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Determinants of urban households' charcoal dependence in Nigeria: An assessment of demographic and economic drivers

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Abstract
The aim of this study is to assess the drivers of charcoal consumption in urban Kaduna, Nigeria. The study employed quantitative cross-sectional survey design involving a structured questionnaire that was administered to 400 household charcoal consumers. The outcomes of the study showed that charcoal is in high demand, and demographic and economic drivers such as household size, level of education, income, and energy prices play a significant role in determining the level of household dependence on charcoal. The study recommended a need to create awareness on the environmental consequences of over-exploitation of forest resources and poor management practices as well as mitigation action that focuses on emissions reduction and the use of clean energy that will bring about environmental sustainability.

Keywords: Urban households, charcoal dependence, environmental sustainability, demographic/economic drivers, Nigeria.

1. Introduction

Despite an increase in per capita income, investment in electrification, and significant renewable energy potential, charcoal remain the dominant source of cooking and heating energy for more than 80% of household in sub-Saharan Africa (Zulu & Richardson, 2013). Charcoal production has increased in Africa over the last two decades, gradually extending Africa's global lead to about 61%. The global production of wood charcoal reached 52 million metrics tons in 2013. However, this increase has not been reflected in the global export because a substantial share is locally consumed. For example, in 2013, wood charcoal exports were about 2 million tons or only 4% of global production, an indication that the significant share of global charcoal output is locally consumed especially in Africa. The Food and Agricultural organization estimates the global production of charcoal to represents about 310 million m3 in round wood (wood fuel) equivalents. More than 15% of global wood fuel production is converted to charcoal; the share of wood fuel converted to charcoal has been increasing continuously. Similarly, Namibian Ministry of industrialization, trade and SME development in 2016, estimates that 30% of the wood fuel is being used for charcoal production in Africa. World Bank (2011) noted that the triple effect of population growth, increased urbanization, and relative price changes of alternate energy sources for cooking are expected to make consumption of charcoal remain at very high levels or even increase in absolute terms over the next decades.

Reviewing the level of charcoal consumption in Africa, a regional study for Southeast Africa estimated that charcoal consumption from 1990-to 2000 grew by about 80% in both Lusaka and Dar es Salaam. From 2001-to 2007, the number of Dar es Salaam households cooking with charcoal increased from 47% to 71%, while

the use of LPG dropped from 43% to 12% (World Bank, 2011). In Kenya, 2 million people depend on the charcoal sector alone, which proves its importance not only as a source of energy but as a source of livelihood. In other urban areas of Tanzania, the share of the population cooking with charcoal remained at 53% (World Bank, 2011). In Nigeria, Sufiyan, Muhammed and Musa (2021) shows that per capita per annum consumption of charcoal is very high with 26,937kg. It has been noted that Nigeria's high consumption of charcoal is linked to the volatility of energy supply in the last three two decades. Even though Nigeria is one of the leading exporters of petroleum products in the world, electricity, kerosene, and LPG supply for household activities such as cooking is very low (Muazu, 2020). Similarly, about 65% of the total energy consumption is taken by the household, probably due to the underdevelopment of the industrial sector. Cooking accounts for about 91% of the total domestic energy consumption in Nigeria (Oyedepo, 2012). Furthermore, increasing urbanization rates could also explain the notable steep increase in charcoal consumption in Nigeria because charcoal is the cooking fuel of many urban dwellers, rather than wood fuel.

In contrast to the significance of charcoal in providing cheap and easy energy to many households in developing countries, climate science views that charcoal burning emits black carbon (BC) as part of visible smoke, which is particulate matter that results from incomplete combustion. (National climate change policy (2021-2030). This accelerates the melting of ice and snow and contributes to regional pollution which can alter climatic conditions and precipitation patterns over a wide area. Large-scale charcoal production in sub-Saharan Africa has been a growing concern due to its threat of deforestation and land degradation. It is cited as the most environmentally devastating phase of the traditional energy supply chain in Nigeria (National climate change policy (2021-2030). The influx of charcoal trucks and cars into many parts of urban areas in Nigeria indicates that many people have discovered the 'milk and honey in the charcoal value chain, with some wealthier and middle-class people involved at its bulk commodity level (Jamala, Abraham, Joel and Asongo, 2013). To this end, there is a great need for a clear assessment of drivers of charcoal consumption in Kaduna North Local Government Area of Kaduna State to provide effective data for environmental sustainability and establish whether or not demographic and economic variables affect charcoal consumption in the study area.

