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HOUSEHOLD FUEL CHOICE IN URBAN KENYA: A MULTINOMIAL LOGIT ANALYSIS

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Abstract

This study applied a logistic regression model to determine the odds ratio of selecting clean versus unclean energy as the main household fuel choice. This study also undertook to establish the coefficients of the factors determining household fuel energy choice. A large microeconomic dataset from KIPPRA's comprehensive study and analysis on fuel use patterns in Kenya (2010) was employed to carry out the analysis. This study employed a multinomial logit regression model to determine the fuel choices and patterns of cooking fuels in urban Kenyan households. The results showed that in addition to income, there are several socio-demographic factors such as education, gender, and age that were important in determining household fuel choice. To encourage clean fuel use, the authorities should carry out public education campaigns, and ensure the availability of these fuels in all areas to avoid harmful effects of biomass fuels and kerosene, and more modern and efficient appliances should be made available at affordable rates to ensure more efficient use of these forms of clean energy.

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Introduction

As Kenya pursues its economic growth and development agenda in the context of a rapidly rising and urbanizing population, the need for timely and reliable data on use and consumption of energy products and services is necessary. Currently, there are inadequacies in the data and statistical support for energy sector planning, with knowledge on consumption data in terms of consumers by fuel type being weak. Even though the country has several fuel types, there is still lack of knowledge on the factors that drive fuel choice and fuel switching by various consumer categories (Kippra, 2010). Past empirical studies have identified a number of factors as determinants in the choice of household fuel. Heltberg (2003) found that income of the household and education level of the household head had a very significant negative impact on wood consumption while at the same time encouraging demand for liquefied petroleum gas (LPG). Ouedraogo (2006) shows that there exist significant relationships between the use rates of firewood, charcoal and liquified petroleum gas (LPG) and household size.

The five main sources of fuel for urban Kenyan households are firewood, charcoal, kerosene, LPG and electricity in that order. Table 1 presents the distribution of sources of fuel in Kenya.

Table 1: Distribution of Fuel

FUEL TYPE	RURAL	URBAN	NATIONAL
	PERCENTAGE		
Firewood	87.7	10.0	68.3
Grass	0.1	0.2	0.1
Charcoal	7.7	30.2	13.3
Biomass Residue	0.4	0.1	0.3
Kerosene	2.7	44.6	13.2
Gas (LPG)	0.7	11.9	3.5
Electricity	0.2	1.8	0.6
Other	0.4	1.1	0.6
TOTAL	100.0	100.0	100.0
Population Sampled	**5,155,105.0**	**1,715,269.0**	**6,866,374.0**

Source: Kenya Integrated Household Budget Survey (2006).

A large percentage of Kenyan urban households still use unclean fuels. Over 85 percent still use traditional biomass fuels or kerosene for their energy needs. This situation is precarious and needs to be addressed if Kenya is to avoid the environmental impact of biomass fuel use; and also to improve health by avoiding indoor pollution within the household (Nyoni et al., 2021). These two aims are in line with the sustainable development goals (Nyoni et al., 2021).

Information on drivers of household fuel choice is needed and a major aspect of this study is to provide vital information on what factors determine household fuel choice with the aim of enabling predictability of future patterns of choice as prices of the fuel type and/or income of the household, which are thought to be the most significant factors in determining choice, change. This will thus enable policy actions to ensure availability of the fuel types that are deemed to be in line with the government's aims and goals. The study will also provide valuable information to allow forecasting of future consumption patterns and enable future provision of fuels in a manner that is affordable to households and sustainable in terms of supply.

Statement of the problem

Use of biomass fuels in households is a major cause of health problems in developing countries due to indoor air pollution (Bruce et al., 2000). For example, the World Health Organization (WHO) estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels (IEA, 2006). Recognizing the adverse effects of use of traditional biomass fuels, the United Nations Millennium Project recommends halving the number of households that depend on traditional biomass for cooking by 2015, which involves about 1.3 billion people switching to other fuels (IEA, 2006). Kenya needs to be on the frontline in combating the negative effects of these polluting fuels (Nyoni et al., 2021). To do this requires information on reasons why unclean fuels are still in use. Information on fuel choice in urban areas of Kenya is inadequate. There are few studies that focus on fuel choices in any or a number of the urban areas. This study will provide valuable information to allow forecasting of future consumption patterns and enable future provision of fuels in a manner that is affordable to households and sustainable in terms of supply.

