

Drivers of Fuel Choice for Cooking among Uganda's Households

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Abstract

This paper examines the factors that Uganda's households consider when making fuel choices for cooking and investigates the key drivers of fuel choice. The study adopts a quantitative cross sectional research design. The dependent variable of the empirical model is a qualitative response variable which defines three mutually exclusive and highly differentiated discrete choices for cooking fuels, namely: the traditional fuel (firewood), the transitional fuel (charcoal), and the modern (LPG & electricity). Results from the study show that the most important drivers of fuel choice for cooking in Uganda's households are: household income, age of household head, gender of household head, marital status, education levels of household head and location of a household. Results also reveal high dependency of firewood as cooking energy source among households in Uganda.

Keywords

Fuel Choice, Cooking Fuels, Households, New Consumer Theory, Uganda

1. Introduction

Over 40% of the global population rely on biomass fuels for their cooking, heating and lighting needs [1]. The use of biomass fuels (mainly firewood and charcoal) combined with inefficient cook stoves is responsible for over 4 million deaths annually due to indoor air pollution [2]. This is even more significant in Sub Saharan Africa where over 720 million people are reported to have died due to indoor air pollution in 2016, the majority of which were women and children [3]. Other consequences of continued use of biomass fuels include deforestation, the withdrawal of children from school, women drudgery, soil erosion and im-

pacts on ecology and food security [4]. Clean fuels such as Liquefied Petroleum Gas (LPG) and electricity have the potential to reduce the social and environmental burden of these biomass fuels, however, the adoption rate for these clean fuels remains excessively low especially in developing countries. Uganda is one of the Sub Saharan African countries with high reliance on biomass fuels at 94% [5] coupled with the increasing annual population growth of 3.7% and the annual growth in energy demand of 7.5%, biomass resources are unlikely to sustain biomass energy consumption in Uganda if the current rate of consumption is sustained [6]. Furthermore, production of biomass resources is carried out using unsustainable and inefficient production techniques. [7] reported that 1 square kilometer of forest cover, is required to produce 50 tons of charcoal and this has led to increasing depletion of forests [8].

The governments of Uganda in conjunction with Non-Governmental Organizations (NGOs) and donor communities have for some time advocated for a transition to clean cooking fuels. The objective is to reduce the negative impacts on the environment and economic burden on households stemming from the inefficient use of biomass fuels for cooking. However, Uganda still lags in terms of percentage populaces that use clean fuels compared to her counter parts in East Africa ([9] [10]). This paper, therefore, aims to answer the question, what drives Uganda's households to choose particular cooking fuel or set of cooking fuels?

Extant studies (for example [11] [12] [13]) have based their explanation of fuel choice on the energy ladder hypothesis. The energy ladder hypothesis postulates that as income increases, households switch from traditional fuels to clean modern fuels. However, contrary to the energy ladder hypothesis, growing evidences suggest that most households stack fuels (use multiple fuels from the upper and lower energy ladder) instead of fuel switching as income increases (see for instance [14] [15]). Anecdotal evidence from Uganda shows prevalent use of traditional fuels (charcoal and firewood) regardless of increment in household income. For example, the few studies that have been carried out in Uganda (see for instance [7] [16]) are all in agreement with the energy ladder theory. [7] examined the use of various forms of cooking energy sources among households and found out that the key determinant of fuel choice was household income. On the other hand, [16] investigated household energy mix in Uganda and made the same conclusion. Elsewhere, the dominance of traditional fuels has been attributed to several factors which include economic, social cultural and environmental factors. However, whereas theoretical assertions confirm that these factors have positive effect on household fuel choices [17], empirical evidence in the existing literature is limited and inconclusive [18]. Therefore, this study aims to contribute to the existing body of literature on household fuel choice by examining the factors that Uganda's households consider when making fuel choices for cooking.

2. Theoretical Framework

The study is anchored on the general framework of new consumer theory [19].

The theory postulates that the consumer's or household's choice of goods is based on the characteristics or attributes they possess and are the basis of consumer preference or utility. These attributes are assumed to be the same across all households, however, the utility derived by the household is subjective and depends on the households' preferences. The information they possess regarding the attributes of the fuels combined with the economic and non-economic factors influences their decision making. The economic factors include availability of the fuel source, price of fuel, household income and expenditure, while the non-economic factors include socio-economic characteristics such as household size, age, gender, house ownership, type of dwelling, location of residence, distance to fuel source, and access to electricity [20]. In the spirit of [21], this study assumes that a household faces a choice among different fuel types, and chooses the option that maximizes its utility.

