Original Article

Socio-Economic Determinants of Household Continued Use of Solid Biofuels (Fuelwood and Charcoal) for Cooking Purposes in Sub-Saharan Africa- Kenya's Situation.

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ABSTRACT

Solid biofuels (fuelwood and charcoal) remain the primary source of household cooking energy in Kenya. This has negatively impacted forest resources, people's health, local climate patterns, and the country's economy. Understanding the determinants of household use of these traditional energy resources is useful in the designing of policies and strategies aimed at facilitating energy transitions towards clean options. The current study evaluated the role of socio-economic factors in the determination of household use of fuelwood and charcoal for cooking purposes in Kenya. A desk study was conducted using the 2015/2016 Kenya Integrated household budget survey data published by the Kenya National Bureau of Statistics (KNBS). Stepwise multiple regression using SPSS was run to determine how household size, female household headship, lack of education among household heads, ownership of housing unit, modern housing, access to credit, access to cash transfers, shock to household welfare, and household level of expenditure affect household utilisation of fuelwood and charcoal for cooking purposes. Results of the regression show that household ownership of a housing unit has a significant positive influence on household utilisation of fuelwood for cooking purposes. Access to credit has a significant negative influence on household charcoal utilisation, while both household expenditure beyond $71 and lack of education among household heads have a significant negative influence on household utilisation of fuelwood and a significant positive influence on household utilisation of charcoal. Therefore, the government of Kenya through its relevant authorities and agencies has a crucial role to play in ensuring that these socio-economic determinants of household use of solid biofuels are

addressed. This is achievable through re-strategising, re-designing and designing policies aimed at facilitating households' transition to clean energy alternatives and sustainable development.

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INTRODUCTION

Throughout history, the types and ways of obtaining energy have been changing. For example, during the agricultural revolution, biomass was the primary household fuel because it was readily available; and was mainly used for cooking and heating purposes (Wrigley, 2013). The then solar-based economy solely relied on land use and biomass utilisation; Fouquet (2011) referred to this as the organic energy economy. However, with the industrial revolution, the energy systems transitioned to the use of fossil fuels including coal, oil, and natural gas, especially due to the high energy demanded to power the manufacturing industries. The steam engine characterised economy, therefore, referred to as the fossil fuel economy (Bithas & Kalimeris, 2016).

Currently, technological advancement has enabled the discovery of renewable energy resources such as wind, biogas, wave, tidal, solar, geothermal, and hydropower. This discovery has provided households, businesses, and even industries with a broad range of energy options and hence the freedom of choice of the type of energy source to use. This continued change in the types and ways of obtaining energy can be attributed to the fact that energy is a fundamental component of human survival, reproduction, and evolution (Bithas & Kalimeris, 2016). Because people's needs keep changing, the demand for energy (in terms of type and quantity) also keep changing in an attempt to meet the varying needs.

However, with the current trends of change in climatic conditions, the global focus has been the shift from fossil fuels to renewable energy in an endeavour to reduce the human-induced greenhouse effect and climate change. Nevertheless, unlike in the developed nations where households are nearly universally electrified and supplied with other clean energy resources such as LPG and biogas, in most

developing countries, household choice of fuel involves weighing options depending on several factors. In some cases, the question of whether to use traditional or modern clean fuel in developing countries is often not relevant, either because the option of modern fuel is not provided or because of other unfavourable local factors.

Currently, despite the invention of a wide range of clean energy technologies, more than 2.7 billion people globally still rely on traditional biomass for cooking, lighting and heating purposes, with the majority living in developing countries (International Energy Agency, 2016). In Sub-Saharan Africa, the region still suffers the challenge of energy poverty as wood, charcoal, and paraffin remain the primary sources of energy for cooking, lighting, and heating. According to the International energy agency (2014)), about 730 million people in the region rely on traditional solid biomass for energy and 80% of household energy demand in the region is used for cooking. This is because households in the region tend to prioritise cooking and lighting energy and are mainly reliant on low-efficiency cookstoves (mostly three stone fire). However, households' choice to use fuelwood, charcoal, and paraffin and the amounts used vary within and across countries and localities.

In Kenya, although there has been a significant reduction in the number of households relying on traditional fuel in the last decade, many households still rely on solid biofuels for cooking purposes, especially in rural areas. In 2009, the population of Kenya's households that relied on solid biofuels for cooking was approximately 82.5% (KNBS, 2015). Wood was the most common cooking fuel as it was used by approximately 64.4% (two thirds) of the households in the country. This comprised 90.3% of rural households who relied on fuelwood for cooking purposes, 7.1% who relied on charcoal, 22.7% of urban households who relied on fuelwood, and 32.8% of the urban population which relied on charcoal (KNBS & SID, 2013).

However, a recent study by the Kenya National Bureau of Statistics shows that currently, approximately about 69.5% of the households in the country rely on solid biofuels for cooking purposes (KNBS, 2018), which is a drop by 13% since the year 2009. This comprises 83.5% of rural households who rely on fuelwood, 8.9% who rely on charcoal, 16.1% of urban households who rely on fuelwood, and 21.9% of the urban population who rely on charcoal.

