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Rural Energy Conditions in Oyo State: Present and Future Perspectives on the Untapped Resources

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ABSTRACT

Over 60% of the Nigerian population still resides within rural spaces. These rural spaces are zones of isolation with a high electricity and energy demand for enhanced livelihoods and settlement liveability. Despite the demand for electricity in these rural areas, they still remains under-serviced as far as accessibility to a stable electricity supply is concerned. Likewise, connection historically to the conventional electricity grid in many rural areas remains a mirage. With rural energy resource potentials remaining untapped, this study made use of both qualitative and qualitative data gathered across 472 rural households in 9 randomly selected rural local government areas (LGAs) to provide a narrative around rural household energy experiences. The study brings to light the abundance of un-utilized renewable resources that could be exploited towards providing electricity for rural households. Several limitations identified include weak political will, a limited profit-orientation of electricity by investors and limited energy choice information to households.

Keywords: Rural Households, Rural Spaces, Electricity, Demand-supply, Renewable-energy, Resources
JEL Classifications: O18, Q42, Q43

1. INTRODUCTION

The relevance of electricity to the development of settlements cannot be over-emphasized. Bhattacharyya (2006) reported a positive relationship between access to electricity, production and the development of small and medium scale enterprise. The relevance of electricity to the livelihoods of citizens has also been reiterated by Kyriakopoulos and Arabatzis (2016). With the undoubted relevance of communal access to electricity, pressure on conventional energy electricity sources continues to increase, resulting in over a billion people in the global population lacking access to electricity (Ulsrud et al., 2015).

Notwithstanding the importance of electricity energy, over 50% of Nigerian communities can be classified to be in darkness owing to a lack of electricity, many of whom are within the rural areas (Aliyu et al., 2015; Bashir and Modu, 2018). While many urban communities are experiencing sporadic power supply (Adeyemi et al., 2017), rural Nigeria is characterized by a lack of electricity infrastructure and connection to the grid (Olatomiwa et al., 2015). Within the Nigerian state, an urban and rural dichotomy exists in the level of service delivery. Infrastructure investments continue to be focused within the urban areas, with rural areas remaining under-serviced. Yet, the paradox of population composition shows that rural Nigeria occupies over 60% of the country's population. The spatial arrangement of rural communities, limited secondary activities and poor financial livelihood conditions continue to limit the possibility of electricity distribution from conventional sources (Bashir and Modu, 2018). Several studies (Sambo et al., 2010; Kumar and Manoharan, 2014; Olatomiwa et al., 2015; Sunderland et al., 2016) have reported the cost of logistics, cost of transmission and distribution, rural weak technological capacity, investor's profit orientation, poor political will and instability and inadequate capital investments in infrastructure as some of

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the limiting factors to rural electricity provision or connection to the conventional grid.

Ibidapo-Obe and Ajibola (2011) and Olatomiwa et al. (2015) state that rural Nigeria mainly depends on the use of fuel wood or self-powered generating sources such as the use of generators to access electricity for household use. Expanding on the roles of electricity accessibility to rural development, Riva et al. (2018) argue that with effective energy policy formulation, planning and implementation for rural areas, the improvement in rural capacity cannot be denied. They argue that the socio-economic conditions and rural households' financial strength and limited livelihood opportunities can be traced to the lack of and limited access to electricity.

The guiding questions to this research are: What is the electricity or energy experience of rural dwellers in Oyo state: And are there hopes of making use of rural renewable energy resources towards improving rural electricity access? Like all rural spaces which are poorly serviced (Gbadamosi and Olorunfemi, 2016; Brinkerhoff et al., 2016), rural households in Nigeria still remain in darkness due to a lack or sporadic access to electricity when compared to urban area (Sunderland et al., 2016). This limited rural access to electricity has been identified as one of the major limitations to the development of rural household capacity and the improved liveability of rural communities (Akuru et al., 2017). Urmee et al. (2009) identified that the increasing isolation of rural areas, optimizing the use of renewable energy resources remains the feasible route to rural electrification. Ulsrud et al. (2015) argue that the proposed use of renewable rural resources in generating electricity for rural areas is down to the resource accessibility, considered electricity affordability and the ease of use of such energy being generated. Bashir and Modu (2018) reported that the ease of maintenance, affordability (in cost of purchase, use or installation) and the eco-friendly nature of renewable energy are some of the reasons why renewable energy is a viable solution to the rural electrification crisis.

This study, in line with the assumption and views of Aliyu et al. (2015) argues that rather than electricity provision based on the distribution networks from the main conventional grid energy sources in Nigeria, rural communities in Oyo State are relatively endowed with potential renewable energy sources that can be channeled into the provision of electricity for rural communities. Thus, using rural Oyo State as a case study, this study shall identify the various renewable energy resources that remain untapped and bring them to light for proposed utilization and optimization.

2. METHODS AND MATERIALS

Oyo State is made up of 3 senatorial districts which comprise 33 LGAs. Primary data through questionnaires and interviews were gathered from the 9 sampled LGAs (Figure 1). Households were selected randomly from the purposively selected 13 villages within the 9 LGAs. For the qualitative data gathered, content analysis was done to further understand rural household electricity-energy experiences and identify the difficulties of these households and how they have adapted over the years. For this study, findings and discussions were thematically provided through the synchronization of both the primary and secondary data gathered.

Figure 1 shows that the sample was drawn across the senatorial district as each district has a representative of 3 LGAs.