2. Literature Review

2.1 Conceptual issues on charcoal value chain

In many developing countries, the woodfuel and charcoal value chain operates informally. However, the value chain has established business activities with a distinct production, carbonization, transportation, and retail line (Muazu, 2019; Naibbi, 2013; Geoffery, 2010). According to Geoffery (2010), many different stakeholders are participating in the following activities: wood production, carbonization, transportation, retailing and distribution, and consumption. Policies and regulations. Wood producers have the largest number in the sector, they are mostly individuals or small informal enterprises. The producers may own and manage their forest, in the case of a private plantation, and have laborers cut wood or do the cutting by themselves, depending on the size of the forest. Blodgett (2011) argue that the general problem of wood producers in the value chain is lack of management and they often have very little knowledge about proper forestry management. Another activity that employs people is carbonization where wood is heated in the absence of sufficient oxygen. This allows pyrolysis to take place, driving off the volatile gases and leaving the carbon or

charcoal remaining. The transportation section is also significant in the charcoal value chain. The role of transporters is the transfer of charcoal from the charcoal producers to the retailers in urban areas. The main gap in the transportation section of the value chain is the lack of direct connection between transporters and retailers due to the influence of middlemen. Another problem is the lack of recovery of charcoal dust. Blodgett (2011) shows that Up to 20% of charcoal is wasted as dust, particularly during the transport process in Rwanda. Another significant group in the charcoal value chain is the charcoal retailers and distributors. Charcoal retailers sell and distribute charcoal to consumers, they are found in many major markets in urban areas as well as many small retailers which sell out in sheds and kiosks. In some cases, charcoal is sold in either bucket or bag. The main setback for retailers in the charcoal value chain is a lack of business management skills.

2.2 Theoretical and Empirical Review

Generally, household energy is classified into two groups. The first group is the modern/conventional form of energy namely, electricity, LPG, kerosene/ paraffin, solar, nuclear, etc. Then, the second group is the traditional/dirty energy source which is the biomass obtained from the environment like woodfuel, charcoal, crop residue, and animal waste (Getamesay, Workneh, Getachew, 2015). These energy types are used for household chores or services such as cooking, heating, and boiling that support the overall improvement of life.

Two prominent theories have been used to explain household behavior with energy consumption in the developing countries. The first one is the energy ladder hypothesis that is rooted in economic theory of consumer behavior championed by Hosier R and Dowd J (1987) and the second theory is the fuel stacking theory that came about from studies conducted by Masera, O and J. Navia, (1996) and Masera, Saalkamp B, Kammen D, (2000) to expound the inability of energy ladder model in capturing other important variables in household energy transition. According to energy ladder theory, an increase in household income propels them to systematically move away from traditional energy to modern energy that is more efficient and user friendly (i.e charcoal-kerosene-LPG-electricity). Fuel switching becomes the central concept of the energy ladder hypothesis, referring to the displacement of one fuel by another. The movement of the household up to a new fuel is automatically a move away from the fuel used before (Van Der Kroon et al, 2013). However, Nazer (2016) argues that there is a strong nexus between household energy transition and the level of economic development. Contrary to the energy ladder hypothesis, the fuel stacking theory argues that households in the developing countries do not switch to modern energy sources as portrayed by the energy ladder theory instead, they consume a combination of fuels as a backup to have a sense of energy security taking into cognizant that complete dependence on commercially-traded fuels leave households vulnerable to variable prices and often their services are unreliable. This may entail combining solid fuels with non-solid fuels. Instead of the households moving up the ladder step by step as incomes increase, households choose different fuels from a menu. We underpinned this study based on the two premises that in the developing countries, certain factors drive households to consume different types of fuels for their activities.

According to Chidumayo and Gambo (2013), Brazil is the world's largest producer and consumer of charcoal, more than 90% of the population have access to electricity yet residential consumption has persisted at 9.7% of the country's total charcoal production. This goes to show that charcoal consumption is driven by many reasons. In Zambia, Nyembe, (2011) founds out that factors driving charcoal

consumption were found to be low income, low wealth and poor household access to electricity. The model suggests that the tendency of using charcoal among formal sector employed household is negative and significant at 5%. Abdullahi, Musa, Idi, Adamu and Yusuf (2017) studied socio-economic determinants of household's fuel consumption in Nigeria. The findings revealed that demographic characteristics, economic status, public awareness and social variables are strong determinants of household's energy choice charcoal, woodfuel and modern energy. Bamiro and Ogunjobi (2015) in Nigeria found that price of wood, price of kerosene, and family size negatively determines household's monthly fuel expenditure. Özcan, Ulay, Gruk (2013) studied the economic and demographic determinants of household energy use in Turkey. Using a multinomial logit model, the result revealed that larger households prefer dirty fuels (charcoal inclusive) over clean fuels.