According to the International Energy Agency (2017)), the continued use of biomass fuels in traditional inefficient ways has a negative impact on people's health, the physical environment, and a country's economy. For example, carbon monoxide, nitrogen dioxide, sulphur dioxide, and particulate matter emitted from the burning of biomass fuels cause indoor air pollution (World Health Organisation, 2017); while carbon dioxide emissions are a leading driver to climate change which impacts negatively on agricultural productivity, and consequently on a country's economy (Muller & Yan, 2016). It is, therefore, essential to understanding households' fuel choice, preference, and trends in energy switching in order to effectively design policies and strategies aimed at facilitating their transition towards clean energy options.

Over the last three decades, many studies have investigated the determinants of household choice of fuel and energy transition (Hosier & Dowd, 1987; Sathaye & Tyler, 1991; Heltberg, 2005; Farsi et al., 2007; Desalu et al., 2012; Rahut et al., 2014; Baiyegunhi & Hassan, 2014; Bisu et al., 2016; Rahut et al., 2017; Song et al., 2018). However, despite this, Joshi and Bohara (2017) note that there still exists a limited knowledge of the determinants of household energy use for different countries and regions across the world. Additionally, given the socio-economic, environmental and geographical

heterogeneity of the different regions studied in previous studies as provided in the literature, the case studies made in those studies may not be precisely generalised for Kenya as a country.

In the current study, the researcher focused on determining the role of socio-economic factors in influencing the household choice to continue relying on firewood and charcoal as cooking fuel in Kenya. To achieve this, a stepwise multiple regression analysis using the 2015/2016 Kenya Integrated Household Budget Survey data was conducted using SPSS. The data, which was collected between the year 2015 and 2016 comprised a study sample of 24,000 households sampled across the nation.

METHODOLOGY

Research Design

This study aimed to determine the socio-economic determinants of household continued use of fuelwood and charcoal for cooking purposes in Kenya. The researcher, therefore, employed a causal (relationship-based) research design to achieve the objectives of the study, which were to determine how family size, female household headship, lack of education among household heads, type of dwellings, ownership of a housing unit (housing tenure), access to credit, access to cash transfers and shocks to household welfare affect the household choice to use fuelwood and charcoal for cooking purposes in Kenya.

A desk study was conducted using the 2015/2016 Kenya Integrated Household Budget Survey data extracted from a report by the Kenya National Bureau of Statistics. The data comprised of a sample size of 24,000 households sampled by the Kenya National Bureau of Statistics were analysed descriptively and through multiple regression modelling using the SPSS package. Additional data on the household level of expenditure and lack of education among household heads were extracted from the 2013 Kenya's inequality report by the Kenya National Bureau of Statistics and Society for International Development.

Study Area

The study was carried out in Kenya; the country is located in the Eastern part of Africa bordering Tanzania on the South, Uganda on the West, Ethiopia on the North, South Sudan on the North West, Somalia on the North East, and the Indian Ocean on the South East. The country's geographical coordinates are 0.0236° S, 37.9062° E. It is sub-divided into 47 Counties and, according to the country's recent population and housing census, the total human population in the country was 47.6 million in 2019.

Kenya was purposively selected for this study given that it is one of the countries with the highest rates of use of traditional fuel for cooking in Africa (Wakeford, 2017). The country, which lies on 582,650km^2 of land is characterised by varying climatic conditions, from mostly cool daily in some regions to always warm/hot in other regions. Additionally, the country is also characterised by the availability of numerous types of energy resources—both renewable and non-renewable—including geothermal, wind, hydropower, wood, charcoal, solar, kerosene, and recently discovered coal and oil resources. However, for some reasons, most households in the country rely on solid biofuels for cooking purposes, mostly firewood in rural areas and charcoal in urban areas.

Study Population and Sampling Procedures

The study sample comprised of the 2015/2016 Kenya Integrated Household Budget Survey sample of 24,000 households sampled by the Kenya National Bureau of Statistics. According to the KNBS (2018), the study sample was obtained from the fifth National Sample Survey and Evaluation Programme (NASSEP V) household sampling frame, which is the frame

operated by the bureau in conducting household-based surveys in the country. The frame is comprised of 5,360 clusters which are then stratified into rural and urban to form 92 sampling strata, and in which case Nairobi City and Mombasa City counties are stratified as being wholly urban.

According to the KNBS (2018), to conduct the survey, a total of 2,400 clusters (comprising of 988 urban and 1,412 rural households) were sampled from the NASSEP V sampling frame. The sample size for each county was then determined independently resulting in a national sample of 24,000 households. Additional data on household-level of expenditure and lack of education among household head was drawn from the 2013 Kenya's inequality report by Kenya National Bureau of Statistics and the Society for International Development. The report, whose focus is geographical or regional inequalities in the country was built from the country's census survey data of 2009.