3. HOUSEHOLD AND COMMUNITY MENTAL HISTORY OF CONNECTION TO THE GRID

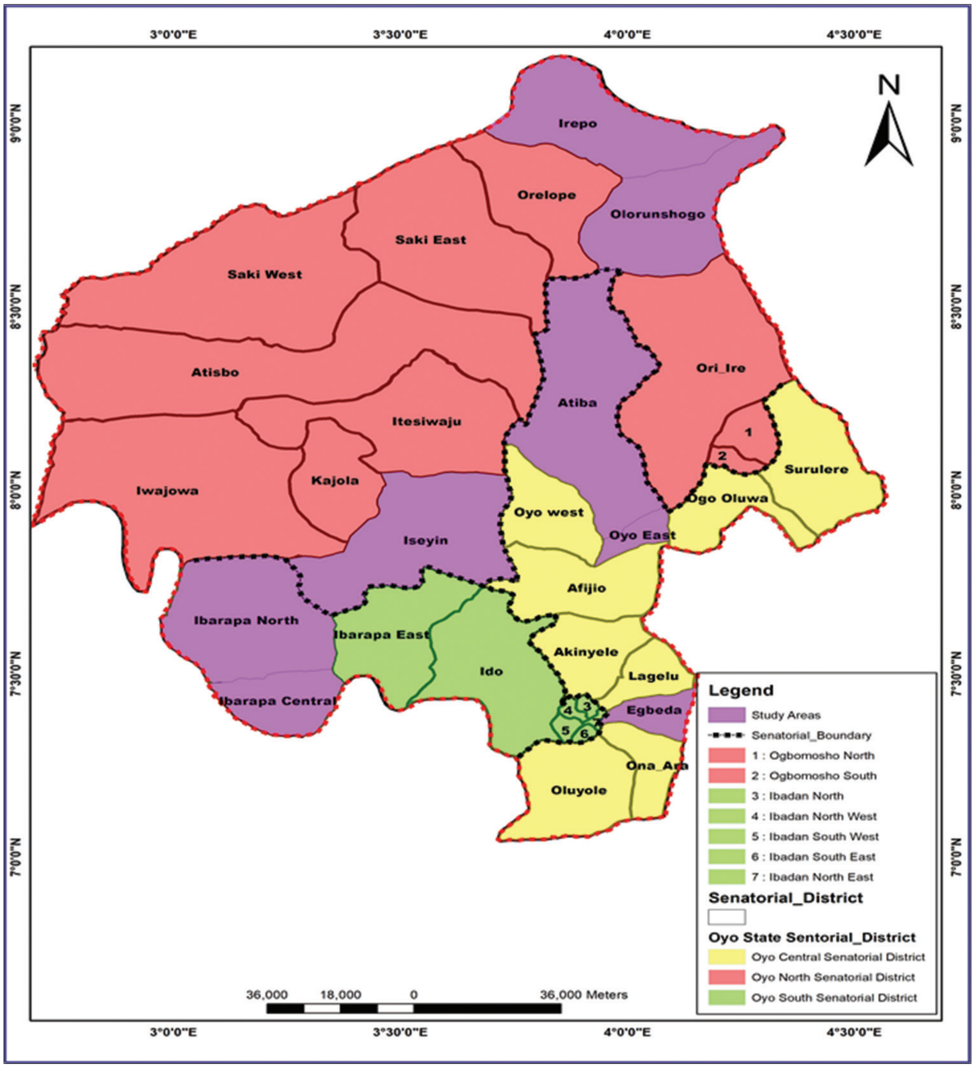
Quantitative data was also collected from the sampled 472 households in the 9 LGAs to identify the condition and history of households within the context of the village's or community's connection to electricity. Table 1 shows that 71% claimed not to be connected to the power grid, while the remaining 29% claim to be connected. In the

Table 1: Connection to electricity power grid across the sampled LGAs

Connection to electricity grid across the sampled LGAs										
Connected to grid	Local government areas									
	Atiba	Egbeda	Ibarapa central	Ibarapa North	Ido	Irepo	Iseyin	Olorunsogo	Oyo East	Total
Yes	0	77	10	0	43	0	0	0	1	131
% within LGA	0.0	96.2	33.3	0.0	100.0	0.0	0.0	0.0	2.2	29.0
No	59	3	20	38	0	38	91	26	45	320
% within LGA	100.0	3.8	66.7	100.0	0.0	100.0	100.0	100.0	97.8	71.0
Total	59	80	30	38	43	38	91	26	46	451
Household responses in relation to frequency of power across the sampled settlements in the LGAs										
Electricity facility condition	Local government areas									
	Atiba	Egbeda	Ibarapa central	Ibarapa North	Ido	Irepo	Iseyin	Olorunsogo	Oyo East	Total
Good	0	3	0	0	12	0	0	0	1	16
% within LGA	0.0	3.3	0.0	0.0	27.9	0.0	0.0	0.0	2.1	3.4
Fair	1	9	1	1	19	1	0	0	4	36
% within LGA	1.7	9.8	3.2	2.6	44.2	2.4	0.0	0.0	8.5	7.6
Bad	58	80	30	38	12	40	91	29	42	420
% within LGA	98.3	87.0	96.8	97.4	27.9	97.6	100	100.0	89.4	89.0
Total	59	92	31	39	43	41	91	29	47	472

Source: Researchers' Fieldwork Analysis (2018). LGA: Local government areas

Figure 1: Map of the study area with Oyo state local government areas



Source: Authors' Mapping (2018)

table, 89% reported the state of electricity to be in a bad condition, 7.6% stated that the power can be fair, while the remaining 3.4% can be said to be good. Based on the field observation which was corroborated by the household responses, it was revealed that from the sampled 13 villages in the 9 LGAs, 10 villages across 7 LGAs never had a history of power connection to the grid. These findings point to the decline in the frequency of electricity for communities with a history of electricity. When interviewed further as to what resulted in the sporadic power supply, some households in places such as Owo-baale and Kishi across the LGAs, reported that the electricity transformer has been faulty for over 3 years. Dwellers in the Kishi area reported that the community has been making use of privately serviced generators or any other household choices, such as solar inverters or batteries for over 6 years. This was said to have negatively paralyzed the economic potential of the community and also led to a decline in household livelihood survival.