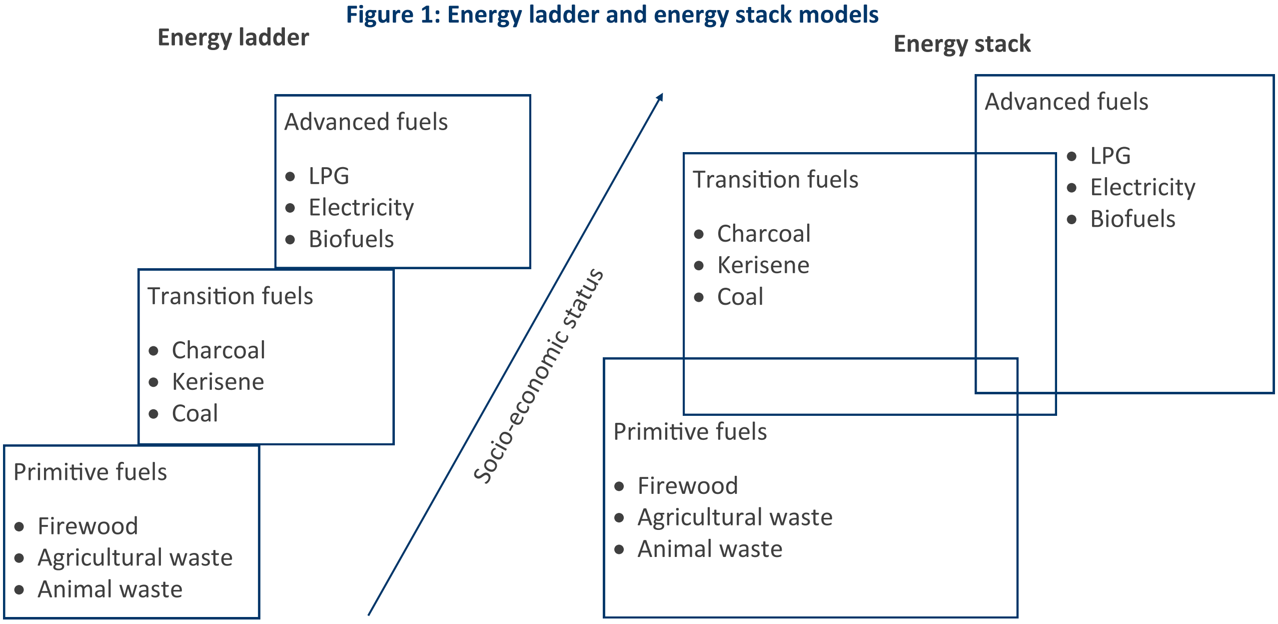
Objective of the Study

The objective of this study is to identify determinants of fuel choices in urban Kenya.

Theoretical literature

Household fuel choice can be explained using the Energy ladder model which argues that households with low levels of income rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive, such as electricity (Gisore, 2017). Those households in transition—between traditional and cleaner (and more efficient) energy sources—consume what are called transition fuels, such as kerosene and charcoal (Heltberg, 2005; Gisore, 2021). This is explained in Figure 1 below.

Figure 1: Energy ladder and energy stack models



Source: *Schlag, N., Zuzarte, F, (2008). Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature. Working paper, Stockholm Environment Institute.*

More recently, it has been argued that households in developing countries do not switch to modern energy sources but instead tend to consume a combination of fuels, which may include combining solid fuels with non-solid fuels as sources of energy. Thus, instead of moving up the ladder step by step as income rises, households choose different fuels from a range of fuels. They may choose a combination of high-cost and low-cost fuels, depending on their budgets, preferences, and low-cost fuels, depending on their budgets, preferences, and needs (World Bank, 2003). This led to the concept of fuel stacking (multiple fuel use), as opposed to an energy ladder (Masera et al., 2000; Heltberg, 2005).