Data Type and Collection Methods

Because this research was conducted through a desk study, only secondary data was collected. The study was mainly based on the 2015/2016 Kenya Integrated Household Budget Survey data, and partly on the 2013 Kenya's inequality data obtained from the Kenya National Bureau of Statistics website. The data collected aimed to provide an understanding of the following household aspects;

1. Household choice of cooking fuel (firewood and charcoal) per county

2. Household characteristics

    (a) Household size
    (b) Gender of the household head
    (c) Education level among household heads

3. Housing conditions

    (a) Household ownership of housing unit
    (b) Type of dwellings

4. Economic factors

    (a) Household access to credit
    (b) Household access to cash transfers
    (c) Shock to household welfare
    (d) Household level of expenditure

Additional secondary information was obtained through a critical review of relevant literature in the library and internet sources. This aimed at providing complementary information in the literature on socio-economic determinants of the household choice of cooking fuel.

Data Analysis, Interpretation, and Presentation

Data were analysed using descriptive statistics and multiple regression models, which were generated using the IBM Statistical Package for the Social Sciences (SPSS) version 25. The results obtained were then presented in the form of percentages, tables, and texts to show the interrelationship between the various components of the study.

RESULTS AND DISCUSSION

Description of Variables

Dependent and Independent Variables

A dependent variable, also known as an outcome variable, is the variable being tested in an experiment or variable being assessed in a mathematical/statistical equation. In the current study, the researcher statistically assessed (through stepwise multiple regression) the household choice of fuelwood and charcoal for cooking purposes in Kenya, as determined by the existing socio-economic conditions. The use of fuelwood and use of charcoal as cooking fuel in Kenya's households are, therefore, the study's dependent variables.

An independent variable, also known as a predictor variable or explanatory variable, is the variable that is controlled in an experiment or a variable that is changed in a mathematical/statistical equation to determine the effect on a dependent variable. Independent variables in different studies vary in number from one to as many as possible, depending on the type of study or data available. In the current study, independent variables are classified into three categories which are (i) household characteristics, (ii) housing conditions, and (iii) economic factors.

Household characteristics include the gender of the household head (female household headship in this case), lack of education among household heads, and household/family size. Housing conditions include the type of household dwellings and ownership of housing

units (housing tenure), while economic factors include household access to cash transfer, access to credit, shock to household welfare, and household level of expenditure.

Assumptions Testing

Before conducting the regression analysis, the assumptions of Linearity, Autocorrelation, Homoscedasticity, Multicollinearity, Normality and outliers were tested to make sure that the available data met the requirements of multiple regression.

Descriptive Statistics

Table 1 below presents the descriptive statistics for the dependent and independent (explanatory) variables used in this study.

Table 1: Descriptive statistics

	N	Min	Max	Mean	Std. Dev
Firewood	47	1.4	97.0	66.057	22.1185
Charcoal	47	2.1	43.1	16.179	10.5277
Female household headship	47	20.3	52.1	33.872	7.0931
Lack of education of HHH	47	11.0	82.0	29.298	20.0184
Household size	47	2.9	6.6	4.317	.8313
Modern housing	47	17.4	99.8	73.153	22.2725
Owning a house	47	8.1	94.6	69.898	18.2565
Access to Cash transfer	47	6.1	66.6	36.347	16.3072
Credit access	47	3.3	64.9	28.981	16.9986
Shock to HH welfare	47	16.8	96.0	62.843	21.1247
Monthly expenditure beyond $71	47	3.0	69.0	25.426	14.3190
Valid N (list wise)	47				

Source: Author's computation

It is clear from the table above that on average, about 66% of households in every county in Kenya rely on fuelwood for cooking purposes, while 16% of the households rely on charcoal. Of all the 47 counties in the country, the least fuelwood-reliant county has 1.4% of its households using fuelwood for cooking purposes, while the most fuelwood-reliant county has 97% of its households relying on fuelwood. On the other hand, the least charcoal

reliant county in Kenya has 2% of its households relying on charcoal, while the most charcoal reliant county has 43% of its households relying on charcoal.

On average, approximately 34% of households in every county in the country are female-headed. The county with the least number of female-headed households has 20% of its households headed by women, while the county

with the most female-headed households has 52% of its households headed by women. Further, on average, 29% of households in every county are headed by uneducated heads. The county with the largest number of educated household heads has 11% of its households headed by uneducated heads, while the county with the least number of educated heads has 82% of its households headed by uneducated heads.

In terms of household size, each household in Kenya has an average of four family members; 73% of households in every county live in modern types of houses, and approximately 70% of the households in each county own the houses where they live. Additionally, over the one year preceding the survey by the Kenya National Bureau of Statistics, an average of 36% of households in every county reported having received a cash transfer, either in the form of currencies or transferrable deposits like a money order or cheque. Approximately 29% of the households also reported having accessed some form of credit over the same period, either in the form of money or goods.

Furthermore, approximately 63% of households in each county reported having experienced a shock or an expected event that negatively impacted their economic status or welfare. This was based on the households'

experience over a 5-year period preceding the survey by the Kenya National Bureau of Statistics. In addition, based on the descriptive statistics table, only 25% of households in each county in Kenya can afford to spend at least $71 in a month. In the worst case, only 3% of households in a county could afford to spend $71 or more, while only 69% of households in the best performing county (Nairobi) could afford to spend a similar amount in a month.

