DETERMINANTS OF HOUSEHOLD ENERGY CONSUMPTION MIX IN CHIKUN LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

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ABSTRACT
The study analyzed household energy consumption mix in Chikun Local Government Area, Kaduna State. A total of 373 questionnaires were used for the analyses, which were selected using a three stage cluster area sampling method. Multinomial Logistic regression method was used for the analysis of the data. The result showed that 46.1% of household uses firewood for cooking, 36. % uses Gas for cooking, and 15.7% uses charcoal. For lighting purpose, 86.7% uses electricity as their main source of lighting, while 9,5% uses kerosene for lighting purpose. The results further revealed that the major determinants of household energy mix are: household energy expenditure and ownership of electrical appliances. The study recommends among others that household should be encourage through the government legislation to improve the use of energy saving appliances against the use of firewood and charcoal. This commitment will reduce the pressure on forest reserve.

Keyword: Household, energy consumption, energy mix
JEDS Codes: D35, J60

1. **Introduction**.

Energy consumption is a crucial determinant of socioeconomic life of the people. Household energy services are required for the purpose of lighting of house, heating of homes, cooking, of food and use with electrical appliances. For the purpose of their usage, the various energy sources include; electricity, firewood, kerosene, gas, charcoal and Liquefied Petroleum Gas. Nigeria household sector energy consumption exceeds other sectors accounting to about 70 percent of the total energy use (Gwatkin, et al. 2000). The main driver of firewood use is the degree of its accessibility. Household living in rural areas spent little time and money to access firewood, while household living in urban areas have to purchase it with higher price. Babanyara & Saleh (2010) revealed that rural-urban migration, high price of kerosene and poverty were the key factors driving demand for firewood in urban Nigeria.

The main energy requirement of Chikun Local Government household is for cooking, lighting and used for electrical appliances and lighting energy is mainly used by electricity and kerosene which have become expensive. The basic share of energy in household budgets combined with its role as a necessary household good especially energy for lighting and cooking are impossible to live without and this take a larger share of household income. Also higher Liquefied Petroleum Gas and Kerosene prices made household switch to charcoal or firewood, or a mixture of firewood and

charcoal. Household who have shifted out of firewood due urbanization, their vulnerability to energy price fluctuations has increased overtime. . Few studies in Chikun Local Government Area, Kaduna State that attempted to unravel household energy consumption focused mainly on one energy source such as electricity, firewood or kerosene as household energy source while neglecting similar study on household energy mix. It is in this light that the research examined households energy consumption mix in Chikun Local Government Area, Kaduna State.

2. Literature Review

2.1 Conceptual Clarification

Energy consumption refers to energy consumed to perform a task, to manufacture goods or service or inhabit a building. In household, energy used include firewood, charcoal, kerosene gas and electricity, and any other energy used for cooking, to lighting a house, for heating, and used with other electrical appliances. In developing countries, increase in population growth results to rapid increase in energy consumption (World Bank, 2007).

Energy mix is by meeting energy needs, every household used the form of energy at its disposal, in different ratio. This is called energy mix, the proportion differs essentially from one location to another, in Nigeria, firewood accorded larger energy mix at the national level taken over 80 percent of the total energy consumed (Zaku et al 2013). The mixture of energy by the household is categorized into needs for cooking (firewood, charcoal, kerosene gas, and electricity), heating (charcoal, gas), appliances (electricity), lighting (electricity, kerosene). For each geographical location, the combination of energy mix by the household depends largely on the availability of resources within the domestic setting, the energy needs that is to be met the extent and type of energy needs policy changes as determined by economic historical, demographic environment, social, and geographical factors (Planete energies, 2020).