Assuming that choice set C includes all the possible fuel types available to a household, and assume that the utility derived depends on the choice made from this set, a household will select that choice that maximizes its utility, that is;

$$U_{ij} = \mu(Z_j, S_i) + \varepsilon(Z_j, S_i) \quad (1)$$

where for any household i , a given level of utility will be associated with any alternative fuel choice j . The utility derived from any alternative fuel type depends on the attributes (Z) of the fuel type and the economic and non-economic factors affecting households' decision. The household decision to choose a particular choice (j) will depend on the fact that the utility got from this set is higher than the utility associated with another choice of fuel. The probability P_{ij} that alternative j is chosen by household i is given by;

$$P_{ij} = \text{prob}(v_{ij} > v_{in}); \quad n = 1, 2, 3, \dots, j; \quad n \neq j \quad (2)$$

Consequently if the i^{th} household chooses fuel type j , then U_{ij} is the highest utility obtainable from among the j possible alternatives.

3. Review of Literature

3.1. Theoretical Literature

The theory of fuel choice is often based on the energy ladder hypothesis. Originally proposed by [22], the energy ladder hypothesis presents the view that households discontinue the use of biomass fuels as their income increases [1]. The energy ladder hypothesis depicts a linear three-stage switching process. The first stage involves a heavy reliance on spans of old biomass fuels, such as firewood, cow dung and straws, etc. while in the second stage household moves to "transition" fuels involving the use of kerosene, coal and charcoal, and in the third stage, they switch to the use of LPG, natural gas or electricity [23]. (Figure 1)

To some scholars (for instance, ([24] [25] [26]), the energy ladder hypothesis overlooks the significance of other factors when making energy choices and has been criticised on these grounds. Instead, the critics of the energy ladder argue

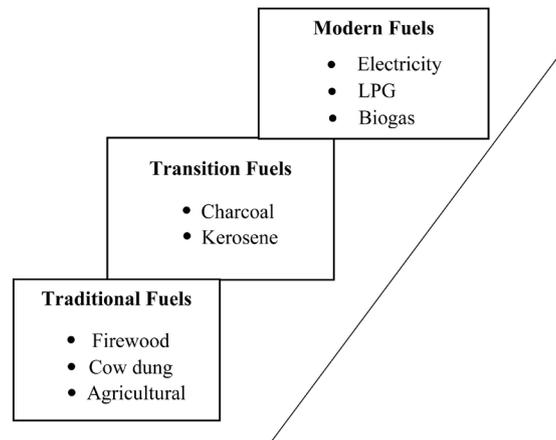


Figure 1. Energy ladder. Source: [20].

that households would use multiple fuels known as fuel stacking as their income increases instead of moving up the “energy ladder”, which means that with an increase in income, traditional fuels are not completely replaced, but are rather used in combination with modern clean fuels.

Energy Stacking

The energy stacking model hypothesizes that households use a range of energy sources regardless of the income levels [27]. The difference among energy portfolios is reflected in the variety of energy sources and their corresponding proportions to total energy. As a result, climbing the energy ladder does not mean abandoning any energy completely [28]. The energy stacking hypothesis is an alternative hypothesis to the energy ladder hypothesis for the better understanding of energy transition of households. The hypothesis asserts that a rise in household income level will result in the shift to the use of modern energy sources such as electricity, which will take place in terms of simultaneous use of both traditional and modern energy sources. For instance, poor households tend to use traditional energy such as biomass, thus an increase in income will necessitate the use of modern energy such as electricity, although the use of traditional energy will not be discontinued for some activities [29]. In Uganda, a large proportion of middle-income households who could in principle afford clean and convenient forms of fuels continue to rely fully or partly on traditional biomass fuels [7]. Several factors such as age, family size, level of education of household head, location, and marital status are important factors that determine household cooking fuel choice [29]. Therefore, income, although very important, is not the only determinant of household cooking fuel choice. Household fuel choice should be explained as a portfolio choice rather than as a ladder process [29].

