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ACCESS TO ELECTRICITY IN SULEJA LOCAL GOVERNMENT AREA OF NIGER STATE, NIGERIA

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ABSTRACT

The duration, legality, and reliability of electricity supply constitute one of the biggest challenges that residents of Suleja LGA have to contend with. These electricity access indicators manifest themselves in limited hours of electricity supply, estimated billing, and abrupt interruption of electricity daily. The electricity challenges encountered threaten the actualisation of the Sustainable Development Goal 7 across the LGA. This study assesses access to grid electricity in Suleja LGA. In carrying out this assessment, the indicators of grid electricity access by employing the Multi-tier energy framework to measure access to grid electricity and the performance of SDG 7 in Suleja LGA was examined. Using data collected from 149 households in Suleja LGA, household socio-economic characteristics were used to evaluate the household determinant of electricity access. The study reveals that acute duration and reliability of electricity access were recorded in Suleja LGA with indexes of 0.26 and 0.17, respectively. Aggregate grid electricity access of 0.61, which implies fair electricity access, was also recorded in Suleja LGA. The study further shows that the income of the household head is the only significant predictor (<.001) of the level of grid electricity access, while other factors do not significantly influence the level of grid electricity access 9 > 0.05. This study thus recommends improving the duration and reliability of grid electricity supplied by the Abuja Electricity Distribution Company (AEDC). The study further recommends that the good indexes recorded for affordability, health/safety, and quality of electricity supply should be sustained by the AEDC.

KEY WORDS Access, Electricity, Duration, Legality, and Reliability

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1. INTRODUCTION

Access to electricity is an integral part of any country's economic and social development (Oyedepo, 2012; Winkler, 2011), as man's daily activities depend largely on electricity. Access to electricity has been a critical issue in time past and present in developing countries, especially those in Sub-Saharan Africa. According to the International Energy Agency (2020), the lowest electricity access rate is recorded in Sub-Saharan Africa, with 75% (770 million) of the population lacking access to electricity. Karekezi et al. (2012) opined that the limited access to electricity in Sub-Saharan Africa negatively affects its population as inadequate access to electricity contributes to the poverty level of the countries in this region.

Amongst the countries in Sub-Saharan Africa, a substantial population of those without access to electricity was recorded in Nigeria (World Bank, 2021). Documented as the largest electricity access deficit in Sub-Saharan Africa and the world, the World Bank (2021) asserts that 43% (85 Million) of the population in Nigeria lack access to electricity, which made the country have the. Poor access to electricity supply has forced households and businesses to rely heavily on diesel and gasoline generator sets as an alternative power source (Adhekpukoli, 2018). The continuous use of fossil fuels posed a threat to realising sustainable development goal 7. The poor access to electricity in Nigeria cuts across all the States of the Federation, with households finding it difficult to access adequate, affordable, reliable, high-quality, and safe electricity services (Nnaji et al., 2010).

The poor electricity supply (acute energy poverty) in Nigeria is not farfetched with the situation of access to electricity in Niger State and its major urban areas, where 44% (2.6 million people) are connected to the grid (Energy Sector Management Assistance Programme / World Bank, 2017). For instance, one would wrongly assume that the resident of Suleja in Niger State enjoys constant access to electricity due to the three hydropower stations located in the State. Nonetheless, the reverse is the case because the residents of Suleja in Niger State are usually plunged into darkness for days due to poor electricity supply by Abuja Electricity Distribution Company (Ugwa, 2020). The high urban population and the inability of the government of Niger State to explore other options for clean energy services are attributed to acute electricity poverty experienced in the State at large (Osunmuyi and Kalfaigaini, 2017; Sanusi and Owoeye, 2016).

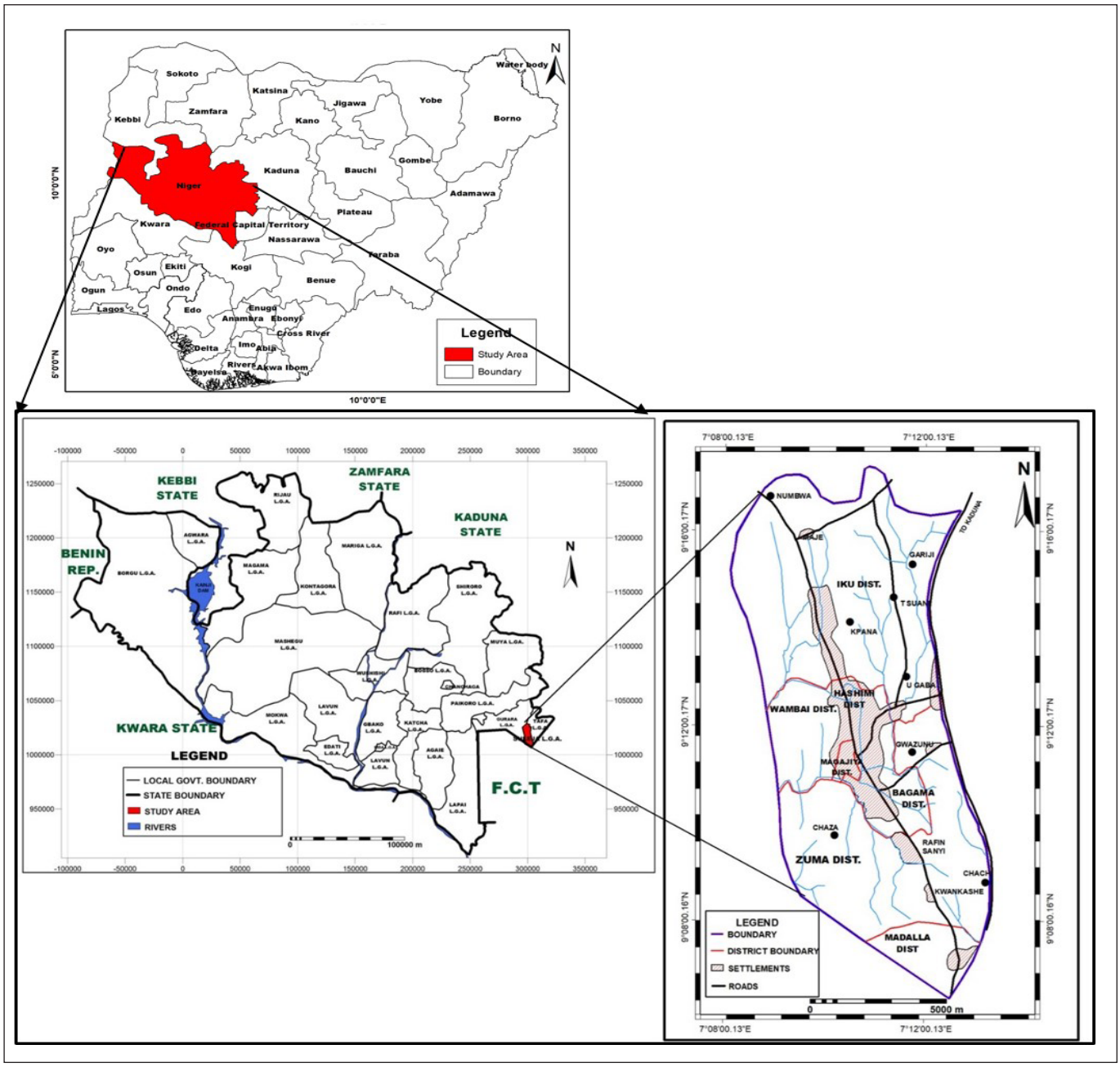
Different approaches and indicators have been used to measure and monitor access to household electricity. These approaches range from Single Indicator (Chen and Ravallion, 2008; Nussbaumer et al., 2012), two binary indicators (Un, 2019), three-dimensional indicators (Kowsari and Zerriffi, 2011), Multidimensional energy poverty index (Berry, 2018; Charlier et al., 2016; Okushima et al., 2017) and the multi-tier energy framework (World Bank and ESMAP, 2015). In all of these approaches, only the multi-tier energy framework gives detailed measurements of the multidimensional nature of electricity access, making the framework possible to determine the performance of the Sustainable Development Goal (SDG) 7 (Bhatia and Angelou, 2015; United Nations, 2019).

