Determinants Of Urban Charcoal Demand In Ogbomoso Metropolis

Ajao, A.O.

Agricultural Economics Department, Ladoke Akintola Univeristy Of Technology, Ogbomoso,
oaajao57@lautech.edu.ng

Abstract: The study analyzes urban households demand for charcoal within the context of overall household cooking fuel consumption, with specific objectives of estimating the respective proportion of expenditure of the main cooking fuel types in total ***fuel expenditure*** and describing the household and fuel characteristics which determine demand for charcoal in urban areas. The study employed the use of cross-sectional data from urban households survey conducted on a sample of two hundred households from ten communities in the area. The data were collected with the aid of structured questionnaire and analyzed using descriptive statistics and Almost Ideal Demand System Model estimated by Ordinary Least Square Regression. It was observed that educational level, household size, electrification status and assets significantly determined the charcoal demand in the study area.
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Kew word: charcoal, almost ideal demand system; fuel

Introduction

Wood fuels (charcoal and fuel wood) play a significant role in the fuel requirements of many developing countries especially Nigeria where there is an increasing dependence due to growing urban population coupled with limited accessibility to the modern alternative fuels. The report of Food and Agriculture Organization (2005) indicates that extraction of trees for wood fuels accounts for sixty one (61) percent of total wood removal globally and that hundreds of millions of people remain completely dependent upon wood for fuels.

In developing countries, wood fuels contribute to 83% of total energy consumption (World Energy Council, 2004), and in the case of charcoal, Africa consumes over 50% of the world's total production of which Nigeria alone consumes about 16%, majority of this charcoal is consumed in urban areas by households for cooking and heating.

In several energy policy documents in Nigeria, it is desirable that household will over time experience a transition from charcoal to more modern fuel types such as kerosene and gas. This transition has not occurred as charcoal has become an increasingly dominant fuel for urban households. Charcoal has remained the most common cooking fuel in Nigeria, and over the year, charcoal supply/demand imbalance in some parts of the country has adversely affected the economic well-being of the people. On the national level, increasing charcoal consumption contributes to deforestation with consequent land degradation and soil erosion.

The widespread and increasing popularity of charcoal among Nigerian urban households is as result of rapid urbanization, high population growth, inadequate supply of the modern alternative fuels at prices which consumers can easily afford, fall in the real income of urban dwellers due to declining economic condition and availability of charcoal at relatively cheaper prices. The situation now in Nigeria is that thousands of bags of charcoal enter most of our urban centres on daily basis every year and these add up to quite a large tonnage of charcoal per year for which trees had to be cut from forest.

In Nigeria the four main cooking fuels used in urban centres are charcoal, fuel wood, kerosene and Liquefied Petroleum Gas (LPG), however, there is a situation of erratic supply of modern fuels (kerosene and gas) and availability of charcoal at relatively cheaper prices, many urban households therefore see the use of charcoal as an alternative way out of this problem of inadequate supply of the modern alternative fuels, hence there is massive shifting to the use of charcoal among urban households, a situation which in turn leads to increase in demand for charcoal among urban households. This increase in demand however has devastating impacts upon the forests, the rural supply areas and agriculture. Adverse impact that are already apparent but which would increase if the trend continues are: soil erosion, less biomass available for all other uses, traditional economic forest products such as fruits, nuts, medicinal trees becoming scarce, and more land being opened for cultivation but fall in agricultural productivity.

Therefore, considering the overall effect of this problem and the need for better understanding of the situation, this study examined the proportion of cooking fuel expenditure in total household expenditure and estimates the respective proportion of expenditure of the main cooking fuel types in total fuel expenditure.

2. MATERIALS AND METHOD:

Chambwera (2004) developed an urban household energy consumption framework in analyzing the urban fuel wood demand among households in Zimbabwe. The energy mix model used as a framework captures the reality that household use multiple energy sources and that the use of different energy sources is associated with several indicators of socio-economic status such as income, household size etc. In addition to the presentation of the physical combination of different energy sources, the framework also presents energy consumption in terms of relative expenditures on different sources of energy. According to him, household fuel wood demand has its basis in household quest to meet their basic livelihood requirement through energy consumption together with other commodities. However, for the scope of this study which is the analysis of urban household charcoal demand within the context of overall household domestic cooking fuel, electricity is not considered as a fuel and will not be included in the framework. Therefore, the framework to be used in this study will be the fuel mix model. This conceptual framework presents the households fuel consumption mix as being influenced by a set policy levers, which include:

a) Household characteristics such as household size, income, value of the fuel-using appliances e.t.c
b) Fuel characteristic such as prices, availability, and convenience.