Therefore, understanding households’ fuel choice is considered under the general framework of new consumer theory [19] [30], which suggests that consumers derive utility not from a commodity but from the attributes embedded in a commodity. Information at households’ disposal about the various fuels influences their decisions which are driven by households’ economic and non-economic

constraints. The economic factors may include availability and market price of fuel, household income and expenditure, while the non-economic factors may include socio-economic characteristics such as household size, age, gender, house ownership, type of dwelling, location of residence, distance to fuel source, and access to electricity [29].

3.2. Empirical Literature

Many studies have found that household fuel choice depends on numerous factors. [31] [32] used Multinomial Logit model to analyze household energy choices and discovered that household income, age of the household head, level of education of the head of the household, household size, the dwelling ownership, occupation of the household head, number of rooms, number of years the house was built, size of the resident, ratio of female in the household, had a positive relationship with the household fuel choice. On the other hand, other studies for instance [33]) and [34] found the same variables to have negative relationship with fire wood use, thereby encouraging the adoption or use of electricity and or gas. These inconclusive findings could be as a result of the studies having been carried out in different environment and using different data. This signifies that energy choice of households varies from one region to another and not all factors are equally important in determining energy choice in different areas and regions.

Furthermore, some studies, for instance [35] [36] [37] employed ordered logit/Probit models to examine the factors that influence household energy choice. variables such as; income, firewood price, education level of household head, share of dwelling with other people, urban household, access to Liquefied Petroleum Gas(LPG) were found to have a positive relationship with the probability of adopting cleaner energy. While other variables, such as; electricity price, price of kerosene, age of the household head, household size, gender (male) of the household head, and access to fire wood, have negative effect on the probability of the use of clean and efficient fuels. The major limitation of these studies is that they assume that the various household energy choice categories are in an ordered ranking manner which is not realistic.

Literature on household fuel choice conducted in both developed and developing countries show that there are limitations in a number of related studies, including the scope covered, model used, the variables included in the study among others. For instance, some studies on household energy choice (for instance [38] [39] [40]) focus only on electricity aspect of household energy consumption, thereby neglecting other aspects like consumption of fuel wood and other solid fuels, households' consumption of kerosene, fuel for transportation, as well as liquefied natural gas as a source of household energy consumption. In addition, some studies such as [41] [42] focus only on fuel wood analysis as a source of household energy neglecting other aspects like; kerosene, electricity gas and transportation. Thus from the literature reviewed, it is shown that not all factors have equal importance in determining the pattern and behavior of

household energy consumption and that energy choices differ in different areas due to differences in socio-economic settings, environmental factors, and cultural factors as well as the average level of development in the area. Moreover, many authors have considered the use of a single energy source in their studies. This study fills the gap by considering multiple energy choices for household cooking.

4. Methodology

The study adopts a quantitative cross sectional research design. The paper uses secondary data, which have been obtained from [5]. Data Analysis was done using STATA statistical package, version 15.0. A multinomial logit model was used to estimate the underlying empirical model. We found this analytical model appropriate because it describes the behavior of consumers when they are faced with a variety goods with a common consumption objective. In addition, we base the choice of the model on its ability to perform better with discrete choice studies as confirmed by [43]. However, its goodness rests on the premise that the phenomena being studied must be highly differentiated by their individual attributes. This condition is fulfilled in our study since our empirical model examines choice between a set of mutually exclusive and highly differentiated fuels such as firewood, charcoal, kerosene, gas, and electricity.

4.1. Theoretical Model

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 [43]. The model can be expressed as follows:

$$Pr[Y = j] = \frac{\exp(\beta'_j X_i)}{1 + \sum_{j=0}^J \exp(\beta'_j X_i)} \quad (3)$$

where;

$Pr[Y = j]$ is the probability of choosing either firewood, kerosene, gas or electricity with firewood as the reference household fuel category; J is the number of fuels in the choice set; $j = 0$ is firewood; X_i is a vector of the predictor (exogenous) factors/variables and β_j is a vector of model parameters.