Various studies on access to electricity in Nigeria have been carried out at the national and the State level (Heinemann et al., 2023; Sanusi and Owoyele, 2016; Ubah et al., 2020; World Bank, 2018), with limited knowledge on the local community's (LGAs included) access to electricity. Also, these studies on access to electricity in Nigeria have not measured the progress of SDG 7 concerning electricity access in local government areas in Nigeria. Against this background, this study aimed to measure access to electricity in Suleja Local Government Area to determine the performance of SDG 7. The specific objectives addressed in this study include: examining the indicators of electricity access, measure electricity access in relation to the performance of SDG 7, and ascertaining the determinant of electricity access

2. STUDY CONTEXT AND SETTING

This study is limited to household access to electricity through the grid connection in the urban area of Suleja Local Government Area (LGA) of Niger State. Suleja LGA is located between latitude 9o 08' 00.16'' N to 9o 16' 00.17'' N and Longitude 7o 08' 00.13''E to 7o 12' 00.13''E (Figure 1). In a State (Niger State) considered the power State of Nigeria, Suleja, a local government area in Niger State LGA, has an optimal mix of the national grid, mini-grid, and Stand-alone systems for electrification. According to the Niger State Bureau of Statistics (2014), 100% of the dwellings in Suleja Urban area are all electrified. Though all the households (100%) in the study area are connected to the national grid, households in Suleja LGA have poor electricity supply (Ugwa, 2020; Usman, 2023).

Figure 1: Suleja Local Government Area - Niger State, Nigeria.



Source: Department of Urban and Regional Planning, FutMinna, 2021

3. REVIEWS OF PREVIOUS STUDIES

3.1. Measuring Access to Electricity and the Performance of the Sustainable Development Goal Seven

The term access to electricity for this study is defined as the ability to avail electricity that is adequate, available when needed, reliable, of good quality, affordable, legal, convenient, healthy and safe, for all required energy services across household, and community uses (World Bank/ESMAP, 2014). Over the years, several authors have used different frameworks to measure access to electricity; these frameworks range from single indicator framework, two binary frameworks, three-dimensional framework, multidimensional energy poverty index and the multi-tier energy framework. Though these frameworks measure access to electricity using different binary but little or no elaborate level of ascertaining the progress of the sustainable development goal 7 (access to affordable, reliable and modern energy services).

The single indicator measures household access to electricity through a specific indicator (e.g. economic activity or income), thereby presenting access to electricity in a narrow path (Nussbaumer et al., 2012). The single indicator is not suitable for determining the progress of SDG 7 owing to its inability to measure access to electricity in multidimensional nature. Similarly, the

double binary indicator framework does not also give an elaborate measurement of access to electricity. It only focuses on the proportion of the population with access to electricity and clean cooking technology (United Nations, 2019). The double indicator framework tends to be convenient for use; the true complexity of electricity access in terms of affordability and reliability is not captured, thereby leading to a disagreement in the definition of SDG 7.

Unlike the single and the double indicator frameworks, the three-dimensional indicators use energy services, devices and carriers to measure access to electricity. This framework focuses on household electricity use patterns which depend on the concurrent decisions on the type of energy service, carriers and energy conversion technologies a household decides to use together. The three-dimensional framework emphasises the energy services instead of the energy quantity to be used by households (Kowsari and Zerriffi, 2011). This implies that the three-dimensional framework is only concerned with electricity services without taking into cognisance of the quality, reliability, affordability and safety of the energy services as captured by SDG 7.

Similar to the three-dimensional framework, the multidimensional energy poverty index (MEPI) focuses on energy services that are based on electricity deprivation as well the intensity of electricity deprivation (Nussbaumer et al., 2012). The methodology of the MEPI relies on the threshold of houses with access to electricity (Berry, 2018). Access to affordable, reliable and modern energy services was not addressed by the MEPI framework.