Empirical literature research gaps

Numerous studies in developing nations have endeavoured to identify the factors that determine household fuel choice. Some have analysed these factors using econometric techniques and others have done this with descriptive statistics. Many studies in Kenya have also studied fuel choice in a few urban areas using econometric techniques but none has focused specifically on urban areas. This study intends to focus on fuel choice within urban households in Kenya and will be analysed using a multinomial logit model.

Theoretical framework

The household's fuel choice consumption decision can be formally derived from the utility maximization problem theorem. The starting point is to consider household preferences, on which, together with household possibilities, consumer behaviour is built. In the classical consumption theory, a consumer is assumed to have a stable preference system which can be described by means of a utility function. Varian (1996) developed the theory of consumer behaviour by deriving demand functions based on model of preference, which is, maximizing behaviour coupled with a description of the underlying economic constraints. The basic hypothesis about consumer behaviour according to Varian (1996) is that a rational consumer will always choose a most preferred bundle from a set of feasible alternatives. This is the hypothesis adopted in this study, that is, utility maximization. Consumer behaviour is commonly presented in terms of preferences on one hand, and possibilities on the other. Preferences provide the justification for the existence of demand functions (Varian, 1996).

Consider a consumer faced with possible consumption bundles in some set Q. The consumer is assumed to have preferences on the consumption bundles in Q, that is, the consumers can rank the bundles as to their desirability. We assume that for the preference system to order the bundle q in Q, the household has a set of axioms that guide such ordering. Once preferences respect the axioms, there exists a continuous utility function which represents these preferences. Given the foregoing, the household aims at maximizing the utility function represented as:

$$U(q) = U(q1, \ldots, qn) \tag{1}$$

from the consumption of commodities qi, i = 1…n.

The maximization model requires the household to choose values of q1, …, qn that satisfy the budget constraint and also give larger values of u (q1, …, qn) than other values of q1, …, qn within the consumption possibilities of the consumer. The limits of the household are imposed by a budget constraint, which specifies the total expenditure x, which is to be spent. When p1, …, pn are the prices of the n commodities, then the standard utility maximization can be expressed as:

$$MaxU(q) subjecttopiqi = x \tag{2}$$

A fuel-focused household utility function may then be derived from the standard constrained utility function by extending it to capture non-economic constraints as well (Browning et. al., 2003). Non-economic factors include a set of household demographic and infrastructural factors (such as level of educational attainment, and cooking practices amongst others.)

Energy is provided by a multiplicity of sources. Each energy source is a commodity with multiple attributes and purposes. Purposes include cooking, heating, lighting, and entertainment, and so on. Attributes include energy content, convenience, safety, speed of cooking, taste given to food, quality of light, and smoke emitted when burned. Energy sources are intermediate inputs in the utility function. Utility is derived from the final goods such as cooked food, heat, entertainment, and light, which energy sources help to produce. The study follows Pundo and Fraser (2006) by expressing the household choice model as follows:

$$U^* = U[Qw(Pw, Pa, Y, \Omega)Qa(Pw, Pa, Y, \Omega)] \tag{3}$$

Where:

U (Pw, Pa, Y, Ω)* is the maximum attainable utility;
Qw is the units of firewood purchased;
Pw is the per unit price of firewood;
Pa is the unit price of firewood alternatives;
Y is household income;
Ω is a set of social factors, and
Qa indicates the units of firewood alternatives purchased.

The regional experience suggests that market prices are insufficient indicators of fuel choice in this region since some fuels can be consumed without being bought in the market. Other factors may play a significant role in determining fuel choice. Availability of the fuel type, availability and cost of burners/stoves that are needed to utilize the energy form and income of the household are other factors that may determine fuel choice. Since prices of market fuels are to a greater or lesser extent the same for all households in the same region, equation 1 is reduced to exclude price and income variables. The reduced form is:

$$U^* = [QW(\Omega)QA(\Omega)] \tag{4}$$

Where:

U (Pw, Pa, Y, Ω)* is the maximum attainable utility;
Ω is a set of social factors;
Qw is the units of firewood purchased and
QA indicates the units of firewood alternatives purchased.