Re-writing Equation (1) gives;

$$P_i = \frac{e^{(b_0 + b_1 X_1 + b_2 X_2 + \dots + b_n X_n)}}{1 + e^{(b_0 + b_1 X_1 + b_2 X_2 + \dots + b_n X_n)}} \quad (4)$$

Re-arrangement Equation (4) using the odds ratio gives the following empirical model:

$$\ln \left[\frac{P_i}{1 - P_i} \right] = b_0 + b_1 X_1 + b_2 X_2 + \dots + b_n X_n + \varepsilon \quad (5)$$

In Equation (5), the quantity $\frac{P_i}{1-P_i}$ is the odds ratio. The logit (log odds) is a linear function of the independent factors X_i 's. Equation (3) 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 (3) we obtain the marginal effects (Greene, 2003).

$$\phi_j = \frac{\partial P_j}{\partial X_i} = P_j \left(\beta_j - \sum_{k=0}^J P_k \beta_k \right) = P_j (\beta_j - \bar{\beta}) \quad (6)$$

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 instance, the expected change in probability of choosing a particular fuel type with respect to a one-year change in age of household head. The model follows from the assumption that the random disturbance terms are independently and identically distributed [43]. In addition, [44] show that even if the number of alternatives is increased (from 2 to 3 to 4) the odds of choosing an alternative fuel remain unaffected. That is, the probability of choosing a particular fuel type is independent of presence of other fuel choices. A positive marginal effect implies an increase in the likelihood that a household will choose the alternative fuel. A negative marginal effect indicates that there is less likelihood that a household will change to alternative fuel.

4.2. Specification of the Empirical Model

Following Equation (3), the empirical model to be estimated is specified as:

$$\ln \left[\frac{P_i}{1-P_i} \right] = \beta_0 + \beta_1 INC + \beta_2 SEX + \beta_3 EDUC + \beta_4 REG + \beta_5 LOC + \varepsilon \quad (7)$$

where: β 's are coefficients of the equation, ε is the residual term

INC = Household income levels; SEX = Sex of household head; $EDUC$ = Level of education of household head; REG = Region where the household is located and LOC = Location of the household.

4.3. Variables Used in the Study and Their Measurement

Cooking fuel choice is the dependent variable. Various socio-economic variables such as income levels of the household, age of household head, education level of the household head, gender of household head, employment status of a household head, marital status of a household head as well as location of the household are investigated as the underlying predictor variables. The study variables, their measurement scales and units of measurement are shown in the following **Table 1**.

5. Results

5.1. Descriptive Statistics

Results in **Table 2** show that of the 15,654 total households, the majority 11,191

Table 1. Study variables, measurement scales and units of measurement.

	Measurement scale	Coding/units of measurement
Outcome variable:		
Fuel choice	Nominal	0-Traditional; 1-Transitional; 2-Modern
Explanatory variables:		
Income of the household head	Ratio	Ug. Shs. earned per month
Sex of the household head	Nominal	0-Female; 1-Male
Age of the household head	Ratio	Complete years
Education level of the household head	Ordinal	0-No education; 1-Primary education; 2-Secondary Education; 3-University Education; 4-Technical Education
Location of the household	Nominal	0-Rural; 1-Urban
Employment status of a household head	Nominal	0-Paid employment; 1-Self-employed; 2-Contributing family worker; 3-Others; 4-Subsistence worker

Source: Compiled by the authors.

Table 2. Key descriptive statistics on the outcome variable.

Type of fuel choice for cooking	Frequency	Percentage (%)
Modern fuels	205	1.3
Transitional fuels	4258	27.2
Traditional fuels	11,191	71.5
Total	15,564	100

Source: Compiled by the authors based on raw data.

(71.49%) use traditional fuels (firewood) for cooking. The minority of the households, 205 (1.31%) use modern fuels (Natural gas and electricity) for cooking. These results suggest that the largest number of Uganda's households rely on traditional fuels for cooking.

The descriptive statistics in **Table 3** indicate that the mean monthly income for households who use modern fuels for cooking is Ug. Shs. 1,353,705 with standard deviation of Ug. Shs. 2,668,195; the mean monthly income of households who use transitional for cooking is Ug. Shs. 687, 199 with standard deviation of Ug. Shs. 2,359,283 and the mean monthly income for households who use traditional fuels for cooking are Ug. Shs. 205, 814 with standard deviation of Ug. Shs. 528,170. The results from the key descriptive statistics on household's incomes indicate that households with higher average monthly income consume modern fuels as compared to households with lower average monthly income. The descriptive statistics on household's income also show a wide variability of monthly household incomes in each fuel choice category, suggesting that Uganda's household monthly incomes deviate from normal distribution.

Table 3. Key descriptive statistics (displayed by fuel choice) on continuous variables.