4. RURAL DWELLERS: HEAT AND ENERGY

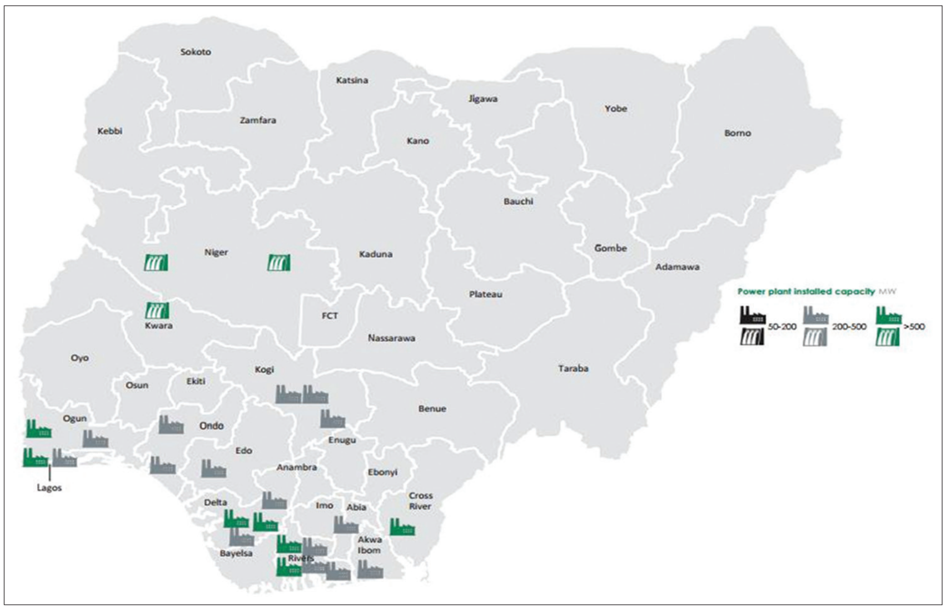
The relevance of power for household livelihoods and to rural dwellers has over the years been emphasized (Bhattacharyya, 2006; Diemuodeke et al., 2016; Osanyinlusi et al., 2017; John et al., 2017; Rathi and Vermaak, 2018). In Africa, the economic viability of rural electrification has been identified as a limitation to rural electricity (Hosier et al., 2017; Okoye and Oranekwu-Okoye, 2018). In Nigeria, limitations to rural electricity have been identified as poor rural electrification financing, a weak and mundane traditional approach, weak technical resources, remoteness, the poor economic base of rural areas and the lack of an electrification plan for remote rural areas (Power Sector Reform Team Bureau of Public Enterprises, 2006; UNDESA, 2014b; Olatunji et al., 2018). Nigeria has a low electrification rate of 45% and an electricity generation capacity of 12500GW generated from 25 plants (Figure 2) which are mainly generated through hydro-electricity and fossil gas (The Africa-EU Renewable Energy Cooperation Programme [RECP]).

Presently, the countrys electricity power available is put at between 3500GW and 5000GW (Sambo et al., 2010; Aliyu et al., 2013; Punch Newspaper, 2018) for a population of over 190million people and a land size area of 923768 sqkm.

Figure 3 shows that energy consumption in the country has been fluctuating over the years. Household consumption was marked by a decline between the years 1981-1993, 1998-2001, 2006 and then 2008-2009. Industrial energy consumption dropped between the years 1995-2005 and later picked up from 2006 to 2010. The decline in manufacturing activities in the country during this period may have accounted for this. Despite the need for electricity across sectors, cases of sporadic power supply within the country have been emphasized (Adeyemi et al., 2017; Oyedepo et al., 2018), most especially rural areas (Olatomiwa et al., 2016; Winkler et al., 2017). Yet, the ever-increasing consumption is not expected to decline (Figures 3 and 4) as it is expected that more isolated areas and rural communities will be continually connected to the electricity grid.

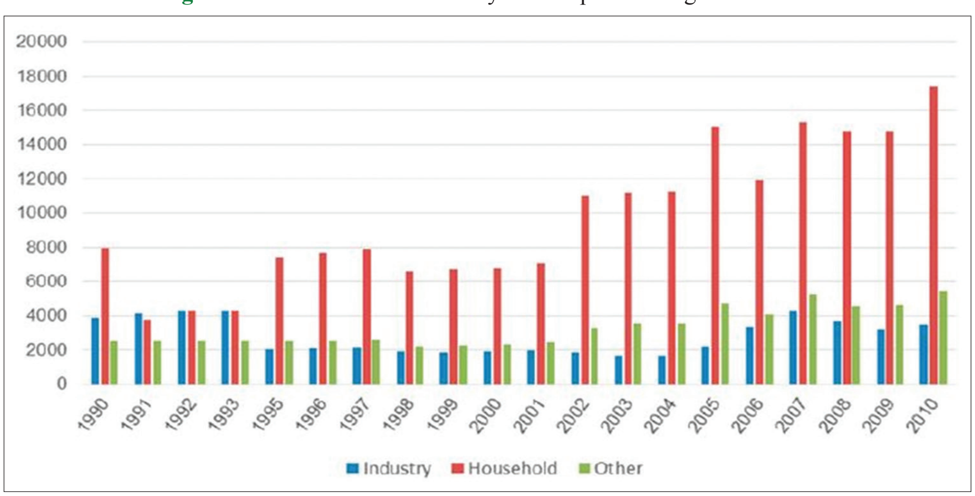
At the forefront of the sporadic power supply and inadequate electricity infrastructure in Nigeria are many rural areas that have never enjoyed the electricity supply since its inception. Based on field observation, interviews and reports, the researchers discovered that rural areas within the study area can be classified based on being connected to the grid but rarely having electricity service to the location or not even being connected to the grid at all. Four distinct types were identified. Rural areas that are connected (many are recently connected) but with no power history (examples are Alagogo village at Iseyin LGA, Alabi village in Ibarapa North and Ajagba village in Oyo-East LGA); rural areas connected to the power grid with a history of electricity but having not enjoyed electricity for so long (over 6 months and some over 2 years) owing to faulty infrastructures (an example is Owo-Baale village in Egbeda LGA); rural areas connected to the grid but sporadic power (examples are Ido village in IDO LGA and Idere at Ibarapa Central LGA); and rural areas never connected to the grid with no history of electricity (example are Iya-Yooyi at Irepo LGA, Gaa-Sidi at Olorunsogo LGA, Olatutu and Gbokoyi at Iseyin LGA and Iya-Ikoko at Ibarapa central LGA).

Figure 2: Distribution of thermal and hydro power plants across Nigeria



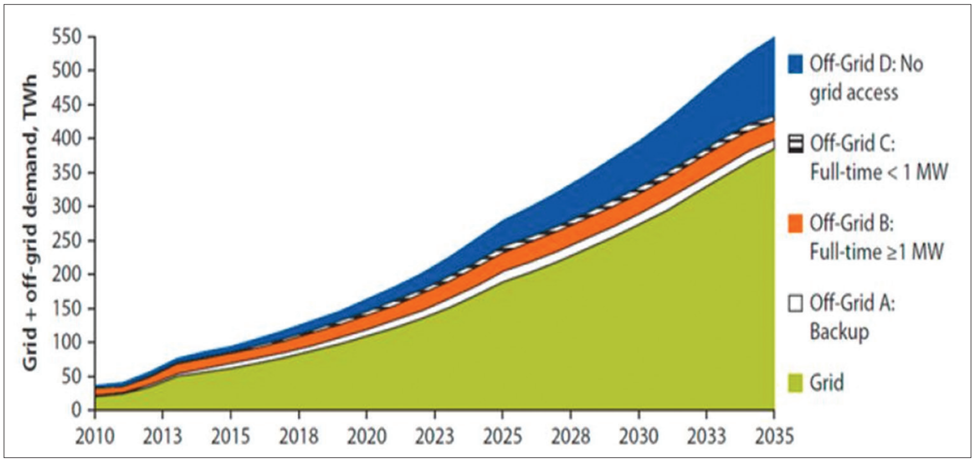
Source: The Africa-EU Renewable Energy Cooperation Programme (RECP) (2018) (https://www.africa-eu-renewables.org/market-information/nigeria/energy-sector/)