Equation 4 shows that a household's choice of fuel is affected by a set of social factors (Ω). In this study, the social factors considered are: age in years of the household head, the level of education of the household head, and the number of people making up the household.

Research methodology

This study was carried in Kenya. Kenya is located in the continent of Africa. Kenya lies across the equator and is found in the eastern coast part of Africa. Maps of World indicate that Kenya's latitude and longitude lie between 0.0236° S and 37.9062° E (KNBS, 2010; Gisore, 2021). The map in Figure 2 below shows the geographical area covered by the study.

Figure 2: Geographical Map of Kenya showing the Study Area

Source: KNBS (2019).

Research study area

The study used a multinomial logit model to estimate the significance of the factors believed to influence a household's choice of energy fuel in urban Kenya. The multinomial logisitic model describes the behaviour of consumers when they are faced with a variety of goods with a common consumption objective. The choice of the model is based on its ability to perform better with discrete choice studies (McFadden, 1974; Judge et al., 1985). However, the goods must be highly differentiated by their individual attributes.

The probability that a household chooses one type of fuel is restricted to lie between zero and one. The model assumes no reallocation in the alternative set and without changes in fuel prices or fuel attributes. The model also assumes that households make fuel choices that maximize their utility (McFadden, 1974). The model can be expressed as follows:

$$\Pr[Y_i = j] = \frac{\exp(\beta'_j x_i)}{1 + \sum_{j=0}^{J} \exp(\beta'_j X_i)} \tag{5}$$

Where:

Pr[Yi = j] is the probability of choosing either firewood, kerosene, gas or electricity with charcoal as the reference household fuel category;
J is the number of fuels in the choice set;
j = 0 is firewood;
Xi is a vector of the predictor (exogenous) factors (variables)
βj is a vector of the estimated parameters.

Re-arranging equation 1, the following is obtained:

$$P_i = \frac{e^{(b_0 + b_1x_1 + b_2x_2 + \ldots + b_nx_n)}}{1+e^{(b_0 + b_1x_1 + b_2x_2 + \ldots + b_nx_n)}} \tag{6}$$

Further re-arrangement using the odds ratio gives the empirical model as:

$$\ln[\frac{P_i}{1-P_i}] = b_0 + b_1x_1 + b_2x_2 + \ldots b_nx_n \tag{7}$$

This can also be stated as

$$[\frac{P_i}{1-P_i}] = e^{(b_0 + b_1x_1 + \ldots + b_nx_n)} \tag{8}$$

In equation (7), the quantity Pi/(1 – Pi) is the odds ratio. The equation (7) has expressed the logit (log odds) as a linear function of the independent factors (Xs). Equation (7) allows for the interpretation of the logit elasticities for variables in the same way as in linear regressions. This equation expresses the odds ratio of selecting a fuel type with respect to the reference category. Differentiating equation (1) we obtain the marginal effects (Greene, 2003).

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j(\beta_j - \sum_{k=0}^{j} P_k\beta_k) = P_j(\beta_j - \overline{\beta_k}) \tag{9}$$

The marginal effects measure the expected change in the probability of choosing one fuel alternative with respect to a unit change in an explanatory variable. For example, (in equation 6) is the multiplicative factor by which the odds ratio would change if X_1 changes by one unit. The model follows from the assumption that the random disturbance terms are independently and identically distributed (McFadden, 1974). In addition, Judge et al. (1985) shows that even if the number of alternatives is increased (from 6 to 7 to 8) the odds of choosing an alternative fuel remain unaffected. That is, the probability of choosing the particular fuel type remains the same if it is compared to one alternative or if it is compared to two or three or four alternative fuels.