2.2 Empirical Review

For some time now studies on household energy demand have shown that energy shifting is not unidirectional and people may move back to solid energy after using cleaner energy forms. Modern energy forms are not perfect replacement and many times certain energy is prefer for special purposes; instead of changing between various energy, household choose to consume multiple energy and convert technology depending on preference, budget and needs (Helberg 2004).The concept of the energy stacking demonstrates that household will tent to allocate their income among the various goods or combination of goods that will maximize utility in accordance with the

neoclassical economic theory assumption. Expenditure of household may consist of three major groups such as, expenditure on energy, expenditure on food and expenditure on clothing. Expenditure on energy is categorized into the expenditures in connection with the various forms of energy: firewood, charcoal, kerosene, LPG and electricity. Based on the model, once a cleaner energy is selected, traditional energy and equipment's are usually kept and households only partially switch.

Other empirical studies also emphasize that in spite of the usual view, Liquefied Petroleum Gas is not a perfect substitute for traditional bio energy and that there are complete preferences of energy which depends on cooking practices (Masera, 2000). The purpose of mixing energy varies and depended not on economic status alone, though the price of energy has crucial direction on household energy decision. Household in some cases consume more than one form of energy because they want to increase the energy supply security. Mekonnen & Kohlin (2009) adopted multinomial logistic model and random utility theory to analyzed factors that determine household energy decision in some selected urban cities in Ethiopia. The results showed that household in the cities mostly chose to increase different number of energy sources as income increases, as alternative of totally shifting from the use of solid energy to cleaner energy.They concluded that households mostly switched to energy mix strategy as their income grow as a result of number of reasons, such as taste, preferences, cooking methods and consumption behavior, cost of energy, technology availability and dependency of supply.

Svoboda (2013) examined the determinants of household electricity consumption. He employed ordinary least square (OLS) regression and observed variables such as ; price of kerosene, electric water heater, temperature, electric clothes dryer, income of the family, dish washer, number of people in house, age of respondents, nature of job private water connection, district of residence, price of gas, per capita expenditure, age of household head, were found to have a positive significant relationship to the households electricity demand. Whereas factors such as electricity price, public water source, change in temperature in the second and also third quarter of the year, household perception in consumption of firewood, pleasure in consumption of firewood, duration when the house was built, educational level of the household head, firewood price were found to be negatively related to the amount of households electricity consumption. The study recommends that improvement in electricity supply will have a significant positive effect on household energy used.

Fidelix et al.(2014) investigates households' energy determinant and uses in Nigeria, by using 2004 data from the National Bureau of Statistics of Nigeria Living Standard Survey. The study employed descriptive statistics and multinomial logistic t model. They showed that majority of households in Nigeria use kerosene for lighting and firewood for cooking because they lack access to modern

energy that is friendly to the environment. The findings also reveals that factors such as educational level of fathers and mothers, per capita expenditure on energy, households' size had significant influence on households' energy consume for cooking purpose. The study recommended that measures should be adequately taken by the government to ensure that majority of the households in Nigeria have access to modern energy that are environmentally friendly.

Baiyegunhi & Hassan (2014) used multinomial logistic model to analyze the factors that determined households' energy consumption decision of cooking in Giwa Local Government Area, Kaduna State. The study found that energy consumption pattern are consistent with the energy stacking theory as firewood is consume together with modern energy, and most households depends fully on firewood as their main energy source. The results further shows that households head, educational attainment, type of dwelling, household size, the duration of cooked food, income, price of firewood were significant determinants influencing decision of household's selection of energy.

Ahmed et al.(2016) examined the factors of energy stacking behavior among households in Bauchi State by using the multivariate analysis. The study appraised the combine influence of four variables which include educational level/exposure of households, size of the household, and income level of household and modern energy supply security on energy adoption decisions of households. The findings reveals that family size, level of income of household educational level of households, make significant impact to the energy stacking behavior of household.

Simon et al. (2019) investigate the nature of exploitation of firewood and its impact on inhabitants of Kakau Daji Village, in Chikun Local Government Area of Kaduna State. The study employed descriptive statistics to analyze the result. The result shows that 57 percent of firewood exploiters were farmers; firewood energy used by 85 percent of the respondents came from farmlands and bush. The results also reveals that 95 percent of the villagers consumed firewood as main form of energy for heating and cooking on daily bases as there is little choice available and affordable them. This means the rate of firewood used is more than the rate of firewood production.