Figure 3: Time-series of electricity consumption in Nigeria in GWh



Source: The Africa-EU Renewable Energy Cooperation Programme (RECP) (2018) (https://www.africa-eu-renewables.org/market-information/nigeria/energy-sector/)

Figure 4: Projected electricity demand in Nigeria in GWh



Source: The Africa-EU Renewable Energy Cooperation Programme (RECP) (2018) (https://www.africa-eu-renewables.org/market-information/nigeria/energy-sector/)

The necessity for rural areas to have access to electrification cannot be denied as households have diverted to other means such as generators and firewood, all of which have implications for the environment. Madu (2016) states that the power policy in Nigeria has always been silent on rural electrification, an area he observed accommodated about 75% of the country's population. He iterates that the power sector reform roadmap launched 5 years ago should be shaped to align with the country's vision 2020. In the argument of Madu (2016), published in the national dailies, he stated that The Federal Government's Rural Electrification Programme known as the Nigerian Rural Electrification Programme, was introduced in 1981 and was focused on connecting all the 774 LGA headquarters, notable towns and villages to the country electricity grid can be said to be a failure.

Identified were insufficient capital, poor performance on the part of contractors and procurement difficulties. This, he reported led to the establishment of the Rural Electrification Agency (REA) and the opening of the Rural Electrification fund in 2006, 25 years after, which focused on the expansion of the main grid to rural areas, the development of isolated and mini-grid systems and renewable Energy power generation. Despite these attempts, rural electrification continually remains a mirage to many villages, thus limiting their livelihoods and capacity. Reiterating the perceived failed governance of the power infrastructure and the dichotomy of infrastructure privilege amongst urban and rural areas, a dweller stated thus:

> "...yes, there is difference. Urban dwellers have access to much infrastructure compared to rural dwellers, like their roads, lights and water but in this rural area for the past 8-12 years we have just been voting with a lot of deception before the election. After the election nothing is done despite the closeness to Sabo (major market) which has all this infrastructure, the numbers of poles required to bring in electricity is not much..." Village Dweller, Akodudu, Atiba LGA.

The neglect of this rural space has been much evident such that rural dwellers no longer think of the neglect as an afterthought or

Plate 1: Electricity lines not connected to Grid at Alabi village (Ibarapa North local government area)

Source: Researchers' Fieldwork (2018)

a coincidental event but instated was that they (dwellers) are being short-changed (even by their political representatives who end up relocating to another area and ignored as other neighbouring towns are often given priorities. Buttressing this perception, a dweller said:

> "...they (government and political representatives) just erect poles for electricity for over 15 years (Plate 1). When we ask after them they say they are now staying in Abuja (Federal capital territory)...?" Village Dweller, Alabi, Ibarapa North LGA.

The late attempts by the government were further observed, as a private business owner has this to say:

> "...For electricity, they have started the rural electrification of this area, but it is quite unfortunate that despite the numbers of farms there, it is just starting. There has been no electricity for the past 4-5 years in this village in this famous local government (Egbeda), so I will rate it poor..." Private business owner, Egbeda LGA.

The need for improved investment, the potential of renewable energy use and the maximization of resources is seen as a means towards improved rural electrification. For instance, Ikere gorge earth-filled dam (located at 8.20408 N, 3.72318 E), with a reservoir capacity of 690 million m^3, has the capacity to generate 3750MW of hydro-electricity and also irrigate 1200 hectares of land (Federal Republic of Nigeria [FRN]-Ogun-Osun River Basin Development Authority, 2015; Adebayo, 2017) but remains under-utilized. Field observations and discussions reveal that livelihoods in fish farming and irrigation farming take place at Ikere Gorge. It was instated by the field and site guide at the Ikere Gorge that there has been over a 20 year plan for the development of the gorge to generate hydro-electricity for the entire Oke-Ogun region. The dam under the Ogun-Osun River Basin Authority continues to be an under-utilized power generation opportunity for the people of Alagogo village and Gbokoyi-Olatutu village, Iseyin LGA and the entire Oke-Ogun environ (Adeyemo, 2016). Buttressing the potential of Ikere Dam, an officer on site had this to say:

> "...This embankment dam is a multi-purpose dam and the water body covers about 40 km, targeted at the power generation, research, training and teaching site (for students of the University of Ibadan and Olabisi Onabanjo University), irrigation farming (having acquired a 12 ha land for this farming purpose), settlement water supply and also fish farming..." Public Officer, Oyo state.

Yet, the residents of the sampled villages in Iseyin, most especially Alagogo village which is the closest to the dam still lack potable water and steady electricity. Many of these villages are reported to be paying to charge their phones, spend a lot on fuel to power their generators and grinding machines and spend a much on batteries for their radio in order to access information and be linked to the world as well as flashlights for sightseeing and terrain navigation at night. An example of the implication of the lack of electricity was instated by a dweller in IDO, who had this to say:

> "...We (dwellers) are not enjoying it (electricity) because it is not regular. We use money to charge our phones ₦50 to charge till it gets full. If there is stable light, then we can use it for whatever we want to use it for..." Village Dweller, IDO LGA.

Reporting the same situation, a dweller at Alagogo and Gbokoyi village of Iseyin LGA reported that they not only pay for the cost for charging their phones, but also pay for transportation by motorcycle which ranges from ₦50 to ₦150 (0.2-0.5 USD at ₦300/$) for those who cannot trek the long distance. Going by this revelation, evidence shows that an average person spends ₦50 ($0.2) every 3 days and between ₦50 to ₦150 (0.2-0.5 USD) on transportation to town, representing average of between ₦150 and ₦300 (0.5-1 Dollar) every week on mobile phone charging. On a monthly basis, this represents between ₦600 and ₦1200 ($2-$4) in rural to urban cash and capital flight. This evidence shows that an average of ₦600 (2 USD) is spent by an average household on the charging of mobile phones in urban areas or town settlements that enjoys electricity infrastructure or sometimes where generators are used. This situation often negatively influences household income and increases household expenditure. Field observation and participant observation evidence revealed that attempts at revitalizing the potentials of Ikere Gorge by non-governmental organisation and academic body such as Charles Odeyale Foundation and Centre for Sustainable Development, University of Ibadan and traditional leaders (Aseyin of Iseyin and Alake of Egbaland). Although renewable sources of energy have been explored for health infrastructure and water infrastructure within the study areas (Plates 2 and 3), it is not for household use.