Data types and sources

The study intends to use secondary data from Kippra's comprehensive study and analysis on fuel consumption patterns in Kenya done in 2010. This study utilised a sampling frame created by KNBS (Kenya National Bureau of Statistics) after the 1999 Population Census. This sampling frame consisted of 1,800 clusters, each on average with 100 households, with the aim of conducting socio-economic surveys. Out of 1,800 clusters, 540 of them were urban and 1,260 were rural. Kippra's comprehensive study and analysis on fuel consumption patterns in Kenya (2010) used a 20% sub-sample of the clusters, resulting in 108 urban clusters and 252 rural clusters. Traditionally, KNBS has randomly selected 10 households in each cluster for any study. Therefore, 1,080 urban households and 2,520 rural households were interviewed. For the purpose of this study, only the urban households totalling 1080 were considered. The sample of clusters was allocated to the districts using the relative household strength of the district within a province. This minimised bias in the selection of the household clusters. The study also interviewed 857 energy providers.

Definition and measurement of variables

The study will focus on a number of variables that affect household fuel choice. The endogenous variables are the various fuel types available to urban Kenyan households. Table 2 shows the measure and definition of variables.

Table 2: Study Variables

Variable	Listing	Measurement	Model Listing	Expected Size	Study that shows result
Household Expenditure on Energy Type	X_1	Continous in Kenya Shillings	Costmonth	Ksh 50.00-35,000.00	Osiolo (2009), Kippra (2010)
Gender of household Head	X_2	Binary 1 = Male; 0 = Other	Gender	1 or 0	Osiolo (2009)
Household Size	X_3	Continous Number	Hhmember	1-19	Ouedraogo (2005), Mekonnen and Kohlin (2009)
Age of Household Head	X_4	Continous Number	Agehead	18- 90	Osiolo (2009), Kippra (2010)
Education of Head	X_5	Continous Number	Education	Years: 1-21	Ouedraogo (2005), Mekonnen and Kohlin (2009)
Household income	X_6	Income in Kenya Shillings	Income	Kshs 1000.00-300,000.00	Kebede (2002)

Source: Own elaboration.

Data analysis

The data were verified and cleaned. This entailed deletion of observations missing entries on any of the variables included within the model. The data were analysed using a logit model to estimate the probability of a household selecting an unclean fuel as its main source of energy versus the probability of selecting a clean source of fuel. The data were also analysed by the multinomial logit model to estimate the determinants of household fuel choice. This enabled us, as stated earlier, to determine the probability of choosing one fuel type over the default type (charcoal) and give the factors responsible for this probability. It also gave the marginal effect which is the increase or decrease in probability of choosing one type of fuel over the default given a unit change in one of the variables that affected fuel choice. Most studies indicate that households use two or more fuels to satisfy the need for energy (Masera et al., 2000; Schlag et al., 2008). Due to this, only the main source as depicted in the data was used for the analysis.

Empirical findings & discussions

Logit analysis for unclean and clean fuels

Table 3 present the logit analysis result for clean and unclean energy fuels.

Table 3: Logit regression results for unclean and clean fuels

Logistic Regression						
Observations		1170.000000		Prob>chi2		0.0000000
LR chi2(6)		533.640000		Pseudo R2		0.0336600
LogLikelihood		-525.931000				
Variable	**Coeff**	**Std Error**	**z**	**P>IzI**	**95% Conf Interval**	
CostMonth	0.0007	0.0001221	5.40	0.000	0.0004207	0.0008995
HHMembers	-0.2343	0.0419659	-5.58	0.000	-0.3165653	-0.1520620
Income	0.0001	0.0000006	10.63	0.000	0.0000507	0.0000737

Education	0.1561	0.0235172	6.64	0.000	0.1100448	0.2022306
Agehead	-0.0088	0.0080377	-1.09	0.276	-0.0245015	0.0070059
Gender	0.1101	0.1816801	0.61	0.544	-0.2459609	0.4662121
Cons	-3.3706	0.4307729	-7.82	0.000	-4.2149260	-2.5263280

Source: Own elaboration.

The coefficient for amount spent by the household monthly (cost per month) was positive meaning an increase in the amount that the households spend in a month would lead to an increase in probability that the household would choose a clean source of fuel as its main fuel.