In determining the progress of SDG 7, the need gap created by these other indices (Single indicators, Double indicators, three-dimensional framework, and MEPI) was filled by the multi-tier energy framework (MTF). This framework defined access to electricity as the ability to obtain adequate, available, reliable, of good quality, affordable, formal, convenient, healthy and safe (UN, 2019:5). Electricity access is measured by the MTF using seven indicators: reliability, affordability, legality, quality, health and safety, duration, and capacity (Energy Sector Management Assistance Programme and World Bank, 2015). The MTF measures electricity services by classifying the services into tiers starting from Tier 0 [no service] to Tier 5 [full service] (Matthew, 2017). The MTF further ascertains explicit performance gaps and electricity access deficiencies in supply. In showing the performance of SDG 7, the MTF clearly defines what affordable, reliable, and modern energy access means, and these indicators can be combined by the MTF (UN, 2019). The summary of the existing framework used to measure access to electricity is explained in table 1.

Table 1: Summary of literature review on the existing framework for measuring access to electricity

Framework	Indicators	Method	Performance of SDG 7
Single Indicator (Chen & Ravallion, 2008; Nussbaumer et al., 2012)	▪ Income	Non-Aggregated	Data do not allow for elaborate measurement of SDG 7
Two binary Indicators (UN, 2019)	▪ % (population) with access to electricity ▪ % (population) with access to cooking energy	Aggregated	Data do not allow for elaborate measurement of SDG 7
Three Dimensional (Kowsari & Zerriffi, 2011)	▪ Energy Services ▪ Energy Devices ▪ Energy Carriers	Aggregated	Data do not allow for elaborate measurement of SDG 7
Multidimensional Energy Poverty Index (Berry, 2018; Nussbaumer et al., 2012)	▪ Household appliance ▪ Electricity Access ▪ Indoor pollution ▪ Energy Expenditure ratio ▪ Income	Aggregated	Data do not allow for elaborate measurement of SDG 7
Multi-tier (Bhatia & Angelou, 2015; World Bank/ ESMAP, 2015)	▪ Quality ▪ Reliability ▪ Affordability ▪ Health and Safety ▪ Duration ▪ Legality ▪ Capacity	Aggregated & Disaggregated	Data gives an elaborate measurement of SDG 7

Source: Author's Compilation, 2023

4. DATA AND METHODS

4.1. Research Design and Sample Size

The cross-sectional design was adopted for the survey for this study. The household population of 53,902 in Suleja local government area served as the sample frame for this study. The household population was divided into the ten administrative wards of Suleja LGA. Using the mathematical model from Miller and Brewer (2003), with a confidence level of 95% and a confidence interval of 5%, the study area's sample size of 149 was deduced. The sample size (149) was proportionally sampled for each administrative ward, and then each household head was randomly selected. The household population and sample sizes are explained in Table 2. The mathematical model by Miller and Brewer is expressed as follows:

$$n = \frac{n}{1 + N} \quad (\alpha)^2$$

Where: n is the sample size, N denotes the Sample Frame, and α represents the confidence interval.

Table 2: Sample Frame and Sample Size for Study Area

	Suleja		
	Wards	**Sample Frame (Households)**	**Sample Size**
1	Bagama A	6806	19
2	Bagama B	4742	13
3	Hashimi A	6818	19
4	Hashimi B	3390	9
5	Iku 1	5765	16
6	Iku 2	6784	19
7	Kurmi Sarki	6888	19
8	Maje North	6646	18
9	Magajiya	4153	12
10	Wambai	1911	5
	TOTAL	**53902**	**149**

Source: Author's Compilation, 2020

4.2. Data Collection and Analysis

The socio-economic data and data on electricity indicators collected through the Open Data Kit were analysed using simple descriptive statistics. The multi-linear regression model was to ascertain the household's electricity access determinant. ArcGIS 10.2 was used for the spatial variation of the electricity indicators in Suleja LGA.

4.2.1. MEASURING ACCESS TO ELECTRICITY

Access to electricity in electricity in Suleja was measured using six indicators which are: Health and safety, duration, reliability, affordability, legality, and quality. The definition of each of the indicators is in Table 2. The multi-tier energy framework developed by World Bank/ESMAP in 2015 was used to measure the index of access to electricity in the study area. This framework is expressed as $\Sigma (P_i * K)$, Where: P^i = proportion of households at the K^{th} tier, and K = Tier number {0, 1, 2, 3, 4, 5}.

Table 3: Localised Multi-tier Energy Framework for Access to Electricity in the Study Areas

Multi-Tier Indicators	Indicators for the Study area	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity							
Duration	Duration	< 4hrs	4 – 8 hours	9 - 12 hours	13 - 16 hours	17 -20 hours	> 20 hours
Reliability	Reliability	> 14 time	Not more than 14 times		3 -13 times		Not more than 3 times
Quality	Quality		Voltage Problem			Stable Voltage	
Affordability	Affordability	>10% of household Income			< 10 %of household Income		
Legality	Legality					Service provided legally through the prepaid meter	
Health and Safety	Health and Safety					Absence of Accidents/ perception of high risk in the future	

Source: Authors' modification, 2021

The electricity access indicators in Table 3 are conceptualized as follows:

Duration: Hours of electricity per day, hours of electricity during the evening; **Reliability**: Number of unscheduled interruptions per week, duration of each interruption; **Quality**: Voltage problems (Inadequate/Adequate); **Affordability:** spending less than 10% of monthly average income on electricity (the national minimum wage of Nigeria served as the benchmark for income). Affordability was calculated as follows Household income > = 10*365Kwh*tariff) **Legality**: connection to the grid through the prepaid meter; **Health and Safety**: the presence of accident and absence of an accident.

The electricity access index range from 0 – 1, with the index of 0 - 0.29 indicating Acute electricity access and 0.30 – 0.49 denoting poor electricity access. The indexes of 0.50 – 0.69 and 0.71 – 1 imply fair electricity access and good electricity access, respectively. In calculating the index for each of the electricity access indicators, values in each indicator were multiplied by their corresponding tiers. The total values for each of the disaggregated indicators were further divided by the number of tiers (5 tiers).

5. RESULTS AND FINDINGS

5.1. Socio-economic characteristics of Respondents

The socio-economic characteristic of the respondents in the study area is explained in Table 4. The socio-economic characteristics revealed that 71.81% of the sampled respondents (household heads) in Suleja LGA were male, and 28.19% were female. A large proportion (28.19%) of the sampled respondents has stayed in Suleja LGA for a period above 21 years. The second largest respondents (22.15%) were those who had stayed in the study area for 6 – 10 years. Respondents who have stayed in the study area for 11 – 15 years constitute 19.46% of the total respondents. At the same time, respondents who have stayed in Suleja LGA for 16 – 20 years were 11.41% of the sampled respondents.