3. Methodology

3.1 Study area

Kaduna North is located between latitudes 10º28' N and 10º37' N and longitudes 7º25' E to 7º37' E. Bordered by Chikun Local Government Area in the South-eastern part, Igabi local government area to the Southwest (Maidamma, 2006). The Local government area consisting of the following settlements: Kawo, HayinBanki, RafinGuza, UnguwanDosa, Badarawa, Malali, UnguwanRimi, UnguwanYero, Unguwan Kanawa, Kabala, Abakpa, Unguwan Shanu, central business district (CBD) and Kwaru. The area had a population of 357,694 as of the 2006 census, and a population projection of 497,783 in 2017 (NPC, 2017). The area has a mixture of populations, but the Hausa tribe is the dominant ethnic group in the area.

3.2 Data source and sampling

Firstly, a reconnaissance survey was carried out to obtain available relevant first-hand information on the physical and human aspects of the study area. Questionnaires were administered to household charcoal consumers of Kaduna North Local Government. (According to 357,694 persons from the data of population census 2006). The sample size was determined by using Yamane formulae thus;

$$n = \frac{N}{1 + N * (e)^2}$$

Where n= desired sample size

N = total population

e = acceptable error limit 0.05

After substituting the numbers into the Yamane formula, the number of samples is 399.9 persons which are rounded off to 400 and the same number of questionnaires were administered to the 12 wards. Purposive sampling was used to capture all the 12 wards that formed Kaduna North LGA namely, Unguwan Sarki, Gabasawa, Kabala, Kawo, Unguwan Shanu/Abapka, Mai burji, Gaji, Liman, Shaba, Hayin Banki, Badarawa/malali, and Unguwan Dosa. In each ward, 33 questionnaires were administered randomly to the household charcoal consumers, except for Unguwan Shanu where 37 questionnaires were administered because of their high density.

4. Results and Discussion

4.1 Demographic drivers of charcoal consumption

Table 1: Marital status and charcoal consumption

Marital status	Frequency	Percentage (%)
Single	92	27
Married	186	54
Divorced	40	12
Widow	4	7
Total	**342**	**100**

Source: Researcher's computations

Table 1 shows that 54% of the married households consume charcoal, while 27% of those that use charcoal are the singles. The divorced and widowed have 20% and 7% respectively. From the result, married households are the major consumers of charcoal. This outcome corroborates the finding of Muazu, Ogujiuba and Tukur (2020) in South Africa showing that as the household marital status changes, the probability of consuming traditional energy will decrease.

Table 2: Educational level and charcoal consumption

Educational Attainment	Frequency	Percentage (%)
Quranic education	44	13
Primary	68	20
Secondary	76	22
Tertiary	140	41
Others	14	4
Total	**342**	**100**

Source: Researcher's computations

Table 2 is trying to establish the nexus between the household level of education and charcoal consumption. It shows that households with tertiary education qualifications consume more charcoal (41%) than households with secondary and primary education (22% and 20%). Meaning that instead of households with tertiary education consuming dirtier wood fuel, they prefer charcoal that is less in terms of environmental pollution and better in thermal efficiency. Lay et al. (2013) used a multinomial model in rural and urban Kenya to show how higher education level is associated with a higher probability of using electricity and solar energy and the lower probability of using wood related energy and kerosene

Table 3: Family size and charcoal consumption

Family Size	Frequency	Percentage (%)
Less than 3	48	14
4-6	72	21
7-10	100	29
10-13	165	19
13 and above	42	12
None	15	5
Total	**342**	**100**

Source: Researcher's computations

Table 3 on family size and charcoal consumption revealed that household with a family size of 7-10 consumes more charcoal than households with a family size of 10-13, 4-6, 13, and above respectively. This result shows a mixed outcome in the sense that a larger household could be a factor in charcoal consumption on one hand, and on the other hand it may not be. The result support the findings of Muller and Yan (2016) which shows that the effect of household size on fuel switching remains ambiguous empirically.