Many households still depend on the use of firewood for their domestic cooking and also the making of goods (Shea butter cream) (Plate 4) sold by some households.

Factfish (2018) reported that 173000 thousand cubic meters of firewood was consumed by households in Nigeria (Figure 5). Owing to no connection to the power grid and in some areas sporadic power supply, fuel-wood consumption is expected to continually increase as presented in Figure 5, resulting in increased deforestation which affects the climate.

Presently, Nigeria is ranked second behind India across the globe (Figure 6) in fuel-wood consumption. These two countries are characterized by an increased demand for energy as many areas still remain unconnected to electricity supplies.

From the field investigation, the research reports that the lack of electricity limits household capacity as many often resort to

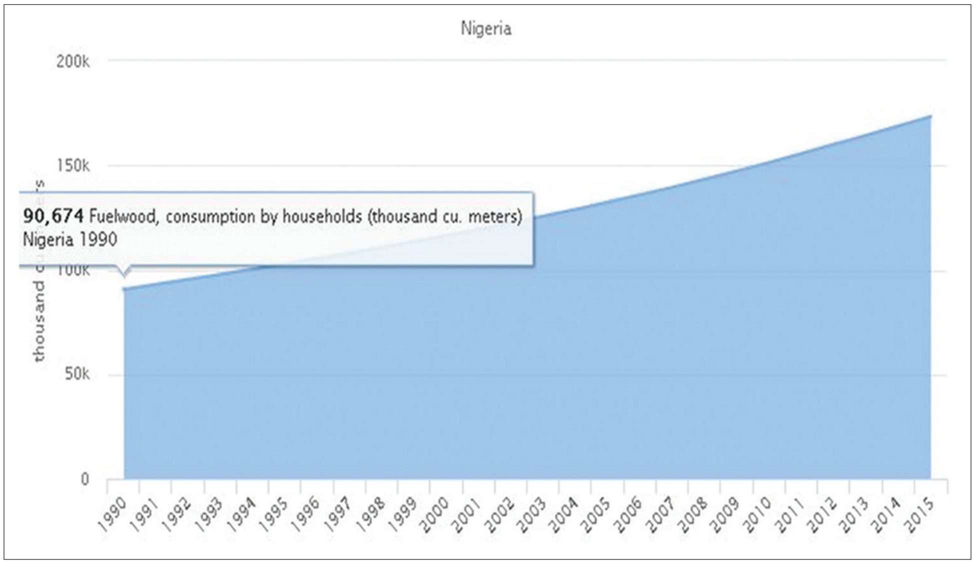
Plate 2: Solar-power water at Akodudu village (Atiba local government area)

Source: Researchers' Fieldwork (2018)

Plate 3: Solar-power water and health centre at Alabi village (Ibarapa North local government area)

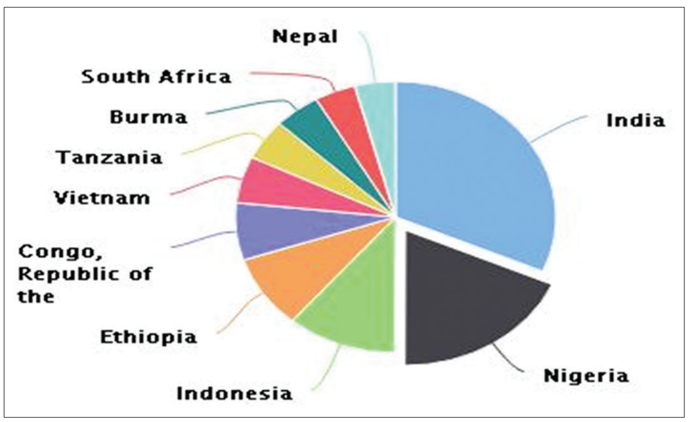
Source: Researchers' Fieldwork (2018)

Figure 5: Fuel-wood consumption in Nigeria 1990-2015



Source: Factfish, (2018)

Figure 6: Comparative fuelwood consumption of top 10 countries from 1990 to 2015



Source: Factfish, (2018)

Plate 4: Fire-wood as alternative energy source at Gaa-Sidi village (Olorunsogo local government area)

Source: Researchers' Fieldwork (2018)

going to neighbouring towns or villages connected to the grid to have their farming machines serviced. This oftentimes makes such villages and dwellers perceive the neighbouring towns and villages as parasite to their survival. Evidence also shows that the solar-powered borehole at Akodudu which is faulty could not be repaired as the community could not afford the cost of purchasing a new one. Thus, they depend on electricity to be connected to the village to have access to quality water. Likewise, the sporadic power supply has limited the pumping of water at Idere, Ajagba, Owo-baale and Akufo villages, which leads to the fetching of water at the stream about 30 min walk away, resulting in health complications for females.

5. RURAL ENERGY IN OYO STATE: LIMITING RURAL POTENTIAL AND MAXIMIZING LOCAL RESOURCES AND RENEWABLE ENERGY

With little being done in rural areas and a continued focus on urban spaces rural spaces and communities continue to be characterized by varying planning issues such as the under-utilization of resources (Effiong et al., 2017; Dehnel et al., 2017; Mlambo, 2018) and a lack of and inadequate electricity (Ogunmodimu and Okoroigwe, 2018). The issue of community electrification and most especially for rural areas, has been traced to be a result of poor electricity infrastructure frameworks, weak capital investment, obsolete technology, corruption, weak political will and under-utilization and limited optimization of renewable energy sources (Lamidi et al., 2017; Garba et al., 2017; The Africa-EU Renewable Energy Cooperation Programme, 2018).

Rural spaces continue to be characterised by limited electricity infrastructure and the villages sampled are characterised by varying arguments and perceptions as to why the areas are limited in these infrastructure needs. Based on field observation, evidence shows that while there are attempts and history of electricity in some villages, the political will towards the return of electricity to these areas has been limited, resulting in a LGA headquarters now being the warehouse location of electricity infrastructure (Plate 5). Evidence based on the spot inquiry revealed that many transformers were relocated to the LGA headquarters since it was not connected to the grid to prevent theft and tampering by thieves and destruction by angry community dwellers.