The respondents' socio-economic characteristics also show large household sizes amongst the sampled respondents in Suleja LGA. The maximum household size in the study area ranged from 4 to 6 persons, accounting for 45.63% of the respondents. The minimum household size (1.34%) ranges from 10 persons and above in a household; 29.54% accounts for households with 1 to 3 persons. Households within the range of 7 to 9 persons accounted for 23.50% of the total respondents. Furthermore, the household income survey reveals that 14.77% of the respondents earned 10000 Naira – 35,000 Naira, a slight

amount above the national minimum wage of Nigeria. A total of 17.45% and 19.46% of the respondents earned an income between 36,000 Naira – 60,000 Naira and 61,000 Naira – 90,000 Naira, respectively. A large proportion of the respondents (40.94%) earned above 100,000 Naira.

The socio-economic characteristic also shows that 1 – 3 bedroom dwells are common in the study area. Table 4 explains that the majority (79.87%) of the residents in the study area dwell in 1 – 3 bedroom homes. The socio-economic characteristic further explains that 75.17% of the household heads in Suleja spent 13 years and above in school. The household heads that spent over 13 years in school were those that passed through the tertiary institutions. The household head that spent 0 – 4 years in school (2.01%) were those that attended the Qur'anic school. At the same time, household heads that spent 5 – 6 years and 7 – 12 years in school were those with primary and secondary school certificates, respectively.

Table 4: Socio-economic Characteristics of the Study Area

Socio-economics Characteristics	Options	Bagama A (%)	Bagama B (%)	Hashimi A (%)	Hashimi B (%)	Iku 1 (%)	Iku 2	Kurmi Sarki	Maje North	Magajiya	Wambai	Pooled for the LGA Percentage
Gender	Male	57.89	69.23	73.68	77.78	81.25	84.21	68.42	77.78	66.67	40.0	71.81
	Female	42.11	30.77	26.32	22.22	18.75	15.79	31.58	22.22	33.33	60.0	28.19
Household Size	1 – 3	42.11	30.77	10.53	11.11	18.75	36.84	36.84	27.78	33.33	60.0	29.53
N = 149	4 - 6	36.84	30.77	57.89	55.56	50.0	36.84	42.11	55.56	58.33	20.0	45.64
	7 - 9	21.05	30.77	31.58	33.33	31.25	21.05	21.05	16.67	8.33	20.0	23.49
	Above 10	-	7.69	-	-	-	5.26	-	-	-	-	1.34
Length of Stay	1 – 5 Years	15.79	23.08	31.58	11.11	-	21.05	10.53	16.67	41.67	20.0	18.79
N = 149	6 – 10 Years	15.79	15.38	31.58	22.22	12.5	21.05	21.05	16.67	33.33	60.0	22.15
	11 – 15 Years	26.32	23.08	21.05	33.33	6.25	15.79	26.32	11.11	25.0	-	19.46
	16 – 20 Years	10.53	23.08	10.53	11.11	18.75	21.05	5.26	5.56	-	-	11.41
	21 Years and Above	31.58	15.38	5.26	22.22	62.5	21.05	36.84	50.0	-	20.0	28.19
Income	10,000 – 35,000	26.32	30.77	-	-	18.75	10.53	15.79	16.67	25.0	-	14.77
N = 149	36,000 – 60,000	5.26	15.38	36.84	22.22	31.25	10.53	15.79	11.11	8.33	20.0	17.45
	61,000 – 90,000	21.05	7.69	10.53	22.22	18.75	21.05	26.32	22.22	16.67	40.0	19.46
	91,000 – 100,000	-	-	10.53	22.22	-	15.79	5.26	11.11	-	20.0	7.38
	Above 100,000	47.37	46.15	42.11	33.33	31.25	42.11	36.84	44.44	50.0	20.0	40.94
Number of Rooms	1 – 3	78.95	52.63	89.47	77.78	56.25	78.95	84.21	88.89	75.0	100	79.87
	4 – 6	21.05	23.08	10.53	22.22	43.75	15.79	15.79	11.11	8.33	-	18.12
N = 149	> 7	-	-	-	-	-	5.26	-	-	16.67	-	2.01
Years spent in School	0 - 4 Years	-	-	5.26	11.11	-	-	-	5.56	-	-	2.01
	5 - 6	5.26	7.69	-	-	6.25	5.26	-	-	8.33	-	3.36
N = 149	7 - 12	21.05	38.46	5.26	22.22	18.75	15.79	31.58	27.78	-	-	19.46
	13 and above	73.68	53.85	89.47	66.67	12	78.95	68.42	12	91.67	100	75.17

Source: Authors' Field Survey, 2021

5.2. Assessing Electricity Indicators in Suleja

The study reveals that 100% electricity connectivity was recorded among the sampled respondent. This result affirms the findings of the socio-economic survey of Niger State, which reveals that 100% of the dwellings in Suleja are connected to the grid (Niger State Bureau of Statistics, 2014). The energy indicators that were used to measure access to electricity are duration, legality, reliability, health and safety, availability, and quality.

5.2.1. AFFORDABILITY OF ELECTRICITY

The affordability of electricity across the ten administrative wards of Suleja LGA is explained in Table 5. The study reveals that a high proportion of the residents of the study area enjoy electricity affordability. The study further shows that residents in Magajiya and Wambai wards enjoy 100% electricity affordability. Of all the ten administrative wards in Suleja, a high proportion (17.65%) of residents who expended more than 10% of their average monthly income on electricity from the grid were located in Maje North. Other administrative wards where residents paid more than 10% of their average monthly income on electricity from the national grid were Bagama A (5.26%), Bagama B (7.69%), Hashimi A (10.53%), Hashimi B (11.11%), Iku 1 (12.50%), Iku 2 (5.00%), and Kurmi Sarki (10.53%).

The respondents that expended less than 10% of their monthly income on electricity supply were categorised under tier 5, while respondents who expended more than 10% of their monthly income on electricity supply were ranked in tier 2.