Regression of the Socio-economic Determinants of Household Use of Fuelwood for Cooking Purposes in Kenya

Stepwise multiple regression was used to assess the ability of nine socio-economic factors—female household headship, lack of education among household heads, family/household size, modern housing, housing tenure, access to credit, access to cash transfer, shock to household welfare, and household expenditure—to predict household use of fuelwood for cooking in Kenya. In the regression, only three predictor variables (owning a house, monthly expenditure beyond $71, and lack of education among household heads) were found to be significant determinants and were entered into the model, while the other predictor variables were excluded, *Table 2* below.

Table 2: Table showing the variables entered/removed in the firewood utilisation model

	Variables Entered/Removed[a]		
Model	Variables Entered	Variables Removed	Method
1	Owning a house	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Monthly expenditure beyond $71	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	Lack of education of HH	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Firewood

From the model summary in *Table 3* below, 93.7% of the variance in the number of households using firewood for cooking is explained by three independent variables; owning a house, monthly household expenditure beyond $71, and lack of education among household heads. Owning a house alone contributes 90.2% of the variance in the number of households using firewood; monthly household expenditure beyond $71 contributes an additional 1.6%, while lack of education among household heads contributes an additional 1.9%.

Table 3: Firewood Model summary

			Model Summary[d]		
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.951[a]	.904	.902	6.9284	
2	.960[b]	.922	.918	6.3352	
3	.970[c]	.942	.937	5.5312	1.883

a. Predictors: (Constant), Owning a house

b. Predictors: (Constant), Owning a house, Monthly expenditure beyond $71

c. Predictors: (Constant), Owning a house, Monthly expenditure beyond $71, lack of education of HH

d. Dependent Variable: Firewood

All the three predictors are also statistically significant at the 5% significance level as shown in ANOVA *Table 4* below and are, therefore, said to make a significant unique contribution to the prediction of household use of fuelwood for cooking in Kenya. This is because, for all the three variables, the significance value is 0.00, which is much less than 0.05. In the final model shown in coefficients table 5, [owning a house, $t = 15.901$, $p = 0.00$ (< 0.05); monthly expenditure beyond $71, $t = 4.552$, $p = 0.00$ (<0.05); and lack of education among household heads, $t = 3.837$, $p = 0.00$ (<0.05)].

Table 4: Analysis of Variance table showing firewood model significance

			ANOVA[a]			
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	20344.321	1	20344.321	423.818	.000[b]
	Residual	2160.114	45	48.003		
	Total	22504.435	46			
2	Regression	20738.524	2	10369.262	258.364	.000[c]
	Residual	1765.911	44	40.134		
	Total	22504.435	46			
3	Regression	21188.871	3	7062.957	230.857	.000[d]
	Residual	1315.564	43	30.595		
	Total	22504.435	46			

a. Dependent Variable: Firewood

b. Predictors: (Constant), Owning a house

c. Predictors: (Constant), Owning a house, Monthly expenditure beyond $71

d. Predictors: (Constant), Owning a house, Monthly expenditure beyond $71, lack of education of HH

In the coefficients *Table 5* below, the contribution of each independent variable to the prediction of the dependent variable (household fuelwood utilisation) at a 95% confidence level is presented. In the final model 3, standardised beta coefficients indicate that owning a house has the highest contribution (0.822) to the model. This means that the variable 'owning a house' has the strongest unique contribution to explaining the variation in the number of households using fuelwood for cooking in Kenya.

The beta value for monthly household expenditure beyond $71 was lower (-0.246); while that of lack of education among household heads was much lower (-0.154), indicating that the variable 'lack of education among household heads' made the least unique contribution to the prediction of household use of fuelwood for cooking in Kenya

Table 5: Coefficients table showing the contribution of independent variables to the firewood model

	Model	Unstandardised Coefficients		Standardised Coefficients	T	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-14.460	4.040		-3.580	.001	-22.596	-6.324					
	Owning a house	1.152	.056	.951	20.587	.000	1.039	1.265	.951	.951	.951	1.000	1.000
2	(Constant)	3.837	6.908		.555	.581	-10.086	17.760					
	Owning a house	.994	.072	.821	13.865	.000	.850	1.139	.951	.902	.586	.509	1.965
	Monthly expenditure beyond $71	-.287	.091	-.186	-3.134	.003	-.471	-.102	-.761	-.427	-.132	.509	1.965
3	(Constant)	11.109	6.323		1.757	.086	-1.641	23.860					
	Owning a house	.996	.063	.822	15.901	.000	.869	1.122	.951	.924	.586	.509	1.965
	Monthly expenditure beyond $71	-.380	.083	-.246	-4.552	.000	-.548	-.212	-.761	-.570	-.168	.466	2.147
	Lack of education of HH	-.170	.044	-.154	-3.837	.000	-.260	-.081	.175	-.505	-.141	.843	1.187

a. Dependent Variable: Firewood

However, other independent variables——female household headship, household size, modern housing, access to cash transfer, access to credit, and shock to household welfare——do not make any significant contribution to the prediction of household use of fuelwood, and were, therefore, excluded from the model.