Informal discussions with residents of Kishi reveal that the entire LGA has been off-grid for over 5 years owing to a community clash that led to the destruction of some assets. A private business owner (Welder) recorded that over the last 5 years, he has had to buy 2 diesel generators to complement each other in order to meet his livelihood needs and service demands. He narrated thus:

> "...This electricity issue is a difficult thing... we (Welders association and LGA dwellers) have attempted to beg the local government chairman and also consult with PHCN-power holding company of Nigeria (Ibadan district) to assist in fixing the lights... All is to no avail... many of us (welders) who couldn't raise money for generator are out of business now... even me, I have changed diesel generators twice in the last 5 years. for what? Just to make end meet..." Private Business Owner (Welder), Irepo LGA.

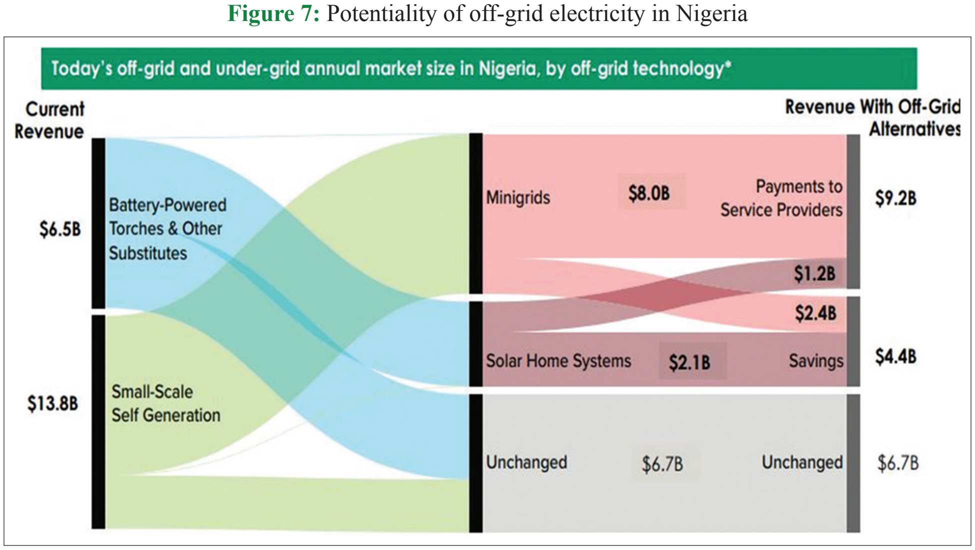
Plate 5: Wasting electricity infrastructure in Irepo LGA headquarters at Kishi

Source: Researcher's fieldwork (2018)

This expression above reflects that a lack of accessibility to rural electricity does translate into household poverty and poor livelihood conditions, which indirectly affect household income, expenditure and service charges in such localities. The neglect by authorities such as the local government, The REA of Nigeria, Power holding company of Nigeria and State government cannot be over-emphasized, but the attempts of the government within the rural space cannot be ignored also. Through the public-private partnership (PPP) between the Federal government of Nigeria and the World Bank, the development of a 5-year Nigeria Electrification Project (NEP) is expected to be kick-started. In this PPP project, the World Bank is expected to contribute $350 million to NEP, with $150 million allocated to mini-grids (Ogunbiyi and Abiola, 2017). Aligning with the moving train of sustainable energy, during the first quarter of 2017, the Federal Government of Nigeria launched a 20,000 rural solar lighting project across rural communities in the country. Additionally, Nigeria's Intended Nationally Determined Contribution (INDC) to the United Nations Conference of Parties 21 (COP21) shows that the Federal Government plans to work towards adding 13GW of off-grid solar power by 2030 (https://www.africa-eu-renewables.org/market-information/nigeria/energy-sector/).

Nigeria has been identified as an attractive and feasible state for mini-grids and solar home systems. With over $14 billion (₦5trillion) spent annually on inefficient electricity generation that is expensive ($0.40/kWh or ₦140/kWh or more), of poor quality, noisy and polluting by Nigerian businesses, the choice of enhancing off-grid electricity sources remains the viable option as it can generate a $9.2B/year (₦3.2T/year) market opportunity for mini-grids and solar home systems that will save $4.4B/year (₦1.5T/year) for Nigerian homes and businesses (Ogunbiyi and Abiola, 2017), with the translating cost saving and revenue undeniable (Figure 7).

Figure 7: Potentiality of off-grid electricity in Nigeria



Source: Ogunbiyi and Abiola (2017)

6. THE SOLAR ENERGY OPTION FOR RURAL HOUSEHOLDS

Some states have attempted exploring the adoption of mini-grids to enhance access to power. Lagos State government for instance, through the Lagos Solar project, a joint investment of Lagos State Electricity Board and the UK Department for International Development (DFID) has installed nearly 5 MWp of solar generated off-grid power for 172 schools and 11 clinics within Lagos State (The Africa-EU RECP). An additional 1.5 MWp is being installed at public health clinics in Kaduna State under the Solar Nigeria programme by DFID. In Jigawa, the Light Rural Nigeria initiative from solar power was used to power 27 villages of an average of 60 household beneficiaries per village (Frederick Stanley ltd-http://fredstanly.com/Light-up-Jigawa.html). This initiative was a collaborative effort between the Federal government of Nigeria and the Jigawa state government. There still remains limited state drive for promoting rural electricity through renewable sources in the state. With only 26% of rural households and families with access to electricity (Oni, 2017), exploring the possibilities of rural mini-grids and solar energy sources can help relieve household expenses on electricity-driven activities, as well as enhance their capacity and productivity.

With the calculated assumption of between ₦600 ($2) and ₦1200 ($4) spent by rural households for the charging of phones per month, this research considers the average of ₦900 ($3) spent per month on the charging of phones. Following the experimental village assumptions provided by Ogunbiyi and Abiola (2017), this figure ($3) represents a $3-$5 less cost estimate of the possibility of providing households with permanent household solar lighting systems (Figure 8).

This study further focused at unravelling the possibility of renewable energy use in Oyo State's rural space. The researchers identify the under-utilization of solar, hydro and wind energy for power generation. Data collected from the Nigerian Metrological Agency (NIMET) by Adejumo et al. (2017) shows that Oyo State and particularly the Ibadan region enjoin an average solar radiation intensity of 142.24 Watts per Sq. meter. Olatona and Adegoke (2015), using solar radiation and sunshine climatic data obtained from the International Institute of Tropical Agriculture (IITA), in Ibadan present the findings that going by the present solar radiation exposure in the tropical region of Ibadan with a minimum solar radiation of 10.71MJm-2 day and an electric conversion efficiency of 10%, this sunshine intake can supply a 1.0 m^2 solar panel a minimum of 44.6 KWhr of energy across the region, establishing an abundance of energy from solar power for households and small-scale industries. Evidence from the field shows that some public facilities such as health-care centres and pipe-borne water make use of solar energy to pump water and also to have their fridges cold in the hospital (Plates 2 and 3).