5.2.2. LEGALITY OF ELECTRICITY CONNECTION FROM THE NATIONAL GRID

In explaining the legality of electricity in Suleja LGA, three categories of residents' connections to the national grid were assessed. That is, residents who were connected to the national grid through a post-paid meter (electromechanical), residents connected to the national grid with a meter, and residents connected to the national grid through a prepaid meter. Table 5 reveals that, a high proportion of residents who connected to the national grid with no meter were predominant in Iku 1 (31.25%) and Hashimi B (22.22%). The issues of electricity connection to the national grid without any form of meter cut across the ten administrative wards of Suleja. The use of outdated post-paid (electromechanical) meters was also found to be in use across the ten administrative wards of Suleja. The study further reveals that estimated billing of electricity where households are charged arbitrarily without considering the appliances used in their homes was common among households with post-paid meters (30.20%) and households without meters (12.08%). The households subjected to estimated billing by the AEDC total 42.28% of the sampled population of all the wards.

The study similarly reveals that no administrative wards in Suleja had a 100% connection to the national grid through a prepaid meter. For this study, the respondents with the electromechanical meter and those not metered were grouped under tier 0 of the multi-tier framework (MTF), which implies poor legality.

5.2.3. DURATION OF ELECTRICITY FROM THE NATIONAL GRID

The duration of electricity supply amongst the wards in Suleja varies from less than 4 hours daily to above 20 hours. High proportions of the respondents across the different wards have access to electricity supply for 4 – 8 hours daily. Residents with access to 4 – 8 hours only enjoy supply between 9 am – 12 pm and 9 pm – 12 am daily. Households that have access to electricity supply from 9 – 12 hours daily have access to electricity supply between 6 am – 12 pm and 6 pm – 12 am daily. The few households in Iku 2, Kurmi Sarki, and Magajiya that had access to electricity supply from 13 hours to 16 hours only enjoyed electricity supply at 8 hours intervals daily. The study further reveals (Table 5) that only 5.26% of residents in Bagama A and Kurmi Sarki correspondingly enjoy above 20 hours of electricity from the grid daily.

Findings reveal that hours of electricity supply by the Abuja Electricity Distribution Company (AEDC) are subject to change without prior notice. Using the duration indicator on the multi-tier energy framework, respondents with a duration of < 4 hours daily fall under tier 0, and respondents that have access to electricity supply from 4 – 8 hours are in tier 1. Tier 2 and Tier 3 comprise respondents with access to electricity between 9 – 12 and 13 – 16, respectively. Furthermore, the least respondents that had access to electricity supply from 17 – 20 and > 20 were on tiers 4 and 5, correspondingly.

5.2.4. HEALTH AND SAFETY OF RESPONDENTS WHILE USING ELECTRICITY

Table 5 explains that a high proportion of the residents across the ten administrative wards had not experienced any form of injuries while using electricity. The study reveals that an uncommon number of respondents in Bagama A (26.32%), Bagama (23.07%), Hashimi A (5.26%), Iku 1 (31.25%), Iku 2 (15.00%), Kurmi Sarki (31.58%), Magajiya (16.67%), Maje North (17.64%), and Wambai (20.00%) had experienced minor injuries, burns or fire without death as a result of an electric spark. Respondents that had encountered one form of accident or the other from the use of electricity were ranked in tier 0 of the MTF, while respondents that had not experienced any form of accident were ranked in the 5th tier of the MTF.

5.2.5. QUALITY OF ELECTRICITY SUPPLIED

The quality of the electricity supply is defined by the voltage/brownout problems encountered in the study area, which made the electricity supply either adequate or inadequate. The study reveals that 100% stable voltage was recorded by residents of Hashimi B and Magajiya wards, respectively. Persistent voltage problem/brownout was common among the residents of 8 administrative wards, which include Bagama A, Bagama B, Hashim A, Ikun 1, Iku 2, Karmi Sarki, Maje North, and Wambai (See Table 5). The respondents that experienced voltage problems/brownouts are ranked in the third tier (3rd) of the MTF. At the same time, the respondents with stable voltage were grouped in the fifth tier (5th) of the MTF.

5.2.6. RELIABILITY OF ELECTRICITY IN SULEJA LGA

The reliability of electricity is determined by the number of unscheduled electricity outages experienced in each of the administrative wards in Suleja per week. The analysis reveals that a high proportion of the respondents across the administrative wards experienced electricity outages more than 14 times or 14 times in a week. Respondents that experienced more than 14 times unscheduled electricity interruptions are grouped in tier 0. Respondents that experienced not more than 14 times unscheduled interruptions were grouped in tier 1. Respondents that experienced 13 – 3 times unscheduled interruptions and those that had not more than 3 unscheduled electricity interruptions were grouped in tiers 3 and 5 of the MTF, respectively. The reliability of electricity in the study area is described in Table 5.

Table 5: Disaggregated Analysis of Access to Grid Electricity in Suleja LGA

Electricity Indicators	Options	Bagama A (%)	Bagama B (%)	Hashimi A (%)	Hashimi B (%)	Iku 1 (%)	Iku 2 (%)	Kurmi Sarki (%)	Maje North (%)	Magajiya (%)	Wambai (%)	Pooled for the LGA Percentage
Affordability	Less than 10%	94.74	92.31	89.47	88.89	87.50	95.0	89.47	82.35	100	100	91.29
N = 149	More than 10%	5.26	7.69	10.53	11.11	12.50	5.0	10.53	17.65	-	-	8.72
Legality	Prepaid Meter	57.90	46.15	68.42	33.33	43.75	65.0	57.89	64.71	75	40	57.72
N = 149	Post-paid Meter	36.85	38.47	26.32	44.45	25	20.0	42.11	23.53	16.67	40	30.20
	No Meter	5.26	15.38	5.26	22.22	31.25	15.0	-	11.76	8.33	20	12.08
Duration	< 4 Hours	26.32	23.08	-	22.22	43.75	-	15.79	-	8.33	20	14.77
N = 149	4 – 8 Hours	57.90	53.85	52.63	55.56	43.75	65.0	42.11	58.82	16.67	20	49.66
	9 – 12 Hours	5.26	23.08	47.37	22.22	12.50	30.0	31.58	35.29	50	60	29.53
	3 – 16 Hours	-	-	-	-	-	5.0	5.26	-	25.0	-	3.36
	17 – 20 Hours	5.26	-	-	-	-	-	-	5.56	-	-	1.34
	> 20 Hours	5.26	-	-	-	-	-	5.26	-	-	-	1.34
Health & Safety	No Injury	73.68	76.92	94.74	100	68.75	85.0	68.42	82.35	83.33	80.0	80.54
N = 149	Minor Injury/Burns	26.32	23.07	5.26	-	31.25	15.0	31.58	17.64	16.67	20.0	19.46
Quality	Stable Voltage	36.84	76.92	52.63	100	56.25	50.0	52.63	58.82	100	20.0	59.73
N = 149	Voltage Problem	63.16	23.08	47.37	-	43.75	50.0	47.37	41.18	-	80.0	40.27
Reliability	More than 14 times	47.37	38.46	52.63	77.78	25.0	45.0	63.16	41.18	16.67	40.0	44.97
N = 149	Not More than 14 times	26.32	46.15	47.37	22.22	18.75	50.0	26.32	52.94	58.33	60.0	39.60
	3 – 13 times	21.05	15.39	-	-	56.25	5.0	5.26	5.88	25.0	-	14.09
	Not More than 3 times	5.26	-	-	-	-	-	5.26	-	-	-	1.34