When a particular fuel mix is considered, the negative effects on the forests, in form of reduction in the availability of economic forest products will be determined through the amount of charcoal in the mix.

In term of expenditure, the ultimate decision of all households is about how much of its total fuel expenditure to allocate to each fuel to achieve maximum satisfaction. The total fuel expenditure will depend on several factors such as income and other household factors.

The allocation of Total Fuel Expenditure (TFE) to individual fuel type will be done in such a way as to maximize fuel utility of household subject to its fuel outlay, the price of the fuels and other factors. The overall household consumption of different household goods and services shall first be considered, fuel will then be assumed to be a compound commodity, which can be broken into its separate components of the different fuel types such as kerosene, charcoal, gas, and fuel wood.

In Nigeria, kerosene, charcoal fuel wood and gas are the principal domestic fuel types in urban areas, therefore, these are the fuels considered in the framework for an analytical purpose. They are the different fuel types that households mix to satisfy their domestic fuel requirement in urban centres.

When fuels of different types are measured in a common unit e.g Mega Joule, (Mj), the household fuel consumption scenario can be put as

$$TQF = Qc + Qk + Qg + Qf \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Where TQF denotes total quantity of fuel consumed (in Mega Joules).

Q_c, Q_k,Q_g and Q_f denote quantities of charcoal, kerosene, gas and fuel wood respectively, all measured in MJ.

To translate these into their respective physical quantities, these appropriate conversion factors of UNEP (1991) fuel density factors can be used.

Charcoal	1kg	=	31MJ
Kerosene	1L	=	35MJ
Gas	IKg	=	23MJ
Fuel wood	1kg	=	16MJ

In term of expenditures the household fuel consumption scenario can be put as:

$$TFE = Ec + Ek + Eg + Ef \quad \ldots\ldots\ldots\ldots\ldots(2)$$

Where TFE is the total fuel expenditure by a household.

Ec, Ek, Eg and Ef are household expenditure on charcoal, kerosene gas and fuel wood respectively.

Total fuel expenditure itself is expressed as a share of total household expenditure such that.

$$\omega_{TFE} = \frac{TFE}{TE} \quad \ldots\ldots\ldots\ldots\ldots(3)$$

where ω_{TFE} is the share of total fuel expenditure in total household expenditure TE.

The share of each fuel in the expenditure mix is a ratio of its expenditure and total fuel expenditure such that for all fuels in the mix, these ratios add to unity $\sum \omega i = 1$.

Where w_i is the share of fuel i defined as;

$$w_i = \frac{Ei}{TFE} \quad \ldots\ldots\ldots\ldots(4)$$

E_i is the expenditure on fuel i which can be expressed as

$E_i = p_i q_i$, and TFE is the total household fuels expenditure

Therefore,
$$w_i = \frac{Piqi}{TFE} \quad \ldots\ldots\ldots\ldots(5)$$

Following Chambwera (2004) approach, the quantity of fuel i consumed can be estimated from the above expression as follow

$$q_i = \frac{\omega i TFE}{Pi} \quad ....(6)$$

And specifically for charcoal, the expression becomes

$$q_c = \frac{\omega c TFE}{Pc} \quad ....(7)$$

The work of Falcao (2002) was on the analysis of the price of fuel wood and charcoal in markets of Maputo city, using the existing wood fuel data. The average nominal prices of charcoal, fuel wood, kerosene and minimum salaries per year since 1985-1997 as well as the consumer price index and inflation rate were compiled from literature. The decade trend of real prices of charcoal and fuel wood was estimated based on regression analysis and exponential model. Alastair (2007) explored the socio-economic role of charcoal and the potential for sustainable production with variety of social science research methodologies such as Participatory Rural Appraisal, with semi-structural interviews combined with transect walks through the charcoal producing districts, as well as a resource mapping exercise to learn about the community's resource base. The analysis of the livelihood and charcoal data involved the use of descriptive statistics, graphical representation and regression analysis to investigate the relationship between kiln inputs and outputs and in order to determine kiln efficiency and conversion rates, which could then be applied to estimate production rates for calculating sustainable production.