Fuel choice	Income of the household head		Age of the household head		
	Obs	Mean	Std. Dev	Mean	Std. Dev
Modern fuel	205	1,353,705	2,668,195	36	11.879
Transitional fuel	4258	687,199	2,359,283	37	12.608
Traditional fuel	11,191	205,814	528,170	45	16.400

Source: Compiled by the authors based on raw data.

The descriptive statistics in **Table 3** also indicate that the mean age of household heads who use modern fuel for cooking is 36 years with a standard deviation of approximately 11.9; the mean age of household heads who use transitional fuel for cooking is 37 years with a standard deviation of approximately 12.6 and the mean age of household heads who use traditional fuel for cooking is 45 years with a standard deviation of 16.4. The descriptive statistics on age suggest that older household heads have a higher preference of using traditional fuels for cooking as compared to younger household heads. In each fuel category, the standard deviation of age is much less than the mean age and the deviation of the mean age of households across the fuel choices is rather small, suggesting that the mean distribution of age among Uganda's household ages is approximately normal.

From **Table 4**, the descriptive statistics show that male headed households dominate the use of all fuel sources. This could be as a result of male headed households being more in number than female headed households. As depicted from **Table 4**, the counts of households vary considerably by the level of education across the fuel choices. This suggests that the household's level of education may have a strong association with the fuel choice for cooking. For instance, degree holder household heads dominate the use of modern fuels while household heads with some primary level of education dominate the use of traditional fuel. The descriptive statistics in **Table 4** further indicate that household heads in paid employment use more of modern energy as compared to self-employed and subsistence workers. Household heads in subsistence farming and those who are in self-employment dominate the use of traditional fuels. Unmarried household heads dominate the use of modern fuels while widowed household heads dominate the use of traditional fuels. Results however indicate that male headed households dominate the use of all the fuel choice categories for cooking. The descriptive statistics in **Table 4** further show that whereas urban households dominate the use of modern fuels as compared to their counterparts in rural areas, the rural households dominate the use of traditional fuels.

5.2. Regression Estimates with Log Odds for Fuel Choice

Table 5 shows the multinomial logistic regression estimates of the household fuel choices for cooking.

Table 4. Descriptive statistics of fuel choice for categorical variables (Figures indicated in the table are counts).

Variable	Variable categories	Cooking Fuel choice			Total
		Modern Fuel	Transitional Fuel	Traditional Fuel	
Sex of household head	Female	49	1462	3313	4824
	Male	156	2796	7877	10,829
Education level of the household head	Degree	62	320	68	450
	Diploma	26	468	263	757
	Higher secondary	20	264	140	424
	Lower secondary	21	571	604	1196
	Some secondary	24	932	1435	2382
	Completed primary	13	503	1637	2153
	Some primary	22	912	4903	5837
Location of the household	No formal education	7	213	2051	2271
	Rural	36	1223	9316	10,575
Employment status of the household head	Urban	169	3035	1875	1994
	Paid employment	106	1847	1994	3947
	Self employed	67	1807	3855	5729
Marital status of the household head	Subsistence	9	3859	10,027	4269
	Unmarried	20	219	118	357
	Married	10	495	1044	1549
	Divorced	12	467	607	1086
	Widow	7	281	1544	1832

Source: Compiled by the authors based on raw data.

Table 5. Multinomial Logistic regression estimates of cooking fuel choice.

Number of obs = 13,757		Prob > chi2 = 0.0000				
LR chi2 (36) = 6637.04		Pseudo R2 = 0.3733				
Log likelihood = -5571.2963						
Cooking Fuel choice	Coef.	Std. Err.	z	P > z	[95% Conf. Interval]	
Modern Fuel for cooking						
Logarithm of income	0.604***	0.0744	7.8	0.000	0.452	0.756
Age	-0.039***	0.0084	-4.66	0.000	-0.056	-0.023
Male	-2.047***	0.328	-6.24	0.000	-2.689	-1.404
Self employed	0.039	0.186	0.21	0.800	-0.326	0.404
Contributing family workers	0.069	1.056	0.06	0.900	-2.001	2.139
Others	-12.26	619.8	-0.02	1.000	-1227.129	1202.602
Subsistence workers	-0.771**	0.381	-2.02	0.000	-1.518	-0.024
Married Household head	-2.302***	0.497	-4.63	0.000	-3.277	-1.327