Source: Authors Field Survey, 2021

5.3. Measuring electricity access in relation to the performance of SDG 7

The Spatial variation to Grid Electricity in Suleja is explained in Table 6. In terms of affordability of electricity, the spatial variation analysis reveals that grid electricity was affordable across the ten administrative wards of Suleja LGA. Unlike the affordability of electricity, which was common among the ten administrative wards of Suleja, a little variation in respect to the legality of connection was found among the ten administrative wards. The study reveals that Bagama B, Hashimi B, Iku South 1, and Wambai had poor legality to electricity connection. Bagama A, Hashima A, Iku South 2, Kurmi Sarki, and Maje North equally had fair legality to electricity connection. It further reveals that only Magajiya ward had good legality to electricity connection with an index of 0.75.

The duration of electricity supply by the Abuja Electricity Distribution Company of Nigeria ranges from acute access to poor access in terms of duration of supply. Administrative wards with an acute duration of electricity include Bagama A, Bagama B, Hashima B, Iku South 1, Iku South 2, Kurmi Sarki, and Wambai. The wards with poor access duration of electricity in Suleja include Hashimi A, Maje North, and Magajiya.

Table 6: Disaggregated Analysis of Electricity Access in Suleja LGA

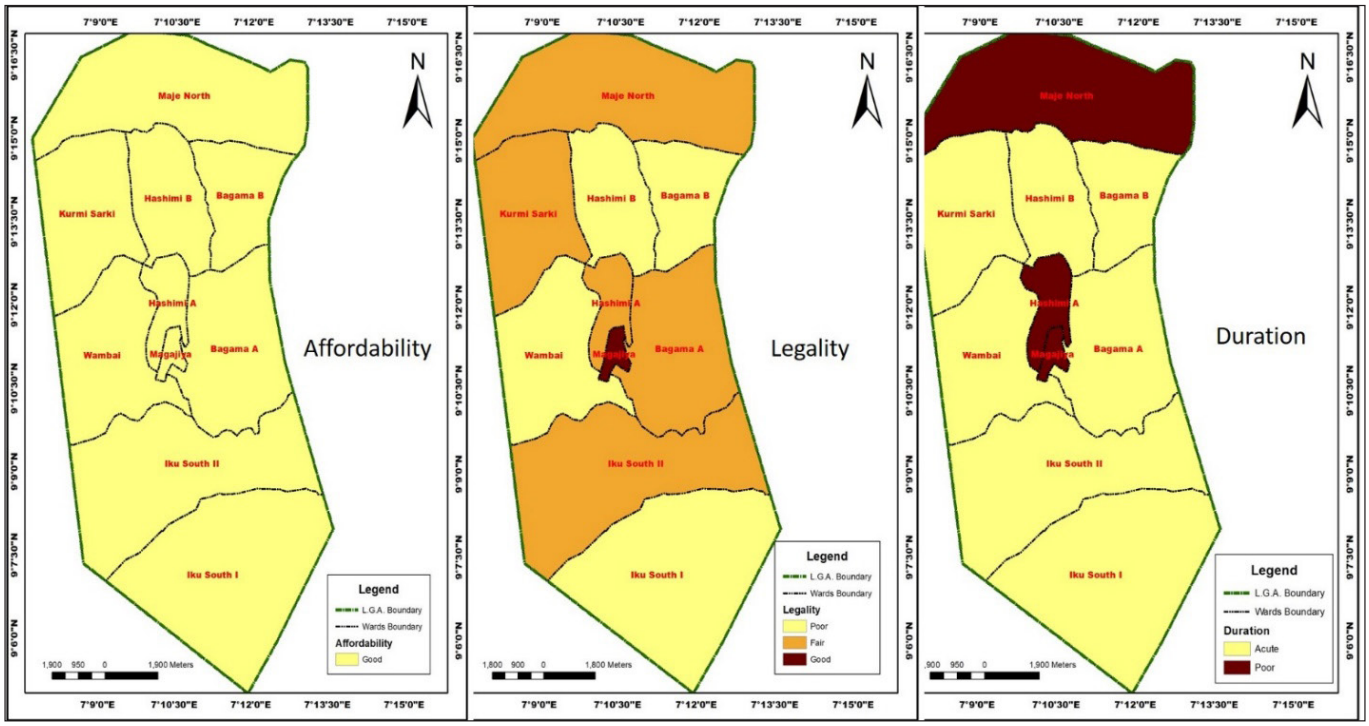
Electricity Indicators	Bagama A	Bagama B	Hashimi A	Hashimi B	Iku South1	Iku South2	Kurmi Sarki	Maje North	Magajiya	Wambai
Affordability	0.97	0.95	0.94	0.93	0.93	0.97	0.94	0.89	1.00	1.0
Remark	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Legality	0.58	0.46	0.68	0.33	0.44	0.65	0.58	0.65	0.75	0.40
Remark	Fair	Poor	Fair	Poor	Poor	Fair	Fair	Fair	Good	Poor
Duration	0.23	0.20	0.30	0.20	0.14	0.28	0.29	0.31	0.38	0.28
Remark	Acute	Acute	Poor	Acute	Acute	Acute	Acute	Poor	Poor	Acute
Health & Safety	0.73	0.77	0.95	1.00	0.68	0.85	0.68	0.82	0.83	0.80
Remark	Good	Good	Good	Good	Fair	Good	Fair	Good	Good	Good
Quality	0.75	0.91	0.81	1.00	0.82	0.80	0.80	0.84	1.00	0.68
Remark	Good	Good	Good	Good	Good	Good	Good	Good	Good	Fair
Reliability	0.23	0.18	0.10	0.04	0.37	0.13	0.14	0.14	0.27	0.12
Remark	Acute	Acute	Acute	Acute	Poor	Acute	Acute	Acute	Acute	Acute
Aggregated Indexes for each of the wards										
Aggregate Index	0.58	0.58	0.63	0.58	0.56	0.68	0.57	0.61	0.71	0.55
	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Good	Fair