Mulenga (2002) combined both statistical and econometric analysis in his empirical strategy to investigate and analyze the demand for and substitution possibilities of charcoal in urban Zambia. The finding suggests that own price, price of kerosene, household income, size of household, size of dwelling and high cost of charcoal substitutes are some major factors that explain the demand for charcoal among urban households in the area. It illustrates further that substitution to more efficient energy forms such as electricity is weak and constrained by lack of funds to pay for electricity connection as well as monthly tariffs. The coefficient of the own-price elasticity is negative, significant and elastic while the coefficient of the household income elasticity is negative, weak, significant and inelastic. A situation which implies that while charcoal is a necessity for most of the households it is also an inferior goods.

The demand for all forms of energy, according to Gamtessa (2002), are price elastic, and cross-price relation indicates that kerosene is a substitute for both charcoal and fuel wood while electricity is a substitute for all the three. In his multivariate analysis of the consumption pattern there are findings that the probability of consuming traditional fuels in general declines with increase in income and the prices of the traditional fuels whereas it increases with the increase in prices of the modern fuels. The probability of consuming modern fuels increases with increase in income and prices of the traditional fuels and declines with an increase in modern fuels prices.

There are many other empirical literatures that concentrate on estimates of wood fuel demand with wide variety of coverage such as African, Asian urban, and rural, higher and lower income groups. Examples include Edmond (2002), Gupta and Kohlin (2003), Amacher *et al.* (2004), Baland *et al.,* (2005), and Chaudhuri and Fall (2003). The summary of such studies by Hyde and Kohlin (2002) indicated that the range of own price elasticity of demand found is -0.11 to -1.47 with only one of ten estimates greater than 1 in absolute value. The prices used in the studies range from market prices to various measures or indicators of households shadow prices for wood fuels.

Comparing the findings from Kebede *et al.*, (2002) on analysis of demand for several fuels among several urban households in Ethiopia with that of Chambwera (2004), there is a consistency as indicated by the negative values of the own price elasticities, and the cross price elasticity of kerosene and fuel wood showed that they were direct substitutes and their combination is an inferior substitute of electricity.

2.1 Sampling Procedure and Sample Size

A multistage sampling technique was used to select a total of 200 households needed for the study. First the two Local Government Areas of the metropolis were purposively selected because of their urban nature. These are Ogbomoso North and Ogbomoso South Local Government Areas. The second stage of the sampling involved random selection of five (5) communities, through balloting system out of the ten (10) communities in each of the Local Government to make a total of ten (10) communities. At the third stage, fifty percent of the total households in each of the selected communities were randomly selected.

The primary data needed for the study mainly centre on at-home consumption of charcoal and other cooking fuels (Kerosene, fuel wood, and LPG) together with other household attributes. The use of a structured questionnaire was made as an instrument for the collection of the data, and this was conducted among a sample of 200 households selected according to the sampling procedure. The questionnaire was administered to heads of households but in the absence of the head of the household, other members of the household such as spouse and grown up child who can provide the required information were interviewed.

2.2 Data collection and analytical technique

Data on household characteristics collected include sex of the head of the household, educational level measured in term of year of schooling, age of the head of household, size of the household, ownership of the house, electrification status of the house, value of all fuel-using appliances possessed by the household, while expenditure data include total expenditure and total fuel expenditure of the households.

Data on the price of charcoal is required to determine the actual quantity consumed given its budget share and expenditure. This charcoal price data was collected separately from the household survey though the data pertains to the same period as the household survey. Charcoal price data was collected from the selling points in a cross-sectional price survey carried out in the entire city covering 50 selling points.

Linear Approximate form of Almost Ideal Demand System (LA-AIDS) in order to determine the relationship between the budget share of each fuel, and the total fuel expenditure, fuel prices faced by households and household characteristics. The OLS regression analyses were carried out using the Limited Dependent Variable/Software (LIMDEP 7.0) package.

2.3 Model Specification

The linear approximate form of Almost Ideal Demand System Model to be estimated is specified according to Deaton and Muellbauer (1980) as follow:

$$\omega i = \alpha i + \beta_i In(TFE/P*) + \Sigma\gamma_{ij} InP_j + \phi X + Ui \quad \text{……………(8)}$$

Where

ωi are the share of household expenditure on fuel i in the total fuel expenditure

αi = the average value of the budget share of fuel i in the absence of price and income effects.