Continued

Divorced household head	-1.042**	0.448	-2.33	0.000	-1.921	-0.164
Widowed household head	-2.340***	0.684	-3.42	0.000	-3.680	-0.999
Some Primary	-0.525	0.485	-1.08	0.300	-1.475	0.424
Completed primary	-0.115	0.513	-0.22	0.800	-1.121	0.891
Some secondary	0.294	0.478	0.62	0.500	-0.642	1.231
Lower secondary	0.743	0.494	1.5	0.100	-0.225	1.710
Higher secondary	1.699***	0.512	3.32	0.000	0.695	2.704
Diploma	1.346***	0.492	2.74	0.000	0.382	2.310
Degree	3.000***	0.492	6.09	0.000	2.035	3.966
Urban	2.233***	0.206	10.85	0.000	1.830	2.636
_cons	-9.416***	1.005	-9.37	0.000	-11.385	-7.447
Transitional Fuel for cooking						
Logarithm of income	0.473***	0.0242	19.58	0.000	0.426	0.520
Age	-0.032***	0.0023	-13.49	0.000	-0.032	-0.027
Male	-1.479***	0.175	-8.44	0.000	-1.822	-1.135
Self employed	-0.174***	0.057	-3.06	0.000	-0.286	-0.063
contributing family workers	-0.172	0.295	-0.58	0.600	-0.750	0.406
Others	-0.258	0.431	-0.6	0.500	-1.104	0.587
Subsistence workers	-1.871***	0.0991	-18.88	0.000	-2.065	-1.677
Married Household head	-0.822***	0.190	-4.34	0.000	-1.194	-0.450
Divorced household head	-0.132	0.195	-0.68	0.500	-0.513	0.249
Widowed household head	-0.877***	0.204	-4.3	0.000	-1.277	-0.477
Some Primary	0.226**	0.110	2.05	0.000	0.010	0.442
Completed primary	0.501***	0.121	4.15	0.000	0.264	0.737
Some secondary	0.934***	0.117	7.98	0.000	0.705	1.164
Lower secondary	1.146***	0.130	8.82	0.000	0.891	1.400
Higher secondary	1.443***	0.170	8.5	0.000	1.110	1.775
Diploma	1.352***	0.142	9.46	0.000	1.072	1.632
Degree	1.801***	0.194	9.27	0.000	1.420	2.181
Urban	1.900***	0.052	36.79	0.000	1.799	2.001
_cons	-5.265***	0.329	-16.02	0.000	-5.909	-4.621
Traditional Energy for cooking (base outcome fuel choice category)						

Source: Compiled by the authors. *** indicates significance at 1% level; ** indicates significance at 5% level and * indicates significance at 10% level.

Table 5 shows multinomial logit estimates of modern fuel (electricity and solar) and transitional fuel (charcoal) with traditional fuel (firewood) being the base fuel choice category for cooking. The coefficients with asterisk(s) indicate

that the corresponding Z-statistic is significant which suggests that the associated explanatory variable has a causal influence on the outcome variable. For instance, the results in **Table 5** show that a one percent increase in household's income is associated with a 0.604 increase in the relative log odds of choosing modern fuel for cooking, and with a 0.473 increase in the relative log odds of choosing transitional fuel for cooking as compared to traditional fuel. Estimates show that age of a household head has a negative effect on the fuel choice for cooking. For instance, a one-year increase in the age of the household head is associated with a 0.039 decrease in the relative log odds of choosing modern fuel for cooking, and with a 0.032 decrease in the relative log odds of choosing transitional fuel for cooking as compared to traditional fuels. The estimates show that the relative log odds of choosing modern fuels for cooking and the relative log odds of choosing transitional fuels for cooking as opposed to traditional fuels will decrease by 2.047 and 1.479 respectively if moving from a female headed household to male headed household. The log odds of choosing modern fuels rather than traditional fuel for cooking are likely to reduce by 0.771 in a household headed by a subsistence worker compared to a household headed by a paid worker. Likewise, the log odds of choosing transitional fuel rather than traditional fuel for cooking by self-employed and subsistence household farmers are likely to reduce by 0.174 and 1.871 respectively compared to households in paid employment. The estimates show that the relative log odds of using modern fuels for cooking compared to traditional fuels reduce by 2.302, 1.042 and 2.340 with married, divorced and widowed household heads respectively. On the other hand, the relative log odds of transitional fuels for cooking compared to traditional fuels reduce by 0.822 and 0.877 with married and widowed household heads respectively. These results suggest that married, divorced and widowed household heads are more likely to reduce the use of modern fuels for cooking whereas married and widowed household heads are more likely to reduce the use of transitional fuels for cooking. Estimates in **Table 5** show that the relative log odds of choosing modern fuel for cooking rather than traditional fuel will increase by 1.699, 1.346 and 3.000 with household heads who had attained higher secondary school, diploma and degree levels of education respectively. Likewise, the results show that the relative log odds of choosing transitional fuel for cooking rather than traditional fuel will increase by 0.226, 0.501, 0.934, 1.146, 1.443, 1.352 and 1.801 with household heads who had completed primary, some level of secondary, lower secondary higher secondary, diploma and degree levels of education respectively. Results in **Table 5** further show that the relative log odds of choosing modern fuel for cooking rather than traditional fuel increases by 2.233 if moving from rural household to urban household. On the other hand, the relative log odds of choosing transitional fuel for cooking rather than traditional fuel increases by 1.900 if moving from rural household to urban household. These results suggest that urban households are more likely to use modern fuel and transitional fuel for cooking as compared to rural household.