4.2 Economic drivers of charcoal consumption

Table 4: Household occupation and charcoal consumption

Occupation	Frequency	Percentage (%)
Farmer	42	12
Trader	92	28
Student	20	6

Civil servant	175	51
Others	10	3
Total	**342**	**100**

Source: Researcher's computations

The result in table 4 links charcoal consumption with household occupations civil servants have the highest charcoal consumption (51%), while traders have 28% thereby creating a big margin between the 2 respondents. The farmers, students, and others have consumption rates of 12%, 6%, and 3% respectively. From the result, civil servants have displayed high charcoal consumption, this may explain the significance of education in household energy consumption where educated households prefer charcoal over wood fuel.

Table 5: Household monthly income and charcoal consumption

Monthly Income	Frequency	Percentage (%)
N1,000-N10,000	148	43
N11,000-N20,000	99	29
N21,000-N30,000	55	16
N31,000-N40,000	20	6
N41,000 and above	20	6
Total	**342**	**100**

Source: Researcher's computations

Table 5 shows that households with higher income between N31,000-N40,000, N41,000, and above as well as N21,000-N30,000 consume less charcoal than the households with N11,000-N20,000 and N1,000-N10,000. This shows that the higher the income the less the consumption of charcoal. The above result was agreed by the Findings of Nyembe (2011) that shows the factors driving charcoal consumption were found to be low income.

Table 6: Utilization of charcoal despite the price increase

Response	Frequency	Percentage (%)
Yes	199	58
No	130	38
Do not Know	13	4
Total	**342**	**100**

Source: Researcher's computations

Table 6 shows that 58% of the households reported that they still use charcoal even when the prices shoot up, the reason being that it is easy to use and environmentally friendly. During periods of charcoal scarcity where prices are inflated by charcoal vendors, households claim that they still purchase charcoal because other fuels are expensive e.g. kerosene and gas. 38% of the households pointed out that they do not use charcoal when prices increase. This is because they have other preferences of energy such as kerosene, corn stalk, and gas .4% said that they do not buy charcoal as such do not know if charcoal prices increase or not, they use either kerosene, gas, or wood fuel.

4.3 Regression analysis of demographic and economic variables on charcoal consumption

Table 7: Regression analysis for the effect of demographic drivers on charcoal consumption

	Coef.	t-stat	P>t
Const	1.742	6.38	0.000
Age	-0.005	-1.75	0.0862*
Marital status	0.432	3.34	0.001***
Educational level	-0.028	-1.86	0.063*
Family Size	0.095	3.85	0.000***
Prob F		0.000***	
R-square		0.420	
Adj R-square		0.379	
Observations		945	

The analyses were presented in Table 7 above. It could be seen from the tables that the F statistics which measure the model's fitness are 0.000. This implies that the two models are significant at 1%. In other words, the models are fit at a 99% level of confidence. The results of the relationship between the demographic variables (age, Marital Status. Educational level, and family size) are presented in Table 7. The result shows that age and educational levels have a negative relationship with charcoal consumption. The results for the two variables are statistically significant at 10%. On the contrary, marital status and family size have a positive effect on charcoal consumption.

Table 8: Regression analysis for the effect of economic drivers on household charcoal consumption

	Coef.	t-stat	P>t
Const	3.398	13.11	0.000***
Income	-0.219	-1.79	0.074*
Price	-0.043	-2.95	0.003***
Employment	-0.023	-1.99	0.032**
Prob F		0.000***	
R-square		0.216	
Adj R-square		0.174	
Observations		945	

The results of the relationship between the economic variables (income, price, and employment) are presented in Table 8 above. The result shows that all three economic variables have a negative relationship with charcoal consumption. The results are not surprising because high employment and high income propel households to opt for an alternative modern energy source. Similarly, the high price of charcoal may drive the household consumers away and as a result, there will be a decline in charcoal consumption. The work of Kuunibe, Issahaku and Nkegbe (2013) in the west region of Ghana shows that as household's monthly income increases, the probability that they will choose traditional fuel also decreases.

4.4 Charcoal consumption and environmental sustainability

Table 9: Effect of charcoal consumption on the environment

Response	Frequency	Percentage (%)
Yes	138	40
No	67	20
Do not Know	137	40
Total	**342**	**100**

Source: Researcher's computations

Table 9 shows that 40% of the households agreed that charcoal consumption has effects on the environment. It also indicated that the effects of charcoal consumption in the households are mainly negative which involves desertification, erosion, loss of wildlife, deforestation, etc. About 20% of the households revealed that charcoal consumption does not have any effect on the environment. Conversely, the result also revealed another scenario, which indicated that people are not aware of the environmental effect of charcoal consumption because 40% of the households show that they do not know the effect of charcoal consumption on the environment.