βi = effects of total fuel expenditure on the budget share of fuel i.

P_j = the price of fuel j

γ_{ij} = effects of the price of fuel in group j on the budget share of fuel i

TFE = the total fuel expenditure

P* = the price index

X = the vector of household characteristics with corresponding co-efficient vector ϕ

U = an error term

The above specified system is the Almost Ideal Demand System model which estimates the shares of expenditure of different fuels including charcoal in total fuel expenditure and how these shares change as fuel expenditure, prices and household characteristics changed. The model was estimated in the analysis using household survey data.

2.4 Variable Definition

The various variables used in estimating the AIDS model are defined as follow:

Educ :- Educational level of the household head.
Sex :- Sex of the household head (Male = 1, Female = 0).
Hhsize :- Household size (Number of individuals in the household).
Elec ::- Electrification status of the house in which household lives (Electrified = 1, Unelectrified = 0).
Room :- Number of room used by household.
LnAsset :- Natural logarithm of value of fuel using appliances possessed by household.
LnTfe :- Natural logarithm of household monthly fuel expenditure.
Own :- Ownership of house.
Pc :- Price of Charcoal.
Pf :- Price of Fuel wood.
Pk :- Price of Kerosene.
Pg :- Price of Gas.
Wc :- Share of charcoal expenditure in total fuel expenditure.
Wf :- Share of fuel wood expenditure in total fuel expenditure.
Wk :- Share of kerosene expenditure in total fuel expenditure.
Wg :- Share of gas expenditure in total fuel expenditure.

Result and discussion:

This section presents the empirical results of estimations carried out using the model earlier presented. According to this model, households decide how to allocate their fuel budgets to different fuels in the fuel mix.

The estimations results recorded a good fit with the Durbin-Watson (DW) statistic showing no significant evidence of autocorrelation. The values of the R^2 for each of the budget share equations show that about 52.8%, 85.5%, 85.3% and 95.7% changes in the budget shares of charcoal, fuel wood, kerosene and gas respectively are as a result of the changes in the independent variables. All parameters estimates jointly tested for each of the budget share equations are significantly different from zero as evident by F statistic.

This is estimated as a system of equations, determining the shares of each fuel in the fuel mix given household total fuel expenditure, the relative prices of the fuel paid by different households and other household characteristics. Table 1 gives the results of the estimations of the fuel expenditure shares of different fuels together with the overall statistics and an indication of the variables that are statistically significant.

The results from the table show that the level of education (which according to Huang *et al.,* (2000) is a measure of social status) recorded a negative but significantly impact on the budget share of charcoal at 10% probability level, but it has no significant relationship on the budget shares of kerosene, fuel wood and gas. This shows that as the level of education increases, households allocate less of their fuel budgets towards the purchase of charcoal, which is a wood fuel. This according to Chambwera (2004) shows that the perception of charcoal as an inferior fuel is higher among more educated household than among less educated ones. Increase in education level according to Huang *et al.,* (2000) determines both the level of exposure of a household to different technologies, styles of life and social status in the society. This increase in the level of exposure positively influences households' preference for the modern fuels but negatively influences their preferences for the wood fuels. Guatemalan studies by ESMAP (2003) also show that better educated households are more likely to move away from wood fuels than less educated ones.