5.3. Marginal Effects after the Multinomial Logistic Regression

The marginal effects show the percentage change in the odds ratio attributable to a unit change in one of the variables as shown in **Table 6**.

From **Table 6**, the marginal effects estimates show that an increase in the household's income by one percent reduces the probability of using traditional fuels by 5.4% while the probability of using transitional and modern fuel increases by 5.1% and 0.3% respectively. The results confirm the energy ladder hypothesis [22], which postulates that as household's income increases, households will move up the energy ladder shifting from the use of traditional fuel to modern fuels. However, the change is marginal which confirm the International Energy Agency's (IAE'S) standpoint that income growth does not automatically

Table 6. Marginal effects and prediction probabilities of multinomial Logit estimates.

	Modern energy		Transitional Energy		Traditional energy	
	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Logarithm of income	0.003***	0.001	0.051***	0.003	-0.054***	0.003
Age of household head	0.000***	0.000	-0.003***	0.000	0.004***	0.000
Sex of the household head						
Male	-0.011***	0.003	-0.157***	0.010	0.169***	0.020
Employment status of household head						
Self employed	0.002	0.002	-0.021***	0.007	0.019	0.066
Contributing family workers	0.002	0.011	-0.041	0.060	0.019	0.033
Others	-0.136	0.006	-0.066	4.875	0.070	2.122
Subsistence workers	0.006	0.013	-0.213***	0.021	0.207***	0.011
Marital status of a household head						
Married	-0.020***	0.005	-0.078***	0.021	0.098***	0.14
Divorced	-0.001**	0.005	-0.007	0.021	0.018	0.061
Widow	-0.002***	0.008	-0.085***	0.022	0.014***	0.149
Level of education of household head						
Some primary	-0.008	0.005	0.025**	0.016	-0.023**	0.012
Completed primary	-0.005	0.008	0.066**	0.018	-0.054***	0.013
Some secondary	-0.004	0.008	0.130**	0.019	-0.103***	0.013
Lower secondary	-0.001	0.008	0.149**	0.020	-0.128***	0.014
Higher secondary	0.008	0.010	0.167**	0.031	-0.164***	0.019
Diploma	0.005	0.008	0.157**	0.025	-0.153**	0.016
Degree	0.020***	0.015	0.181	0.035	-0.216**	0.04
Location of the household						
Urban	0.010***	0.003	0.205***	0.005	-0.216***	0.004

Source: Compiled by the authors. *** indicates significance at 1% level; ** indicates significance at 5% level and * indicates significance at 10% level.

lead to a greater uptake of clean fuels for cooking [10]. Age of household head reduces the probability of using transitional fuels and modern fuels for cooking by 0.3% and 0.0% respectively, but it (age) increases the probability of using traditional fuels for cooking by 0.4%. We find this result making sense because as the household heads grow older, they tend to get inclined to traditional fuels as a matter of habit as compared to younger household heads. In many developing countries like Uganda, where savings are inadequate and investment in capital is relatively low, the older you get, the less income you have. As a result, older household heads tend to stick to traditional fuels which are cheap and readily available. Our results are supported by findings other scholars in related studies for instance, [30] and [32].