The coefficient for household members was large and negative and this implies that as the number of persons in the household decreased, the higher the probability that the household used a clean source of fuel as its main fuel. Due to its size, it was the most significant influence on the probability of choosing a clean source of main fuel.

The coefficient for monthly household income was not as large and was positive and this means an increase in the household income led to an increase in probability that the household used a clean source of fuel as its main fuel choice.

The coefficient for education attained was also positive but larger than income and this means the more educated the household head, the more likely she will choose a clean source of fuel as the main household fuel. Education was the second most significant influence on probability of choosing a clean fuel source.

The coefficient for age of the household head was negative meaning the older the household head, the probability was lesser that she was to choose a clean source of fuel as the main household fuel type. Gender was the gender of the household head, the positive coefficient means a male head increases the probability that the household will utilise a clean source of fuel as the main household fuel type.

Logit regression analysis for drivers of choice of fuels

Table 4 presents the multinomial logit regression result.

Table 4: Multinomial logit regression results for main choice of fuels

Multinomial Logistic Regression						
Observations		1170.00000000		Prob>chi2		0.0000000
LR chi2(30)		686.11000000		Pseudo R2		0.1923000
LogLikelihood		-1441.09520000				
Firewood	**Coeff**	**Std Error**	**z**	**P>Izl**	**95% Conf Interval**	
CostMonth	-0.0003	0.00025620	-1.33	0.183	-0.0008434	0.0001611
HHMembers	0.1008	0.05341030	1.89	0.059	-0.0039303	0.2054341
Income	-0.0001	0.00001270	-2.56	0.010	5.73E-050	7.63E-07
Education	-0.0502	0.02896270	-1.73	0.083	-0.1069253	0.0066063
Agehead	0.0495	0.01111970	4.45	0.000	0.0276721	0.0712606
Gender	-0.0297	0.02985070	-0.10	0.921	-0.6147279	0.5553992
Cons	-2.7674	0.62557050	-4.42	0.000	-3.9934500	-1.5412590
Kerosene/ Charcoal	**Coeff**	**Std Error**	**z**	**P>Izl**	**95% Conf Interval**	
CostMonth	0.0001	0.00017570	0.69	0.049	-0.0002233	0.0004656
HHMembers	-0.3434	0.05289180	-6.49	0.000	-0.4470648	-0.2397330
Income	-0.0001	0.00000874	-0.26	0.799	-0.0000193	0.0000149
Education	0.0011	0.02502020	0.04	0.965	-0.0479485	0.0501287
Agehead	0.0033	0.00934270	0.35	0.724	-0.0150153	0.0216072
Gender	0.0992	0.20968250	0.47	0.636	-0.3117830	0.5101574
Cons	0.4755	0.45068870	1.05	0.291	-0.4079163	1.3587510

LPG	Coeff	Std Error	z	P>Izl	95% Conf Interval	
CostMonth	0.0005	0.0001545	2.99	0.003	0.0001593	0.0007650
HHMembers	-0.3286	0.0541352	-6.07	0.000	-0.4347202	-0.2225140
Income	0.0001	0.0000662	9.25	0.000	0.0000483	0.0000742
Education	0.1599	0.0304021	5.26	0.000	0.1003858	0.2195600
Agehead	0.0099	0.0101919	0.97	0.331	-0.1006190	0.0298897
Gender	0.1451	0.2318660	0.63	0.531	-0.3093235	0.5995744
Cons	-3.7374	0.5743894	6.51	0.000	-4.8632370	-2.6116730
Electricity	**Coeff**	**Std Error**	**z**	**P>Izl**	**95% Conf Interval**	
CostMonth	0.0008	0.0001464	5.76	0.000	0.0005561	0.0011301
HHMembers	-0.3191	0.0530683	-6.01	0.000	-0.4231069	-0.2150830
Income	0.0001	0.0000663	8.67	0.000	0.0000445	0.0000704
Education	0.1434	0.0293707	4.88	0.000	0.0858726	0.2010037
Agehead	-0.0159	0.0104811	-1.52	0.129	-0.0364739	0.0461150
Gender	0.1927	0.2273186	0.85	0.396	-2.5278680	0.6382858
Cons	-2.7897	0.5450435	-5.12	0.000	-3.8579430	-1.7214120
Residues	**Coeff**	**Std Error**	**z**	**P>Izl**	**95% Conf Interval**	
CostMonth	0.0005	0.0067370	0.68	0.050	-0.0008609	0.0017799
HHMembers	-0.2366	0.2402668	-0.98	0.325	-0.7075226	0.2343061
Income	0.0001	0.0000403	0.15	0.881	-0.0000729	0.0000849
Education	0.0204	0.1252294	0.16	0.871	-0.2250526	0.2658374
Agehead	0.0668	0.0367777	1.82	0.069	-0.0053144	0.1388513
Gender	1.1682	1.0309960	1.13	0.257	-0.8525566	3.1888740
Cons	-7.3756	2.6414070	-2.79	0.005	-12.552630	-2.1985050