Table 10: Charcoal consumption and health-related problems

Response	Frequency	Percentage (%)
Yes	200	58
No	60	18
Do not Know	82	24
Total	**342**	**100**

Source: Researcher's computations

Table 10 revealed that charcoal consumption is accompanied by some health-related problems. According to the result, 58% of the households attested that their families have experienced health-related problems ranging from eye infections, fever, chronic cough, catarrh, injuries, etc, as most of the people are from Unguwan Rimi GRA, Unguwan Dosa, and Unguwan Sarki who are government workers and have knowledge about issues regarding global warming. About 18% reported that they do not experience any health challenges resulting from charcoal usage, especially in areas such as Unguwan Shanu, Rafin Guza, Kabala, Badarawa, Kawo, etc. as most of them have little knowledge about issues of global warming. While 24% indicated that they are not aware of any illness caused by charcoal consumption. World Health Organization, shows that 1.5 million people die every year from respiratory diseases related to smoke inhalation; most of them women and children. The use of biomass fuels like charcoal and firewood for cooking or heating leads to high levels of indoor air pollution; especially when burned on traditional stoves or open fires indoors

4.5 Household primary type of fuel used

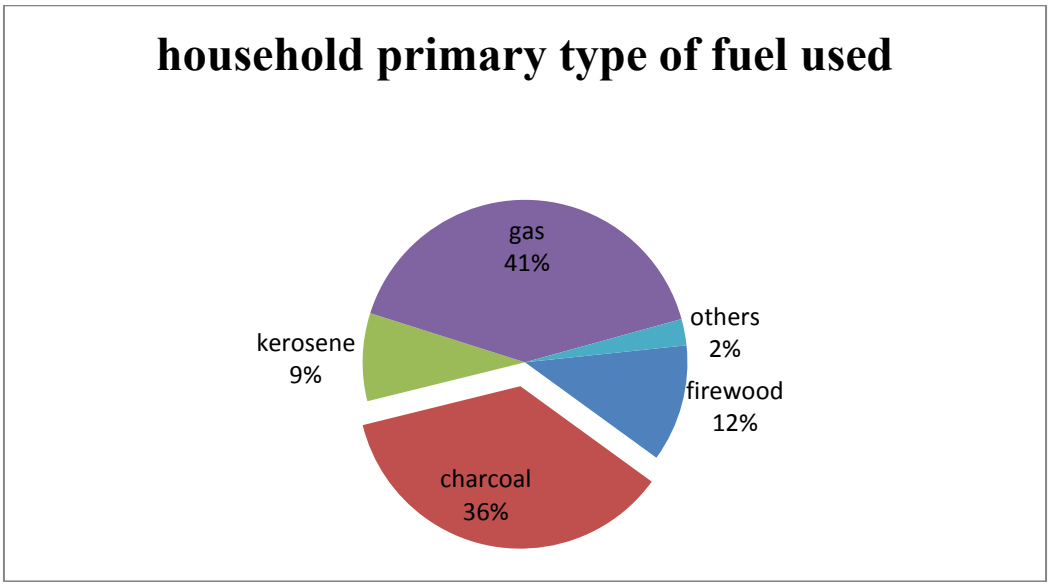

Figure 1: Household primary type of fuel used

The above chart in Figure 1 depicts the percentage of fuel types used by households. 12% of households use wood fuel as their primary energy. 41% use gas as their primary energy source for domestic activities. 36% also indicated their preference for charcoal as their primary energy, while 9% consume kerosene as domestic energy. From the result, it is evident that charcoal and gas possess the highest percentage as most households prefer to use them because they are convenient and also affordable compared to other sources of energy (kerosene and electricity).

5. Conclusion and Recommendations

This study was carried out essentially to assess the drivers of household charcoal consumption and environmental sustainability in Kaduna North LGA. The study has established that charcoal is one of the major energy sources for the households in the area signifying a widening demand for charcoal on one hand, and increasing pressure on the remaining forest trees on the other hand. Therefore, for Nigeria to achieve the Nationally Determined Contribution (NDC) of reducing its greenhouse gas (GHG) emissions intensity of GDP by 20% by 2030, there is an urgent need to address the driving factors of household's energy consumption such as education, family size, income and price of energy. Thus, strict actions need to be taken to ensure climate resilience, particularly in the area of expansion of energy supply based on renewable and other low carbon technology alternatives. More so, there is a need to create awareness and education on the environmental consequences of over-exploitation of forest resources and poor management practices as well as mitigation action that focus on emissions reduction and the use of clean energy that will bring about environmental sustainability.

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