The probability of using modern fuels and traditional fuels for cooking reduces by 1.1% and 15.7% respectively if the household is male headed; but the probability of using transitional fuels for cooking increases by 16.9% if the household is male headed. These results suggest that male headed households have preference of traditional fuels as compared to transitional and modern fuels. We find this result surprising given the cultural values the males tend to attach to their food preparation methods most especially in developing countries like Uganda. Moving from a household head in paid employment to a household head in self-employment, the probability of using transitional fuels reduces by 2%. The probability of using transitional fuel in household headed by subsistence worker reduces by 21% and increases the probability of using traditional fuels by 20%. This is supported by the findings of [45] who found that occupation is much more important than income in the cooking fuel transition. Residing in urban areas increases the probability of using modern fuels by 1%, increases the probability of using transitional fuels by 20% and reduces the probability of using traditional fuels by 21%. The estimated coefficient for household head's education is positive and statistically significant at 5% for the probability of a household choice of transitional fuels as their main cooking fuels and statistically significant at 1% for the use of traditional fuel. A household head who has completed some primary has a probability of 0.6% of using transitional fuel and a probability of 0.2% of not using traditional fuel. A household head who has completed primary education has a probability of 0.7% of using transitional fuel and a probability of 0.5% of not using traditional fuel. A household head who has completed some secondary, lower secondary and higher secondary have a probability of 13%, 15% and 17% of using transitional fuel respectively and a probability of 10%, 12% and 16% of not using traditional fuel. A household head who has completed diploma education has a probability of 16% of using transitional fuel and a probability of 15% of not using traditional fuel. Household heads with a degree have a probability of 0.2% of using modern fuel and a probability of 21% of not using traditional fuel. This implies that an increase in household head's education is likely to influence the choice of modern and transitional fuels over traditional fuel. A possible explanation is that, increased level of education improves households' income, taste, knowledge of fuel attributes

and preference modern clean fuels. A highly educated household head is likely to lack time to collect fuelwood because of the opportunity cost of the time and would rather purchase fuelwood alternatives which are cleaner but expensive *ceteris paribus*. This finding is consistent with the finds of [29].

6. Conclusion

The study presents the set of key factors that determine the choice of cooking fuels in households of Uganda. The study uses cross sectional data from [5]. The MNL analysis estimates show that the log odds of choosing modern as well as transitional fuels over the traditional fuel increase with household incomes, household having higher secondary, Diploma or Degree education levels and a household located in Urban. On the other hand, estimates show that the log odds of choosing modern as well as transitional fuels over the traditional fuel decrease with age of household head, household head being male headed, household head being in subsistence employment, household head being a married female household head being divorced and household head being widowed. The study results thus show that the most important drivers of fuel choice for cooking in Uganda's households are: household income, age of household head, gender of household head, marital status of the household head, education level of the household head, employment status of the household head and location of a household. The paper further reveals high dependency of firewood as cooking energy source among households in Uganda.

7. Policy Implications

From the study, the following implications were drawn;

1) Many households continue to rely on traditional fuels, and this finding implies that there will be a decline in agricultural productivity through deforestation, loss of natural habitat for wildlife and not forgetting the impact on the health of women and children. To mitigate the negative consequences of heavily relying on firewood, policy makers should make modern fuels more accessible and affordable so that firewood and charcoal be used and harvested more sustainably. There is also need to sensitize communities on the role of environment and the danger they pose when they misuse it.

2) Government should provide incentives and enabling environment for private sector participation in supply of modern energy. Improvement of infrastructure in the countryside will encourage private sector investment and hence removal barriers to accessing of cleaner fuels.

3) Government and other sectors stakeholders should also encourage demand for modern energy through promotion of cleaner energy by making them more accessible and affordable.

8. Study Limitations and Areas for Further Research

This study uses cross sectional data from [5]. This data is a one-survey period

data. A similar study can be extended to cover a panel of the UNHS data covering previous periods as well as the most recent period when the data is available. In this case, panel data analytical techniques may be employed, and the analysis involving comparison with the results of the one-survey period studies may reveal whether or not there has been social-economic transformation in the energy choice for cooking among Uganda's households. The quantitative nature of the study is also a limitation. The study may be improved if a similar qualitative study is carried out and field interviews conducted.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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