Source: Own elaboration.

The results of the multinomial regression above reveal the following: The base category was charcoal and this could have been because more residents used charcoal in urban areas due to its availability and it was relatively cleaner and easier to use than firewood. Thus, the comparisons of the fuel were all compared to charcoal as the base category.

Seven percent of households chose firewood as their main source of fuel. The coefficients for firewood were negative for monthly cost income and education and this implied that as one or more of these factors increased, the probability that one chooses firewood over charcoal decreased. If the household head was male, the lower the probability was for him to choose firewood over charcoal. An older household head and or a large household increased the probability that the household chose firewood over charcoal as its main source of fuel.

Almost twenty percent of households chose kerosene as their main source of fuel. The factors that led to an increase in probability that a household would select kerosene over charcoal include fewer household members, increased years of education, increased monthly cost, increased age of household head and male household head. An interesting finding was an increase in income led to a decrease in probability that one would choose kerosene over charcoal; this however, was of very low significance.

Liquefied Petroleum Gas (LPG) and electricity were also found to be popular among the residents. The most significant factors that encouraged households to use either of them over charcoal are: increased monthly cost of fuel, increased income, more years of education, male household head and a smaller household. However, an older household head meant an increase in the probability that one would choose LPG over charcoal but a decrease in the probability that one would choose electricity over charcoal.

Marginal effects estimation

The marginal effects show the percentage change in the odds ratio attributable to a unit change in one of the variables. An example i in row 1 column 2 -0.997 shows that the odds ratio of selecting firewood over the default fuel type (charcoal) decreased by 0.99% after income of the household increased by one unit. Table 5 present the marginal effect regression result.

Table 5: Marginal Effects Analysis

Variable	Firewood		Kerosene		LPG	
	Coefficient	Change on Odds Ratio	Coefficient	Change on Odds Ratio	Coefficient	Change on Odds Ratio
CostMonth	-0.0003	0.9997	0.0001	1.0001	0.0005	1.0005
HHMembers	0.1008	1.1060	-0.3434	0.7094	-0.3286	0.7199
Income	0.0000	1.0000	0.0000	1.0000	0.0001	1.0001
Education	-0.0502	0.9511	0.0011	1.0011	0.1600	1.1735
Agehead	0.0495	1.0507	0.0033	1.0033	0.0099	1.0100
Gender	-0.0297	0.9708	0.0992	1.1043	0.1451	1.1562
Cons	-2.7674	0.0628	0.4754	1.6087	-3.7375	0.0238

Variable	Electricity		Residues	
	Coefficient	Change on Odds Ratio	Coefficient	Change on Odds Ratio
CostMonth	0.0008	1.0008	0.0005	1.0005
HHMembers	-0.3191	0.7268	-0.2366	0.7893
Income	0.0001	1.0001	0.0000	1.0000
Education	0.1434	1.1542	0.0204	1.0206
Agehead	-0.0159	0.9842	0.0668	1.0690
Gender	0.1927	1.2126	1.1682	3.2161
Cons	-2.7897	0.0614	-7.3756	0.0006

Source: Own elaboration.