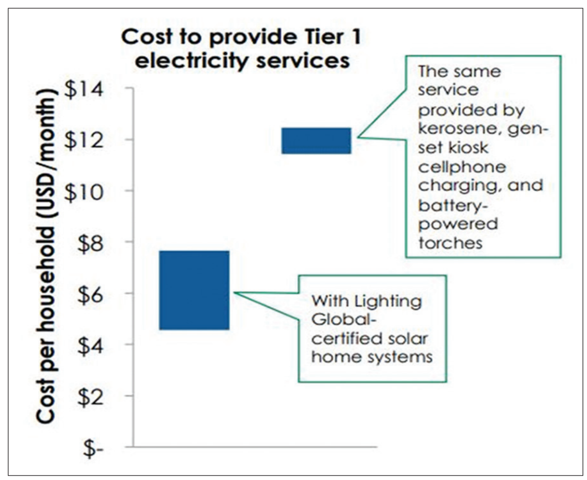
Nonetheless, the maximization of this energy source has not been full harnessed for household usage and small-scale businesses. At Alabi village, a village dweller was asked if he is aware of solar energy for household usage. He responded thus:

> "I don't know of the electricity from the sun (PVC) and I have not seen such done in this community... I know they put one for use in the pumping machine at the maternity centre, but it didn't last and we didn't know such also can be used at home..." Village Dweller, Alabi, Ibarapa North LGA.

Although field observation revealed that some peri-urban LGAs and households in such areas have benefitted from the private sector driven solar inverter initiative which was introduced by Mobile Telecommunication company MTN. This solar inverter has the capacity to power 4 electric bulbs, a TV set and 1 standing fan (Plate 6). The villages within the rural space are not aware of such an independent off-grid power opportunity. Buttressing the limited information about the technology and the perceived high cost, a dweller in Akufo village of Ido LGA had this to say:

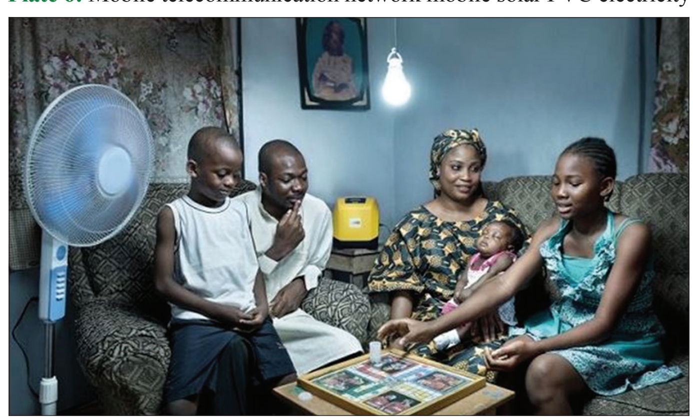
> "...my children told me of one done by MTN (Mobile Telecommunication Network PVC Solar panel that can power a television set and 4 electric bulbs) that you buy and pay with airtime... although when they told me we were at home (town/city) and we didn't need it... I didn't follow up as it was quite expensive for us and we don't know how it works..." Village Dweller, Akufo IDO LGA.

Figure 8: Potentiality of Off-grid electricity in Nigeria



Source: Ogunbiyi and Abiola (2017)

Plate 6: Mobile telecommunication network mobile solar PVC electricity



Source: Okafor (2018)

7. RURAL OYO STATE AND HYDROLOGICAL RESOURCES: THE UNTAPPED ENERGY

Hydro-electricity is one of the major energy sources in Nigeria. Oyo State is not an exception as rural and urban areas of the state are characterised by water resources that have the potential of being utilized for the generation of electricity. One such place is the Asejire Dam located at the boundary of Oyo State and Osun State. The dam is the major water generating site for the city centre and industrial plants close to the facility. The dam, locate at 7° 21^{1} 45^{11} N, 4° 08^{1} 00^{11} E, of the Egbeda local government area has a daily capacity of 186,000 cubic meters of water per day (Map 1).

The potential of the dam in supplying water to about 85% of the metropolitan area of the city was reported (Channels Television, January 6 2014), but the viability of the dam in generating electricity for the neighbouring communities has not been explored. Fadairo et al. (2017) identified that the dam has a high potential for generating electricity. They state that with the hydropower generation ability of the dam at 1.425 MW and a Kaplan turbine which can be used to generate, a small hydropower scheme is do-able. They state that notwithstanding the irregularity in water inflow and the reservoir capacity, the dam can conveniently be used for power generation of up to 1.42 Megawatts.

Brimmo et al. (2017) identified that the potential of hydropower to be generated from the water resources that Oyo State is endowed with is possible. Evidence based on pre-feasibility studies and water capacity evaluation and investigation shows that Sepeteri dam (Map 2), constructed by Ogun-Oshun River Basin and Rural Development Authority (O-ORBRDA) located in Saki-West LGA with a capacity of 1.5 mcm, has the capacity of providing 194

Map 1: Asejire Dam in Egbeda LGA and Environ

Source: Google earth (Accessed 12 October 2018)

Map 2: Sepeteri dam in Saki-West local government area and Environ

Source: Google earth (Accessed 12 October 2018) kw of energy at a capital cost of 722,411 USD invested and an annual revenue of over 82000 USD (Brimmo et al., 2017; Oyo State Government [OYSG], 2017). Using the energy household service calculation of Hagadone (2015), 194 KW will be able to service 194 homes (at 1 MW=1000 homes).

This form of energy will be sufficient to power the entire region of Oyo State. Brimmo et al. (2017) further explained that Sepeteri dam is not the only potential energy source within Oyo State. Their study identified that the Omi River in Ido LGA (one of the sample LGAs) also has the capacity of producing 625 KW if 2,017,796 USD is invested, with an estimated annual revenue of over 285000 USD. This estimated energy generated has the capacity of lighting 625 homes within the Omi River environ. The assumption of Adejumobi et al. (2013), without practical feasibility studies points out that 10 additional hydrological sites in the state have the potential of being used to generate electricity for the surrounding rural community (Table 2).

Studies by Adeosun et al. (2011) and Raphael et al. (2016) reported that of all the potential energy sources, Ikere gorge with a reservoir capacity of 565 mcm covering a land area of 87 km^2 and surface area of 47 km^2 and a water level of 273.5 m, has the capacity of generating 6 MW of electricity for 6000 homes (Map 3).