Regression of the Socio-economic Determinants of Household Use of Charcoal for Cooking Purposes in Kenya

Just like in the case for fuelwood, stepwise multiple regression was used to assess the ability of nine socio-economic factors: female household headship, lack of education among household heads, family/household size, modern housing, housing tenure, access to credit, access to cash transfer, shock to household welfare, and household expenditure level to predict household use of charcoal for cooking purposes in Kenya. In the regression, only three predictor variables (access to credit, monthly expenditure beyond $71, and lack of education among household heads) were found to be significant determinants and were entered into the model, while the other predictor variables were excluded, *Table 6* below.

Table 6: Table showing the variables entered/removed in the charcoal utilization model

		Variables Entered/Removed[a]	
Model	**Variables Entered**	**Variables Removed**	**Method**
1	Credit access	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Monthly expenditure beyond $71	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	Lack of education of HH	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Charcoal

From the model summary in *Table 7* below, 34.8% of the variance in the number of households using charcoal for cooking is explained by three independent variables; credit access, monthly household expenditure beyond $71, and lack of education among household heads. Access to credit alone contributes 16.9% of the variance in the number of households using charcoal, monthly household expenditure beyond $71 contributes an additional 9.3%, while lack of education among household heads contributes an additional 8.6%.

Table 7: Charcoal model summary

			Model Summary[d]		
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	.432[a]	.187	.169	9.5991	
2	.543[b]	.294	.262	9.0423	
3	.625[c]	.390	.348	8.5030	1.304

a. Predictors: (Constant), Credit access

b. Predictors: (Constant), Credit access, Monthly expenditure beyond $71

c. Predictors: (Constant), Credit access, Monthly expenditure beyond $71, lack of education of HH

d. Dependent Variable: Charcoal

All the three predictors are also statistically significant at the 5% significance level as shown in ANOVA table 8 below and are, therefore, said to make a significant unique contribution to the prediction of household use of charcoal for cooking purposes in Kenya. This is because, for all the three variables, the significance value is less than 0.05. In the final model shown in coefficients table 9, [access to credit $t = 2.401$, $p = 0.021$ (< 0.05); monthly expenditure beyond \$71 $t = 3.583$, $p = 0.001$ (< 0.005) and lack of education among household heads $t = 2.600$, $p = 0.013$ (< 0.05)].

Table 8: Analysis of variance table showing the charcoal model significance

ANOVAª						
Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	951.832	1	951.832	10.330	.002ᵇ
	Residual	4146.427	45	92.143		
	Total	5098.259	46			
2	Regression	1500.662	2	750.331	9.177	.000ᶜ
	Residual	3597.597	44	81.764		
	Total	5098.259	46			
3	Regression	1989.328	3	663.109	9.172	.000ᵈ
	Residual	3108.931	43	72.301		
	Total	5098.259	46			

a. Dependent Variable: Charcoal

b. Predictors: (Constant), Credit access

c. Predictors: (Constant), Credit access, Monthly expenditure beyond \$71

d. Predictors: (Constant), Credit access, Monthly expenditure beyond \$71, lack of education of HH

In the coefficients *Table 9* below, the contribution of each independent variable to the prediction of the dependent variable (household charcoal utilisation) at a 95% confidence level is presented. In the final model 3, standardised beta coefficients indicate that monthly household expenditure beyond \$71 has the highest contribution (0.469) to the model. This means that the variable 'household monthly expenditure beyond \$71' has the strongest unique contribution to explaining the variation in the number of households using charcoal for cooking purposes in Kenya.

The beta value for lack of education among household heads was lower (0.367), while that of access to credit was much lower (-.311); indicating that the variable 'access to credit' made the least unique contribution to the prediction of household use of charcoal for cooking purposes in Kenya.

Table 9: Coefficients table showing the contribution of independent variables to the charcoal model

				Coefficients[a]							
Model	**Unstandardised Coefficients**		**Standardised Coefficients**	**T**	**Sig.**	**95.0% Confidence Interval for B**		**Correlations**			**Collinearity Statistics**	
	B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**	**Zero-order**	**Partial**	**Part**	**Tolerance**	**VIF**
1 (Constant)	23.934	2.790		8.579	.000	18.315	29.553					
Credit access	-.268	.083	-.432	-3.214	.002	-.435	-.100	-.432	-.432	-.432	1.000	1.000
2 (Constant)	18.018	3.481		5.175	.000	11.002	25.034					
Credit access	-.275	.078	-.444	-3.507	.001	-.433	-.117	-.432	-.467	-.444	.999	1.001
Monthly expenditure beyond $71	.241	.093	.328	2.591	.013	.054	.429	.312	.364	.328	.999	1.001
3 (Constant)	7.345	5.251		1.399	.169	-3.244	17.935					
Credit access	-.193	.080	-.311	-2.401	.021	-.355	-.031	-.432	-.344	-.286	.843	1.186
Monthly expenditure beyond $71	.345	.096	.469	3.583	.001	.151	.539	.312	.480	.427	.828	1.208
Lack of education of HH	.193	.074	.367	2.600	.013	.043	.343	.298	.369	.310	.711	1.406

a. Dependent Variable: Charcoal

However, in this case, other predictor variables—female household headship, household size, modern housing, owning a house, access to cash transfer, and shock to household welfare——do not make any significant contribution to the prediction of household use of charcoal in Kenya and are, therefore, excluded from the model.

