can significantly transform livelihoods and health outcomes (Romero-Lankao et al., 2023; UNDP, 2021). Remarkably, the consistent statistical significance across all three relationships demonstrates that community-based renewable energy access is not only an environmental imperative but also a foundational driver of socioeconomic empowerment and health equity in developing urban centres like Zaria.

Conclusion

This study demonstrates that community-based renewable energy systems significantly contribute to sustainable livelihoods and public health equity in Zaria Metropolis. Strong positive correlations were observed between green energy access (r = 0.652), socioeconomic participation (r = 0.490), and infrastructure-driven health access (r = 0.653) with sustainable livelihood outcomes, all at a high level of statistical significance (p = 0.000). These results confirm that decentralised renewable energy systems support income generation, improve healthcare access, and reduce social disparities. The findings align with global research highlighting the transformative power of renewables when guided by inclusive, locally driven models (Pearce, 2020; Sharma et al., 2024). Moreover, the evidence reinforces the importance of linking energy interventions with livelihood and health goals to maximise impact in low-resource urban settings. Thus, community-centred renewable energy initiatives should be prioritised as a strategic tool for achieving equitable and sustainable development in Nigeria.

Recommendations

1. Policymakers and stakeholders should promote participatory planning in energy projects to align technologies with local needs and ensure ownership and sustainability.
2. Programs should integrate skill development to increase local capacity in installing, maintaining, and managing renewable systems, especially for youth and women.
3. Solar technologies should be prioritised for primary health centres to ensure continuous service delivery, particularly in off-grid areas.
4. Governments and development partners should establish innovative funding mechanisms, such as public-private partnerships, to scale community-based energy.
5. National and local policies must be harmonised to support decentralised energy deployment through incentives, subsidies, and regulatory frameworks (UNDP, 2021).
6. Regular assessments should be conducted to track the socioeconomic and health outcomes of renewable projects and inform evidence-based adjustments.

References

Adamu, A., Audu, I. A., Danjaji, A. S., Gadanya, H. S., & Garba, N. (2020). Green infrastructure from economic, social, and environmental perspectives: A tool for achieving sustainable cities in Nigeria. *Sokoto Journal of Geography and the Environment, 2*, 34–46.

Africa Enterprise Challenge Fund (AECF) & ENEA Consulting. (2022). *Lessons from AECF's project portfolio: Scaling up mini-grids through public-private models in Africa*. https://www.aecfafrica.org/reports/scaling-mini-grids

Agoundedemba, M., Kim, C. K., & Kim, H.-G. (2023). Energy status in Africa: Challenges, progress, and sustainable pathways. *Energies, 16*(23), 7708.

Akorede S. N., Muhammed, A. S., Isiaq, A. T., & Akorede, A. A. (2022). Impact and prospects of maternal health care services on maternal health in Zaria Local Government of Kaduna State. *International Journal of Advanced Research in Multidisciplinary Studies, 2*(1), 60-66. https://alhikmahuniversity.edu.ng/IJARMS/index.php/journal/article/view/15/15

Alfa, H. H., & Ahmadu, M. A. (2021). Analysis of healthcare facilities in Zaria Local Government Area, Kaduna, Nigeria. *Journal of Research in Environmental and Earth Sciences, 7*(8), 15–23.

Braveman, P., Arkin, E., Orleans, T., Proctor, D., & Plough, A. (2011). What is health equity? And what difference does a definition make? Robert Wood Johnson Foundation.

Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: Practical concepts for the 21st century* (IDS Discussion Paper No. 296). Institute of Development Studies.

Golden, J., Huang, S. Y., Katz, J., Malloy, D., Mukasheva, A., Noel, S., Rashidi, R. A., Ubbiyev, N., & Wang, J. (2023). *Integrating e-mobility with mini grids in rural Nigeria: A SIPA Capstone Project*. Columbia University School of International and Public Affairs (SIPA) & Rural Electrification Agency (REA).

Ikwuoma, S. U., Amaechi, V. U., Njoku, C. S., & Olemeforo, E. I. (2024). Sustainable energy solutions: Opportunities and challenges in Nigeria. *International Journal of Scientific Engineering and Science, 8*(11), 59–65. http://ijses.com/

International Energy Agency. (2021). *Scaling-up mini-grids for rural electrification: Global report*. https://www.iea.org/reports/mini-grids-for-universal-energy-access

International Renewable Energy Agency (IRENA). (2017a). *Renewable energy benefits: Measuring the economics*. https://www.irena.org/publications

Isma'il, M. (2016). Spatial mapping of renewable energy potentials in Zaria, Kaduna State, Nigeria. *Savanna*, *23*(1), 1–10.

Maccido, M. N. (2014). Strengthening the standard of physical and health teachers' education in Nigeria: The way forward. *Journal of Education Research and Development, 8*(2), 2014.

Nazarov, A., Sulimin, V., & Shvedov, V. (2024). Renewable energy sources: Global implementation experience. *E3S Web of Conferences, 474*, Article 01030. https://doi.org/10.1051/e3sconf/202447401030

Okedele, P. O., Aziza, O. R., Oduro, P., & Ishola, A. O. (2024). Renewable energy policies and global socioeconomic impacts: A comparative study of policy implementation and outcomes. *IRE Journals*, *8*(6), 1706653.

Oyedepo, S. O., & Babalola, P. O. (2016). *Renewable energy technologies in Nigeria: Challenges and opportunities for sustainable development*. Retrieved from https://www.researchgate.net/publication/316216084

Pearce, J. (2020). Decentralised renewable hybrid mini-grids for rural communities: Culmination of the IREP framework and scale up to urban communities. *Sustainability, 12*(18), 7411. https://doi.org/10.3390/su12187411.

Renewables in Africa (RiA). (2025, May 23). *Empowering communities: The socioeconomic impact of renewable energy projects in Africa*. https://www.linkedin.com/pulse/empowering-communities-socioeconomic-impact-renewable-energy-ria

Romero-Lankao, P., Rosner, N., Efroymson, R. A., Parisch, E. S., Blanco, L., Smolinski, S., & Kline, K. (2023). *Community e-ngagement and equity in renewable energy projects: A literature review* (NREL/TP-5400-87113). National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy23osti/87113.pdf

Serrat, O. (2017). *The sustainable livelihoods approach*. In *Knowledge solutions* (pp. 21–26). Springer. https://doi.org/10.1007/978-981-10-0983-9_5 (Licensed under CC BY-NC 3.0)

Sharma, L., Singh, J., Dhiman, R., Vargas Nunez, D. R., Ba, A. E., Joshi, K. J., Modi, B., Padhi, A., Tandon, J. K., & Seidel, M. (2024). *Advancing solar energy for primary healthcare in developing nations: Addressing current challenges and enabling progress through UNICEF and collaborative partnerships*. Cureus, 16(1), e51571. https://doi.org/10.7759/cureus.51571

Soto, E. A., Hernandez-Guzman, A., Vizcarrondo-Ortega, A., McNealey, A., & Bosman, L. B. (2024). *Solar energy implementation for health-care facilities in developing and underdeveloped countries: Overview, opportunities, and challenges*. Cureus, 16(1), e51571. https://doi.org/10.7759/cureus.51571

Zickafoose, A., Ilesanmi, O., Diaz-Manrique, M., & Adeyemi, A. E., Walumbe, B., Strong, R., Wingenbach, G., Rodriguez, M. T., & Dooley, K. (2024). Barriers and challenges affecting quality education Sustainable Development Goals in Sub-Saharan Africa by 2030. *Sustainability, 16*(7), Article 2657. https://doi.org/10.3390/su16072657.