8. POTENTIAL OF RENEWABLE WIND ENERGY FOR RURAL COMMUNITIES OF OYO STATE

Pre-dated to the early 90s, the Nigerian state with a land mass of 923768 km^2 about 1000 km away from the Atlantic shoreline is undoubtedly characterised with the little or no potential of maximising wind energy resources (Fagbenle and Karayiannis, 1994; Brimmo et al., 2017) despite her great potential. Mohammed et al. (2013) reported a looming energy crisis in the country if renewable energy resources such as wind energy is not fully integrated into the National grid and fully maximised by the energy coordinating agencies and ministries.

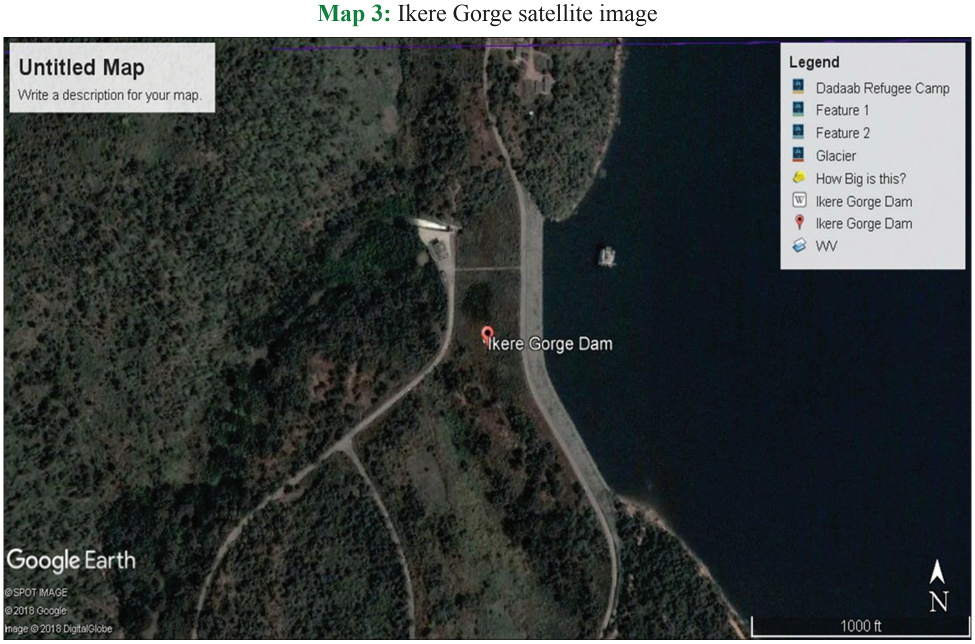
Within Oyo State, the potential of using wind energy, especially in the pumping of water, was well articulated by Ayodele et al. (2018a). It was summarised that the pumping of water in the Oke-Ogun region (Iseyin area) using wind energy (at a cost of

Table 2: Potential small hydro-power generating sites in Oyo state

Name of site	LGA located	Suggested turbine	Calculated energy generation
Tage	Irepo	Turgo	116.2
Olupo	Olorunsogo	Turgo	95.00
Fofo	Saki-West	Crossflow	270.00
Ona	Ibadan North-West	Crossflow	148.26
Oyo	Oyo-West	Crossflow	130.30
Oba	Orire	Crossflow	139.20
Opeki	Ibarapa Central	Turgo	126.80
Esinowu	Atisbo	Turgo	126.80
Konsi	Orelope	Turgo	105.60
Okugba	Ibarapa North	Turgo	105.60

Source: Adejumobi et al. (2013). LGA: Local government area

Map 3: Ikere Gorge satellite image



Source: Google earth (Accessed 12 October 2018)

\$0.014/m^3/day) is considered more economical and cost-effective when compared with public utility (\$0.37–0.6/m^3/day). Although studies by Fadare (2008; 2010) and Ajayi (2010) have identified Ibadan to experience an average wind speed and power density of 2.947 m/s, using a 20-year wind data across the senatorial districts of Oyo State (Adaramola and Oyewola, 2011) and the GIS modelling (Ayodele et al., 2018b), a small and medium wind turbine can be used in the generation of energy within the state based on a monthly mean wind speed range from 2.85 m/s to 5.20 m/s; monthly power density average of between 27.08 W/m^2 and 164.48 W/m^2, and yearly average power density range of 67.28 W/m^2 and 106.60 W/m^2.

9. CONCLUSION

The increasing rate of urbanization continues to increase urban demand for electricity. Hence, producing service industries, agencies and investors continue to focus on urban spaces. The urban economies of scale coupled with the profit-oriented drive of electricity generation and distribution by investors in Nigeria, the fate of rural dwellers in enjoying rural electricity or to be connected when compared to urban areas remains a mirage. Thus, planning for electricity inclusiveness for rural areas is focused on the use of rural resources. Undeniable is the shock facing rural households as a result of a lack of electricity or the continuous poor servicing facing rural household dwellers. In an attempt to curtail the downgrading of the economic potentiality of rural areas is the optimization of rural resources to benefit the rural people. This study further avers the need to utilize renewable energy sources for the development of rural economies.

Although the study did not extensively document the cost implications of a lack of or limited access to electricity, nonetheless, based on interviews, evidence shows a loss of sources of livelihood for some welders in one of the sampled rural villages and likewise the cost of charging phones was also reported. Similarly, the benefit of electricity within health centres and also for the pumping of water is highly imperative to the livelihood of the people. A conclusion is drawn that one of the easiest routes by the public government for rural dwellers to enjoy the dividend of good governance is in the provision of social and physical infrastructure that can help promote the economy of the rural people. The authors draw the conclusion that there is a need for proper investment in rural renewable energy and rural people need to be sensitized on the electricity generating options available for the community and households, such that rural dwellers can also be connected.

Evidence based on field observations and interviews revealed that generators and other fuel powered engines (grinding and welding engines), battery supported flashlights and fire-wood are the main sources of energy in the sampled rural areas. Dwellers depend on generators to charge their phones and lamps, many (such as traders, welders and pepper grinders) also make use of petrol or diesel powered engines to operate their livelihood-based machines. Households generally make use of flashlights powered by batteries and rechargeable lamps as a form of light for easy navigation at night.

This study professes the need for proactive political support and will towards the effective servicing of faulty electricity infrastructure and quick repairs as the need presents itself in communities such as Kishi. Likewise, community dwellers need to be educated on the operation of some of the renewable powered infrastructure such as the one used to pump water in order to prevent the spoiling of the infrastructure and at repair costs well beyond the villages' capability. Finally, this study identifies the need for the quick completion of rural electrification projects across the state and connection to the grid for rural dwellers' benefit.

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