Table 1: Shares of individual fuels

Variable	w_c	w_f	w_k	w_g
Constant	-.331 (-.997)	.790 (4.376)	-.042 (-.132)	.584 (3.911)
Sex	.003 (.076)	-.032 (-1.390)	.015 (.372)	.014 (.723)
Edu	-.005(-1.842)*	-.001 (-.775)	.005 (1.517)	.001 (.658)
Hhsize	.054(1.652)*	.023 (1.170)	-.098(-2.769)***	.020 (1.230)
Hhsizesq	-.006(-1.482)	-.002 (-1.048)	.009 (2.769)***	-.002 (-1.013)
Own	-.030 (-.805)	.023 (1.116)	-.034 (-.943)	.041 (2.472)**
Room	.025(1.532)	.001 (.062)	-.012 (-.753)	-.014 (-1.860)*
Elec	.051 (.821)	-.035 (-1.041)	-.037 (-.615)	.022 (.770)
LnAsset	-.006 (-.243)	-.044(-3.057)***	.056 (2.197)**	-.006(.483)
Pc	-.171(-5.987)***	.072 (4.616)***	.051 (1.840)**	.049 (3.792)***
Pf	.124 (2.906)***	-.295(12.781)***	.163 (3.968)***	.008 (.421)
Pk	-.001 (-.014)	-.004 (.233)	-.002 (-1.550)	-.002 (-.132)
Pg	.242 (2.328)***	.011 (.191)	.227 (2.255)**	-.480(-10.249)***
LnTfe	.032(1.344)	-.002 (-.173)	-.051(-2.132)**	.020(1.787)*
R^2	.528	.863	.861	.960
D.W	1.924	1.774	1.760	1.842
F	19.09	108.02	106.03	405.80

Source: author's computation
Figure in parenthesis are t-values.
***, ** and * represent significance at 1%, 5% and 10% respectively.

Household size is only significant in the budget share equations of the two fuel types, that is, charcoal in which it is significant at 10% level with a positive relationship and kerosene in which it is negatively related to its budget share at 1% probability level. This pattern as observed in the budget share equations of charcoal, fuel wood and kerosene follows the fuel consumption pattern in India, which is also a developing economy similar to Nigeria, according to Filippini *et al.,*(2004) which reveals that larger households consume less modern fuel than smaller households. Evidence from Guatemala (ESMAP 2003) also confirms this pattern. The sign of the coefficient of the square of the household size is however positive and significant in the budget share equation of kerosene. This reveals the U curve characteristics of kerosene which explains the fact that when household size initially increases, the decline in the consumption of kerosene consumed for uses such as cooking is larger than the increase in the quantity of kerosene consumed for other uses such that the share of kerosene initially decline, however as household continues to increase, the number of household members who need kerosene for the minor uses increases and the absolute amount of kerosene in total expenditure starts to rise, again, following a U curve pattern.

The value of fuel – using appliances recorded a 1% significant relationship in the budget share equation of fuel wood and a 5% significant relationship in the budget share equation of kerosene with a negative relationship in the budget share equation of fuel wood and a positive relationship in the budget share of kerosene. The relationship however in the budget share equations of charcoal and gas is negative and insignificant. The implication of this is that the share of kerosene increases as the value of fuel-using appliances used by household increase but the share of fuel wood in total fuel expenditure decreases with increase in the value of the fuel using appliances. Thus, access to more appliances enables households to use more kerosene. This finding agrees with finding from Chambwera (2004) and Gebreegziabher (2007). This is likely to be as a result of availability of more of appliances that use more of kerosene because the types of fuel using appliances possessed by households affect the extent to which households use a particular fuel (Linderhof 2001).

Total fuel expenditure is found to be significant at 10% level for gas budget share equation and at 5% level for kerosene budget share equation. It is negatively related to the budget share of kerosene but positively related to the budget share equation gas. This indicates that increase in the households' fuel expenditure will cause them to allocate more of such fuel budget to gas and less of it to kerosene purchase. For charcoal, the positive sign of the coefficient of Total Fuel Expenditure (although not significant) is consistent with the result from Mulenga (2002), while for kerosene and gas, the results agree with the results from Chambwera (2004) This therefore classifies kerosene as a necessity and charcoal and gas as luxuries among the households in the area. This pattern may be as a result of the reported inadequate supply of kerosene and availability of charcoal at relatively cheaper prices in the area.

The coefficient of the price of charcoal is significant in the budget shares equations of the four fuels with an expected negative sign in the budget share of charcoal and positive sign in the budget share equations of the other three fuel types. This implies that increase in the price of charcoal will cause households to reduce the budgetary allocation to charcoal and increase their budgetary allocation to fuel wood, kerosene and gas.

The price of fuel wood was found to be significant in the budget share equations of charcoal, fuel wood and kerosene. It however has an expected negative sign in the budget share equation of fuel wood. This implies that an increase in the price of fuel wood will cause households to increase their budgetary allocation to charcoal and kerosene but reduce their budgetary allocation to fuel wood.