Source: Authors' Field Survey, 2021

The reliability of electricity supplied by AEDC varies from acute reliability access and poor reliability access. The spatial variations explained that acute reliability access was widespread amongst nine administrative wards (Bagama A, Bagama B, Hashimi A, Hashimi B, Iku South 1, Iku South 2, Kurmi Sarki, Magajiya, Maje North, and Wambai) in Suleja. The spatial variations further reveal that poor reliability of electricity was only prevalent in Iku South 1. In terms of the quality of electricity, Wambai wards were more associated with electricity brownouts and voltage fluctuation. Out of the ten administrative wards in Suleja, only the respondents in Wambai ward had a fair electricity quality, while respondents in the remaining nine administrative wards had a good quality electricity supply (Table 6).

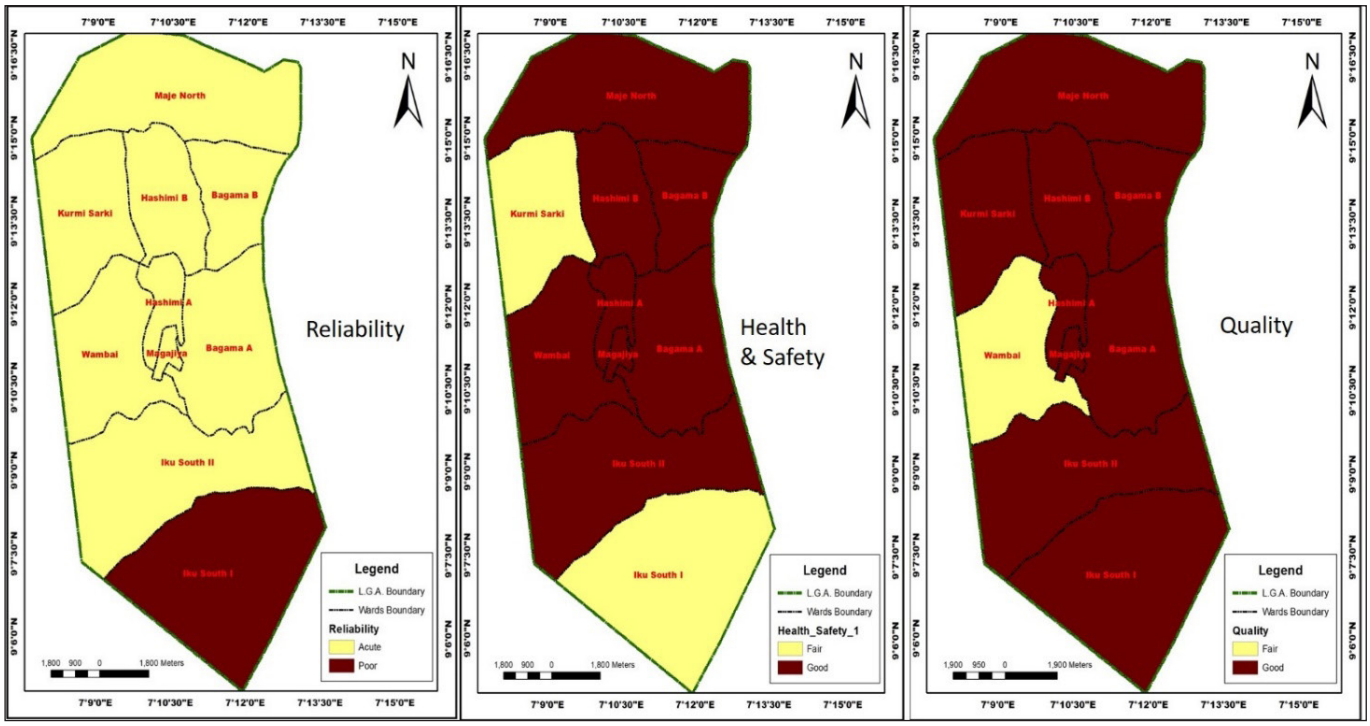
Ten administrative wards have enjoyed good access to Healthy/Safe electricity indicator in Suleja: Bagama A, Bagama B, Hashimi A, Hashimi B, Iku South1, Magajiya, Maje North, and Wambai. The respondents in Kurmi Sarki and Iku South 1 have either experienced minor injuries or burns from the use of electricity, thereby making electricity fairly healthy and safe for the respondents in these wards. The spatial variation of the indicators of electricity in Suleja LGA is represented in Figure 2 and Figure 3.

Figure 2: Spatial variation of Affordability, Legality, and Duration of Electricity.



Source: Authors' Mapping, 2023

Figure 3: Spatial variation of Reliability, Health & Safety, and Quality of Electricity.



Source: Authors' Mapping, 2023

Examining SDG 7 using the MTF in the study area shows that with average indexes of 0.26 and 0.17 for duration and reliability, respectively, Suleja LGA is performing poorly in these indicators (See Table 6). The acute electricity access indexes recorded for duration and reliability shows that households in the study area do not have access to electricity from the national grid when needed. The overall summary of the indicators of SDG 7 in Suleja reveals that household Affordability of electricity was good while access to reliable modern energy was acute. The summary of the aggregated electricity access in the entire local government area infers that grid electricity in Suleja LGA is fair, with an average index of 0.61.