Adamu et al.(2020) analyzed the applicability of the energy ladder hypothesis on household demand for energy in Nigeria, they reviewed the various forms of household energy used and examined the implication of their reliance on traditional energy source as well as energy ladder hypothesis. The findings reveals that the reliance on energy form at the bottom part of the ladder by majority of household in Nigeria is connected with increasing level of poverty consistent with the energy ladder model, but do not agrees with the view of total energy shifting because most household tend to have combination of different sources of energy for their uses. The study recommends that government and other stakeholders should formulate policies that will encourage consumption of cleaner energy forms with a view to minimizing the environmental negative effect of traditional energy

consumption on health as well as improved human lives. The difference conclusion arrived at these empirical studies is that they were conducted in different continent, different countries, and in different environment by using different methodology and data for study and analysis.

Le et al(2023) examined the determinants and approaches of household energy consumption.The study employed article summation and text mining to create an overview of household energy consumption with success of prediction models to determine the most significant drivers and simulation methods. The findings revealed that the data driven method was widely used, and improved modeling is the technological option to be consider in predicting energy demand. The findings demonstrated the importance of occupant-related parameters, which primarily focus on occupant behaviors. Increase in energy consumption requires more studies in household in Asia-Pacific areas. They recommend that clear vision of analyzing household energy consumption in the early stage, pursue and develop saving energy measures and policies.

Tian et al (2024) carried out a comprehensive bibliometric analysis of household energy consumption on research articles from the web of core science collection since year 2000.The findings reveals among others that prevalence examination clearly shows the urgent subject matter, from energy consumption and its determinants, factors impacting the environment and their assessment and energy-saving technologies and measures to for the reduction of emission. Empirical literature reveals that economic models,including input-output models and life cycle assessment, are used in household energy consumption analysis.The study provided that security improvement and engagement with customers of smart home technology, and making sure that sustainable availability and stability and also pay key attention to low income and old households during intervention programme. This implies that household energy consumption differs from one place to another, and not all factors are important and will be considered in examining energy consumption in different places.

3. Methodology

Energy stacking is mostly observed in rural areas of the less developed countries and to a smaller level in urban areas. Heltberg(2004) emphasized that in countries, such as Ghana, Nepal and Nigeria, it is observed by a larger size of the population. Based on the assumptions of neoclassical economic theory, households use the concepts of separation and multi-stage budgeting system in maximizing their satisfaction. Disposable income is always a concern for many households, many of them are tend to determine first, how much of their income will be used on energy and then determine how much to be spent on the various source of energy and the quantity and quality of such energy. The energy stacking model allowed for inclusion of variable to be used on econometric

modeling based on the foundation of neoclassical tradition.

3.1 Sources of Data

The data of the study was drawn from households in Chikun Local Government Area of Kaduna State projected population figure of 502,500 based on the 2016 National population commission projection and Kaduna State Bureau of Statistics.

3.2. Sample Size and Sampling Technique

The study adopted a formula developed by Taro Yamane (1967) and determined the size of the sample at 95% level of confidence and 5% degree of variability.

The sample size was determined by the formula as follows:

$n = N / 1 + N(e)^2$

Where,

N = population size

n = sample size

e = error margin

$n = N / 1 + N (e)^2 = 502, 500/1+502,500(0.05)^2 = 400$ respondents.

For data collection for the study, a total of 438 questionnaires were administered instead of a predetermined sample number of 400. This was to reduce challenge of low response rate.