DISCUSSION

This study applied stepwise multiple regression to investigate the ability of nine socio-economic factors: female household headship, lack of education among household heads, family/household size, modern housing, housing tenure, access to credit, access to cash transfer, shock to household welfare, and household expenditure level to influence household use of solid biofuels (fuelwood and charcoal) for cooking purposes in Kenya. Four of these factors, namely household ownership of a housing unit, lack of education among household heads, household expenditure beyond $71, and access to credit have shown to be significant determinants of household use of these biofuels in the country.

Household ownership of a housing unit has a significant positive influence on household use of fuelwood for cooking, and access to credit has a significant negative influence on household use of charcoal. Both household expenditure beyond $71 and lack of education among household heads have a significant negative influence on household use of fuelwood, while the same (two) factors have a significant positive influence on household utilisation of charcoal as cooking fuel. Therefore, although the available data could not provide for the understanding of the energy stacking concept in Kenya's households, it is clear that an improvement in household socio-economic status greatly influences the household transition from the use of primitive fuel (fuelwood) to transition fuel (charcoal) in the country. This implies that household energy transition in the country can be said to go along with the energy ladder concept.

Normally, household welfare has been shown to be strongly correlated to household income level (KNBS & SID, 2013). Therefore, household surveys often capture data on household expenditure as proxies for estimating household income, given that household incomes are usually not easy to measure. Similar to the findings of (Ogwumike et al., 2014), the current study findings show that the level of monthly household expenditure is inversely related to household use of fuelwood but positively related to household use of charcoal. This means that when the number of households spending $71 and above in Kenya increases, the number of households using firewood decreases while that using charcoal increases.

The average household expenditure per adult equivalent in Kenya is approximately $34 (or Ksh 3,440) per month (KNBS & SID, 2013). Inequalities in consumption expenditure are also significantly high across counties in the country. In the best performing county (Nairobi), the average monthly household expenditure per adult equivalent is $71 (or Ksh 7,200), when compared to the poorest county where the average monthly expenditure per adult equivalent is $12.87 (or Ksh 1,300) (KNBS & SID, 2013).

Therefore, those households that are in a position to spend $71 and above in Kenya are considered to be economically stable and can afford clean energy resources. Such households tend to move from firewood utilisation towards charcoal. This is because based on the energy ladder model, charcoal is classified as a transition fuel and is preferred for cleanliness as opposed to firewood which is classified as a primitive fuel. This explains the reason behind the decrease in the number of households relying on fuelwood and the increase in the number of those using charcoal as the number

of households spending $71 and above increases.

From the study findings, lack of education among household heads has a negative influence on household use of fuelwood and a positive influence on household use of charcoal. This, however, is against the conceptualisation that it would have a positive influence on both solid biofuels. These study findings are similar to those of a previous study on household cooking energy preference in urban Ouagadougou, Burkina Faso (Ouedraogo, 2006). The study indicated that the lack of education among household heads is a significant determinant of household preference for firewood. This is mainly because education is one of the major determining factors of human development, as it provides more opportunities and leads to increased incomes (KNBS & SID, 2013).

In fact, the lack of equal opportunities for access to education is said to have such negative long-term consequences as intergenerational poverty persistence (KNBS & SID, 2013). Specifically, the education level of household heads is a significant determinant of household income level, the health of children, and other socio-economic aspects of a household (Kovacevic, 2010). In the current study, the lack of education among household heads is a deterrent to household transition to clean fuel options. However, if provided with the opportunity for higher educational attainment and equality of access across all populations; there is bound to be an enhancement in labour market participation, a rise in economic growth, and long-term equitable income distribution. This would in return enable households to transition towards clean energy use.

On the other hand, household ownership of a housing unit is a very strong positive (0.822) determinant of household firewood utilisation according to the study findings. This means that as the number of households owning a house in Kenya increases, the number of households using fuelwood for cooking purposes also increases. This goes in tandem with the findings of (Bisu et al., 2016) in their study in Bauchi Metropolis, Nigeria, where dwelling ownership was found to have a very significant influence on household preference for fuelwood utilisation.

Household preference for fuelwood among households that own dwellings is a common occurrence, especially among rural households because such households also own pieces of land from where firewood and other agricultural wastes are easily obtained. These pieces of land also provide storage space which is a requirement for households relying on fuelwood, as fuelwood needs larger storage space compared to other types of fuel. In addition, household ownership of land also increases the chances of household fuel production as an economic activity (firewood sale) (Hiemstra-van der Hors & Hovorka, 2009). When this happens, a source of traditional fuel (firewood) to other households is provided, thereby increasing their household utilisation.