5.4. Determinants of Electricity Access in Suleja

To examine the influence of socio-economic attributes of household heads on the level of electricity access among the households sampled. The hypothesis was set and stated thus:

The null hypotheses (H0): there is no statistically significant relationship between socio-economic variables and electricity access

Multiple linear regression analysis was conducted, where five (5) socio-economic factors were loaded as the independent variable (IV), and the level of electricity access was loaded as the dependent variable (DV). The independent variables loaded are Household size, Years spent in school, the income of the household head, Years Spent in the community, and the number of rooms occupied. In contrast, the level of electricity access was loaded as the dependent variable.

The multi-regression model indicated that the predictors explained 20% of the variance, and a significant collective effect was found, having recorded an F-value of 5.84, R2 = 0.2, and a p = <.001. However, the coefficient Table (Table 7) shows that the income level of the household head is the only significant predictor (<.001) of the level of electricity access, while other factors do not significantly influence the level of electricity access 9 > 0.05. This implies that households and neighborhoods with a better income would have good access to electricity. That is, an increase in income would translate to improved electricity access in Suleja. Other factors, like the number of rooms, years spent in school, years spent in the community, and household size, do not significantly influence the level of electricity access, as explained in Table 7

Table 7 Summary of Regression Model for Determinant of Electricity Access

R	R2	Adjusted R2	Standard Error of the Estimate		
0.45	0.2	0.16	3.05		
Model	df	F	P-Value		
Regression	6	5.84	<.001		
	Unstandardised Coefficients	Standardised Coefficients			
Model	B	Beta	Standard error	t	p
(Constant)	15.33		2.53	6.06	<.001
Household Size	0.18	0.12	0.13	1.43	.156
Years spent in school	0.07	0.05	0.1	0.69	.491
Household Average Monthly Income	0	0.36	0	4.32	<.001
Years Spent in the Community	-0.03	-0.11	0.02	-1.33	.185
Number of rooms	-2.74	-0.33	1.83	-1.5	.136

Sources: Author's Analysis, 2023

6. DISCUSSIONS

The electricity access indicators considered for this study were affordability, legality, duration, health & safety, quality, and reliability. The study reveals that a good index indicator for affordability recorded in the ten administrative wards across Suleja LGA is an indication that electricity from the grid was affordable. But considering the epileptic power supply from the grid, households are forced to incur additional costs to power their generator sets which may not be affordable (Umar, 2021).

Poor and acute indexes recorded in the access indicators of duration and reliability across the ten administrative wards of the study area can be attributed to the incessant electricity outages from the national grid. According to the International Energy Agency [IEA] (2019), the duration of electricity from the national grid is short and unscheduled outages of electricity from the national grid can take hours or sometimes days in Nigeria. The prolonged unscheduled outages of electricity in Nigeria are also an indication that the reliability of electricity is acute in the country. This assertion is apparent in Suleja, as households can stay for days without electricity from the national grid (Ugwa, 2020).

The assessment of legality of electricity connection in the study area to the national grid through the prepaid metering system shows that only 57.72% of the households of the study area were legally connected to the national grid through the prepaid meter. The inability of 42.28% of the households in the study area to be connected to the national grid through the prepaid meter

is solely attributed to the inability of the AEDC to distribute prepaid meters to households. These findings was affirmed by Elumoye, 2021; Jimoh, 2021, who opined that the AEDC fail to distribute prepaid meters to Nigerians despite the government releasing 33billion Naira for its mass production. The inability of the AEDC to provide 100% metering through the prepaid meter cut across the ten administrative wards of Suleja.

The instance of estimate billing by AEDC found among households with post-paid meters (30.20%) and households without meters (12.08%) in Suleja, agrees with other empirical research. These empirical researches conclude that households on post-paid and households unmetered were found to be facing irregularities of fixed monthly charges and estimated charges by electricity companies in Nigeria (Abba, 2020; Abdulwahab, 2009; Soyemi et al., 2021). Okafor et al., 2017; Oyedepo, 2012, also believed that the outdated post-paid meter encourages electricity theft and non-payment of electricity bills by consumers, prompting the electricity distribution companies in Nigeria to charge arbitrarily.

The study reveals that of all the ten administrative wards in Suleja, Magajiya wards tend to have good indexes for the indicators of Health and Safety, Legality, and Quality of electricity. An aggregate index of 0.71 (good) for electricity access was also recorded for Magajiya ward. The good electricity access index recorded in Magajiya ward can be ascribed to the fact that the ward is a high-income neighbourhood. This finding also affirmed the multi-linear regression analysis results that suggest increased income will translate to good electricity access in Suleja.

SDG 7 seeks to ensure universal access to affordable, reliable, and modern energy services (IEA, 2019; UN, 2019; World Bank, 2018). In checking the performance of SDG 7 in Suleja LGA, the indicators of reliability and duration of access to modern energy tend to be lagging behind. Though the study reveals that electricity (modern energy) from the grid was affordable, the acute indexes for reliability and durability of electricity from the grid imply that households in Suleja do not have access to modern energy service that is reliable. The aggregated index (fair) for the study area is also an indication that realising the SDG 7 before 2030 may not be feasible.

7. CONCLUSION AND RECOMMENDATION

This study has successfully used the multi-tier energy framework to measure access to electricity in Suleja LGA of Niger State using six indicators of health & safety, affordability, legality, reliability, duration, and quality. Though all the households were connected to the grid electricity in the study area, the aggregate indicators of energy access indicate that access to grid electricity in the study area was fair. This study, therefore, recommends that the duration of grid electricity supply in the study area should be improved upon by the AEDC as this will help enhance the indicators of reliability and duration. Improved grid electricity supply by the AEDC will also mean access to reliable electricity, which is the tenet of SDG 7.

To enhance the indexes of legality across the ten administrative wards of Suleja LGA, the Federal Government of Nigeria and the AEDC Should ensure that all households are metered through the prepaid meter. Since prepaid meters can eliminate estimated billing, limit electricity theft, and give the actual power used by the consumers (Dike et al., 2015; Ogbuefi et al., 2019 Dahunsi et al., 2021). The use of outdated post-paid meters in the study area should be phased out completely by the AEDC. Also, the unmetered households should be provided with prepaid meters as this will help address the legality of connection.

The good performance indexes of specific indicators of health & safety, quality, and affordability of grid electricity should be sustained by the AEDC. Further Studies can be carried out in the area of comparative analysis of household access to grid electricity at the State and National levels.

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