As such, cluster area sampling method was used as one of the most suitable technique for the collection of data for the study. The survey covered all the 12 wards in Chikun Local Government Area. A three stage cluster area sampling method was used in choosing respondents. In the first stage, the twelve (12) wards were categorized into urban and rural wards. A total of six (6) wards were used from urban areas, while six (6) wards were also used from rural areas. These give a total of twelve (12) wards as sampled wards. At the second stage, five (5) communities were randomly chosen from each chosen wards in the urban areas, which gives a total of thirty (30) communities from the urban areas. On the other hand, four (4) communities were randomly chosen from the chosen wards from the rural areas, making a total of twenty four (24) communities from the rural areas. This gives a total of fifty (54) as sampled communities that were used in the study. In the final stage nine (9) households were chosen systematically from each of the chosen communities of the urban areas making a total of 270($30 \times 9=270$) household that were chosen from the urban areas. Also 7 households were systematically chosen from each of the chosen rural communities making a total of 168($24 \times 7=168$) households that were chosen in rural areas. Therefore, a total 438 questionnaires were distributed to respondents.

To achieve the objective of the study, multinomial logit model was used to examine the determinants

of household energy consumption mix. The justification for the adoption the multinomial logistic model is rooted on the fact that the dependent variable which is household energy consumption is a nominal or categorical variable with more than two choices or categories. These choices or categories include: liquefied petroleum gas, electricity, charcoal, firewood and kerosene. Hence, the multinomial logit model is shown in equation 1 below

$$\Pr(Y_t=J) = \frac{e^{\beta iXi}}{\sum_{it}^{i} e^{\beta iXi}} \quad \ldots\ldots\ldots\

Table 4.1. Distribution of Households Source of Energy use for Cooking and Lighting

Energy use for Cooking	**Frequency**	**Percentage (%)**
Firewood	170	46.1
Charcoal	58	15.7
Kerosene	3	.8
Gas	133	36.0
Electricity	5	1.4
Energy use for Lighting		
Firewood	1	.3
Charcoal	3	.8
Kerosene	35	9.5
Gas	10	2.7
Electricity	319	86.7

Source: **Researcher's Computation, 2021**

Table **4.1** revealed that 46.1 per cent of the households uses firewood as energy source for cooking, 36 per cent uses Gas, 15.7 per cent uses charcoal, 1.4 percent uses electricity, while 0.8 per cent uses kerosene for cooking. Also the table revealed that 86.7 per cent of the households uses electricity for lighting, 9.5 per cent uses kerosene 2.7 per cent uses Gas, 0.8 percent uses charcoal while 0.3 per cent uses firewood for lighting purpose.

Table 4.2. Estimates of Multinomial Logic Model of Determinants of Household Energy Consumption Mix in Chikun Local Government Area, Kaduna State, Nigeria.

(Reference Category=Electricity)

Household Energy Consumption Mix		B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Firewood	Intercept	134.257	5.481	599.921	1	.000			
	Household Size	1.452	1.028	1.995	1	.158	4.273	.570	32.055
	Household Energy Expenditure	-29.102	.779	1394.261	1	.000	2.297E-13	4.986E-14	1.058E-12
	Ownership of housing unit	-.524	.908	.333	1	.564	.592	.100	3.509
	Ownership of Electrical Appliances	-4.589	.926	24.543	1	.000	.010	.002	.062
	Age of household head	.638	.662	.929	1	.335	1.893	.517	6.932