Also, wealth and income levels are important economic factors that significantly influence the household choice of fuel (Ouedraogo, 2006; Ogwumike et al., 2014; Bisu et al., 2016). In the current study, access to credit is a significant contributor to household welfare and is shown to have a negative influence on household utilisation of charcoal for cooking purposes in Kenya. This means that as the number of households accessing credit increases, the number of households using charcoal decreases. This is because access to credit tends to improve household economic welfare, which means they can afford clean energy alternatives, therefore, moving away from charcoal utilisation towards other cleaner energy options (such as electricity and LPG). In the case of households in Kenya, credit can be obtained from many sources, which include

commercial banks, microfinance institutions, mortgage finance, government funds, insurance companies, SACCOs, religious institutions, NGOs, employers, merchants/shops, shylocks, relatives/friends/neighbours, mobile platforms, and self-help groups (*chamas*) (KNBS & SID, 2013).

Addressing the coping capabilities of the poor has been identified as one of the best ways to address woodfuel overutilisation, which brings about its scarcity (Cooke et al., 2008). From the findings of the current study, household ownership of a housing unit, access to credit, household-level of expenditure, and lack of education are the major socio-economic factors that should be addressed in order to enhance the household transition from solid biofuels over-reliance in Kenya. Although globally, wood fuels are not considered a major driver of deforestation (Boucher et al., 2011), at a local level, they produce negative environmental, health, and economic impacts. This is especially true for charcoal production, given its high potential to lead to forest degradation and the associated GHGS emissions (Boucher et al., 2011).

CONCLUSION, POLICY IMPLICATIONS, AND RECOMMENDATION

Conclusion

Solid biofuels (fuelwood and charcoal) are the main source of household cooking energy in Kenya, as 69.5% of the households in the country rely on these biofuels for cooking purposes. Rural households are the most reliant on these biofuels at 92.4%, while about 38% of urban households in the country rely on these solid biofuels. The current study investigated the role of socio-economic factors in influencing household use of solid biofuels (fuelwood and charcoal) for cooking purposes in Kenya. These factors were broadly classified as household characteristics, housing conditions, and economic factors. Specifically,

the following nine factors were assessed for their contribution to variation in the number of households using fuelwood and charcoal (separately) for cooking purposes in the country:

i. Family size
ii. Female household headship
iii. Lack of education among household heads
iv. Household ownership of a housing unit (housing tenure)
v. Type of dwelling
vi. Household access to credit
vii. Household access to cash transfers
viii. Shock to household welfare
ix. Household level of expenditure (beyond $71)

Stepwise multiple regression using the Statistical Package for Social Scientists was used to estimate the determinants of solid biofuels utilisation. Regression results for household utilisation of fuelwood showed that household ownership of a housing unit, household expenditure beyond $71, and lack of education among household heads are significant determinants of household use of fuelwood for cooking purposes in Kenya. The beta coefficients for the three variables were 0.822, -0.246, and 0.154, respectively. The variables were also shown to be statistically significant at the 5% significance level.

Further, regression results for household utilisation of charcoal showed that household access to credit, household expenditure beyond $71, and lack of education among household heads are significant determinants of household use of charcoal for cooking purposes in Kenya. The beta coefficients for the three variables were -0.311, 0.469, and 0.367, respectively. Further, the variables were shown to be statistically significant at a 95% confidence level.

Therefore, household ownership of housing unit is the most significant determinant of household utilisation of fuelwood for cooking purpose in Kenya, followed by the household level of expenditure and then lack of education among household heads. On the other hand, household-level of expenditure is the most significant determinant of household utilisation of charcoal for cooking purposes in the country, followed by a lack of education among household heads and household access to credit. The trend of household transition from the use of primitive fuels (fuelwood) towards transition fuels (charcoal) and advanced fuels was also shown to go along with the energy ladder model, whereby households' preference for cleaner fuels increased with the improvement in socio-economic status.

Although solid biofuels are not the primary cause of deforestation, according to previous research, fuelwood collection and charcoal production significantly contribute to the degradation of already disturbed forests. Similarly, fuelwood and charcoal burning are associated with adverse health effects on people's health. This is because biomass fuels collection is often time-consuming and is known to cause serious health problems from the heavyweights carried, while biomass burning causes indoor air pollution, which impacts negatively on people's health and is a significant contributor to the emission of greenhouse gases which leads to global warming and climate change. Therefore, addressing the socio-economic determinants of household utilisation of solid biofuels in Kenya as identified in this report is necessary for the reduction of pressure on degraded land, improvement of public health and climate change mitigation.

Policy Implications

As Kenya strives to become a middle-income country as envisaged in her vision 2030, the government and policymakers have a huge role to play to ensure that all households in the country get access to modern, clean energy resources. This is one way that the country will be liberated from the encumbrance of underdevelopment and transition towards the achievement of sustainable development. From the findings of this study, four socio-economic factors; household ownership of housing unit, household level of expenditure, lack of education among household heads, and access to credit are the main determinants of household use of solid biofuels for cooking purposes in the country; all of which need to be addressed.