The marginal coefficients of all fuels are all about 1%, this means that monthly cost is quite significant in households' decisions on fuel choice. This study found monthly cost to be important in determining choice of main fuel. This finding was in line with both Osiolo (2009) and Kippra (2010) findings though the coefficient value was lower in this study thus less important compared to the previous studies.

These coefficients are slightly lower than 1% but are all negative except for firewood. This means that household size is a significant factor in determining household fuel choice. The two previous studies Osiolo (2009) and Kippra (2010) found households with numerous members likely to choose firewood and charcoal while those with fewer members chose LPG and electricity. This study's findings are similar to the previous studies thus larger households are more likely to select unclean fuels as their main fuel choice.

The marginal coefficients of all fuels are all about 1% and all are positive, this means that monthly cost is quite significant in households' decisions on fuel choice. This study found that increase in the household income led to an increase in probability of choosing LPG and electricity over charcoal and a decrease in probability of choosing kerosene and firewood over charcoal. Kippra (2010) found that an increase in income led to an increase in the probability that a household selects electricity, LPG and kerosene over firewood. Thus, household income was important in determining whether a household would select a clean source of fuel as its main fuel type. Osiolo (2009) did not use income but instead chose household expenditure on fuel and as expenditure increased, so did the likelihood that a household will select a clean source of fuel as its main fuel type.

The marginal coefficients of all fuels are above 1% and all are positive, this means that education is more significant in households' decision on the fuel choice than the other factors (Thomi & Naftaly, 2021). This study revealed increase in the education in years of the household head led to an increase in probability of choosing LPG and electricity over charcoal but led to a decrease in probability of choosing kerosene and firewood over charcoal. Waweru (2021) found household heads with more years of education or those who had completed university were more likely to select LPG and electricity (clean fuels) over firewood (unclean fuel).

The marginal coefficients of all fuels are all above 1% and for kerosene, LPG and residues and about 1% for electricity and firewood are positive, this means that this variable is quite significant in households' decisions on fuel choice. It is the second most significant after years of education of the household head. This study revealed an older household head was more likely to choose LPG and kerosene over charcoal but less likely to choose electricity and firewood over charcoal. Osiolo (2009) did not consider age in the regression but Kippra (2010) found older household head to be more likely to choose electricity over kerosene firewood or charcoal.

The marginal coefficients of all fuels are all above 1%, for all the fuels this is a significant factor in determining household fuel choice ranking just after age of the household head. This study found a male household head was more likely to choose electricity, LPG or kerosene over charcoal and less likely to choose firewood over charcoal. Osiolo (2009) found that gender was not an important determining factor while Kippra (2010) found that a male head is likely to choose only electricity over other fuels.

Conclusion and Recommendations

The factors most significant in determining household fuel choice include years of education of the household head and number of members of the household. These increased the probability of choosing electricity, LPG and kerosene over charcoal. Other factors include income and monthly cost. As these increased, the probability that a household chose electricity, LPG and kerosene over charcoal decreased the probability that a household will choose firewood over charcoal. A male household head was more likely to choose electricity, LPG and kerosene over charcoal and less likely to choose firewood over charcoal.

Due to the fact that some households still used firewood as their main choice of fuel, it would be advisable to encourage use of more efficient wood stoves. Education on the availability and benefits of these stoves will go a long way in ensuring that these stoves are utilized effectively. Effective use will result in a decreased demand for firewood. This will minimize the environmental impacts of firewood use. It will also ensure households suffer less from indoor air pollution since the burning of the firewood will be more efficient and thus produce less smoke.

The probability of clean fuel use was still about 20 percent lower than unclean fuel use. It is recommended that the county and national government educate the population on the harmful effects of the unclean fuels and also make adequate plans to ensure these clean forms are affordable and available in all areas. Also, payment plans that ensure the upfront cost of appliances like gas cookers and electric cookers is reduced will assist the population in utilizing more of clean forms of energy.

Areas for further research

Further research may focus on the effect of household fuel energy choice on environment and health of household.

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