	Household income	-.423	.760	.310	1	.577	.655	.148	2.905
	Educational Level	-1.366	.990	1.903	1	.168	.255	.037	1.777
	Type of residence	.361	.925	.152	1	.696	1.435	.234	8.788
Charcoal	Intercept	126.897	5.132	611.418	1	.000			
	Household Size	1.630	.959	2.891	1	.089	5.103	.780	33.401
	Household Energy Expenditure	-25.631	.400	4113.252	1	.000	7.391E-12	3.377E-12	1.618E-11
	Ownership of housing unit	-.540	.860	.394	1	.530	.583	.108	3.143
	Ownership of Electrical Appliances	-3.927	.907	18.758	1	.000	.020	.003	.116
	Age of Household head	.273	.611	.200	1	.655	1.314	.397	4.354
	Household income	.078	.664	.014	1	.906	1.081	.294	3.975
	Educational Level	-.861	.921	.875	1	.350	.423	.070	2.569
	Type of residence	.179	.811	.048	1	.826	1.196	.244	5.865
Kerosene	Intercept	125.247	4.979	632.792	1	.000			
	Household Size	1.786	.922	3.755	1	.053	5.967	.980	36.344
	Household Energy Expenditure	-24.498	.334	5382.359	1	.000	2.295E-11	1.193E-11	4.416E-11
	Ownership of housing unit	-.473	.829	.326	1	.568	.623	.123	3.165
	Ownership of Electrical Appliances	-3.378	.887	14.510	1	.000	.034	.006	.194
	Age of Household head	.033	.577	.003	1	.954	1.034	.334	3.203
	Household income	-.036	.616	.003	1	.953	.964	.288	3.227
	Educational Level	-.963	.899	1.149	1	.284	.382	.066	2.221
	Type of residence	-.585	.773	.573	1	.449	.557	.122	2.535
Gas	Intercept	114.478	4.575	626.153	1	.000			
	Household Size	1.294	.869	2.215	1	.137	3.648	.664	20.051
	Household Energy Expenditure	-22.416	.000	.	1	.	1.841E-10	1.841E-10	1.841E-10
	Ownership of housing unit	-.640	.809	.625	1	.429	.527	.108	2.575

Ownership of Electrical Appliances	-1.829	.853	4.599	1	.032	.161	.030	.854
Age of Household head	-.182	.556	.107	1	.744	.834	.280	2.480
Household income	-.213	.600	.126	1	.723	.809	.250	2.619
Educational Level	-1.011	.881	1.319	1	.251	.364	.065	2.043
Type of residence	.472	.713	.438	1	.508	1.604	.396	6.490

This section indicates the relationship that exists between the determinants of household energy consumption mix. The multinomial logit estimate in Table 4.2 revealed that household energy expenditure is negative and has a significant relationship with the use of firewood. The result indicate that a 1 per cent increase in household energy expenditure will reduce the use of firewood by 29.1 per cent. The results corroborate with Mekonen & Kohlin (2009) which indicate negative relationship between household choice of energy and household energy expenditure on firewood. Ownership of electrical appliance is negative and significant statistically for firewood. The result showed that a 1 per cent increase in Ownership of electrical appliance will reduce the use of firewood by 4.48 per cent. Household energy expenditure is negative and has a significant relationship with the use of charcoal. The result revealed that a 1 per cent increase in energy expenditure will reduce reduce the use of charcoal by 25.6 per cent. Ownership of electrical appliance has a negative and significant relationship with charcoal.
The result showed that a 1 per cent increase in Ownership of electrical appliance will reduce the use of charcoal by 3.92 per cent. Also, household energy expenditure is negative and has a significant relationship with the use o of kerosene. The result indicate that a 1 per cent increase in energy expenditure will reduce the use of kerosene by 24.4 per cent. Ownership of electrical appliance has a negative and significant relationship with kerosene. The result showed that a 1 per cent increase in Ownership of electrical appliance will reduce the use of kerosene by 3.37 per cent. Further, household energy expenditure is negative and has a significant relationship with the use o of Gas. The result indicate that a 1 per cent increase in energy expenditure will reduce reduce the use of kerosene by 22.4 per cent. Ownership of electrical appliance has a negative and significant relationship with kerosene. The result showed that a 1 per cent increase in Ownership of electrical appliance will reduce the use of kerosene by 0.82 per cent.It is important to note that income is key determinant in energy switching, it is not the factor that determine energy mix.

5. **Conclusion and Recommendation**

The study analyses household energy consumption mix household in Chikun Local Government Area, Kaduna State. The study showed that most households in Chikun Local Government Area, use firewood, Charcoal, kerosene and Gas for cooking, while is use for electricity for lighting purpose. From the findings, the study therefore, recommended that:

1. Households should be encourage by government legislation to improve the use of energy saving appliances against the use of firewood and charcoal.
2. Household should devote more of their expenditure on energy towards the use of Gas as an alternative cooking energy source to reduce the usage of firewood and charcoal. This commitment will reduce the pressure on forest reserve.

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