The price of gas recorded a 5% significant positive relationship in the budget share equation of charcoal and kerosene, and expected negative relationship in the budget share equation of gas, which is significant at 1% level. This indicates that an increase in the price of gas cause households to allocate more of their fuel budget to charcoal and kerosene and less of it to gas.

It is therefore evident that household characteristics such as educational level of the household head, household size and the fuel characteristics such as prices of charcoal, fuel wood, and LPG are very important in determining household budget allocation to charcoal among urban households.

Estimation Of Own And Cross Price Elasticities of Charcoal

Table 2: Marshallian Own price and cross price elasticities of charcoal.

Quantity changes ↓ Price changes →

	Charcoal	Fuel wood	Kerosene	Gas
Charcoal	-1.40	0.26	-0.03	0.51
Fuel wood	1.04	-5.21	-0.31	0.16
Kerosene	0.17	0.38	-0.95	0.52
Gas	1.98	-0.07	-1.44	-25.02

Source: author's computation

The estimated parameters of the AIDS equation form the basis of elasticities which are important for assessing the impact of policies on quantities demanded. The Marshallian (uncompensated) elasticities are reported, and the estimates of Marshallian own price and cross price elasticities given below in Table 2 shows that the own price elasticities of charcoal, fuel wood, kerosene and gas are found to be negative, consistent with theoretical expectation and the magnitude very high which is an indication that they are elastic and sensitive to changes in their own prices. This is consistent with elasticity estimates from Ethiopia (Kebede *et al*., 2002) and Zimbabwe (Chambwera 2004).

The estimates of cross price elasticities of fuel wood, kerosene and gas in response to the changes in the price of charcoal show prevalence of substitution between charcoal and fuel wood, charcoal and gas and charcoal and kerosene. The estimates of Marshallian elasticities shown on the table 2 above therefore indicate that 10% rise in the price of charcoal will increase the demand for fuel wood, kerosene and gas by 10.4%, 1.7% and 19.8% respectively.

The estimates of cross price elasticities of charcoal, kerosene and gas in response to change in the price of fuel wood indicated that 10% rise in the price of fuel wood will increase household demand for charcoal and kerosene by 2.6% and 3.8% respectively while it will decrease household demand for gas by 0.7%. For kerosene, the estimates of cross price elasticity showed that a 10% increase in the price of kerosene will cause households to reduce their charcoal, fuel wood and gas consumption by 0.3%, 3.1% and 14.4% respectively. The estimates of cross price elasticity of charcoal, fuel wood and kerosene showed that a 10% rise in the price of gas will cause 5.1%, 1.6% and 5.2% increase in the quantities demanded of charcoal, fuel wood and kerosene respectively.

The results from the test conducted on the specified null hypotheses are shown in the table below. It was observed that educational level, household size, electrification status and assets significantly determined the charcoal demand in the study area and have the expected signs

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Table 3: Test of significance of coefficients of the socio-economic variables

Variables	Coefficients	T- ratio
Sex	.330	.076
Educational level	-.005	-2.842
Household size	.054	2.652
Owner ship	-.030	-.805
Number of room	.025	1.532
Electrification status	.051	3.821
Asset value	-.006	-.430
Constant	.032	1.344

Table 4: Test of significance of coefficients of the price variables.

Variables	Coefficients	T- ratio
Price of charcoal	-.171	-5.987
Price of fuel wood	.124	2.906*
Price of kerosene	-.001	-.014
Price of gas	.242	2.328**
constant	0.32	

The result of Table 4 revealed that of all the price variables, only the price of kerosene was not statistically significant in the budget share equation of charcoal. The prices of charcoal, fuel wood and gas were statistically significant, therefore, the null hypothesis was accepted for the price kerosene and was rejected for the prices of charcoal, fuel wood and gas.

CONCLUSION:

This study empirically analyzed the household charcoal demand by urban households within the context of overall household cooking fuel consumption using an Almost Ideal Demand System. The following conclusions were drawn based on the major findings of the study. It was observed that the households in the area allocate about 12% of their total expenditure to cooking fuels purchase which could further be broken down to 47%, 7%, 44% and 2% to charcoal, fuel wood, kerosene and gas respectively. The average quantity of charcoal consumed per month by an household in the study area is about 46.4kg. This provides a view of the current status of charcoal demand in the urban area.

It was observed that educational level, household size, electrification status and assets significantly determined the charcoal demand in the study area and have the expected signs

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