Therefore, first, the government through its relevant ministries, departments, and agencies has a crucial role to play in offering public awareness campaigns against over-reliance on fuelwood, especially among rural households who are the majority owners of houses they live in the country. These campaigns should emphasise the health, environmental and economic importance of household utilisation of alternative clean and efficient energy sources.

Second, the government has a role to play through its relevant ministries, departments, and agencies to ensure the implementation of proper minimum wage bill at all levels of employment, as well as the creation of job opportunities. This will ensure that households' disposable income is enhanced, consequently leading to an increase in the household level of expenditure, a situation that will contribute towards the transition to clean energy alternatives, as evidenced in the study findings. In addition, this transition could also be enhanced through the adoption of policies aimed at improving household accessibility to different fuel technologies, which will in return diversify the household fuel choices.

Third, education is a key determinant of household welfare. Therefore, the government of Kenya through the ministry of education and

other relevant agencies has a critical role in ensuring countrywide access to education. This is important as it will mean more households in the country will be headed by educated people, people who can make better fuel choices because they are enlightened and have a high disposable income because education increases their employability.

Fourth, access to credit has shown to have a positive influence on the household transition towards clean energy sources. The government of Kenya can, therefore, tackle the yoke of over-utilisation of solid biofuels in the country by increasing lending to individual households for small-scale clean energy projects. For example, the government can offer credit to households who would like to install household biogas as a way of encouraging their transition towards clean energy resources. Micro-finance institutions and other lending institutions can also play a significant role in enabling the household transition to clean energy by increasing lending and softening their lending terms for affordability by rural households.

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REFERENCES

Baiyegunhi, L. J. S., & Hassan, M. B. (2014). Rural household fuel energy transition: Evidence from Giwa LGA Kaduna State, Nigeria. *Energy for Sustainable Development*, *20*(Supplement C), 30–35. DOI: 10.1016/j.esd.2014.02.003

Bisu, D. Y., Kuhe, A., & Iortyer, H. A. (2016). Urban household cooking energy choice: An example of Bauchi metropolis, Nigeria. *Energy, Sustainability and Society*, *6*(1), 15. DOI: 10.1186/s13705-016-0080-1

Bithas, K., & Kalimeris, P. (2016). Chapter 2: A Brief History of Energy Use in Human Societies. In *Revisiting the Energy-Development Link*. Cham: Springer. DOI: 10.1007/978-3-319-20732-2_2

Boucher, D., Elias, P., Lininger, K., May-Tobin, C., Roquemore, S., & Saxon, E. (2011). Chapter 8: Wood for Fuel. In *The Root of the Problem: What's Driving Tropical Deforestation Today?* (pp. 79–86). Cambridge, MA: Union of Concerned Scientists. Retrieved from https://www.sandischwartz.com/wp-content/uploads/2020/02/UCS_RootoftheProblem_DriversofDeforestation_FullReport-1.pdf

Cooke, P., Köhlin, G., & Hyde, W. F. (2008). Fuelwood, forests and community management – evidence from household studies. *Environment and Development Economics*, *13*(1), 103–135. DOI: 10.1017/S1355770X0700397X

Desalu, O. O., Ojo, O. O., Ariyibi, E. K., Kolawole, T. F., & Ogunleye, A. I. (2012). A community survey of the pattern and determinants of household sources of energy for cooking in rural and urban south western, Nigeria. *The Pan African Medical Journal*, *12,* 1-12. DOI: 10.11604/pamj.2012.12.2.1436.

Farsi, M., Filippini, M., & Pachauri, S. (2007). Fuel choices in urban Indian households. *Environment and Development Economics*, *12*(6), 757–774. DOI: 10.1017/S1355770X07003932

Fouquet. (2011). A brief history of energy. In Evans, J. & Hunt, L. C. (eds), *International Handbook on the Economics of Energy* (pp. 1–19). Edward Elgar Publishing.

Heltberg, R. (2005). Factors determining household fuel choice in Guatemala. *Environment and Development Economics*, *10*(3), 337–361. DOI: 10.1017/S1355770X04001858

Hiemstra-van der Horst, G., & Hovorka, A. J. (2009). Fuelwood: the "other" renewable energy source for Africa?. *Biomass and bioenergy*, *33*(11), 1605-1616.

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources and Energy*, *9*(4), 347–361. DOI: 10.1016/0165-0572(87)90003-X

International Energy Agency. (2014). *Publication: WEO 2014 Special Report: Africa Energy Outlook*. Paris, France: International Energy Agency. retrieved from https://www.iea.org/reports/africa-energy-outlook-2014

International Energy Agency. (2016). *Energy and Air pollution*. Paris, France: International Energy Agency. Retrieved from https://www.iea.org/reports/energy-and-air-pollution

International Energy Agency. (2017). *Bioenergy and biofuels*. International Energy Agency. Retrieved from https://www.iea.org/topics/renewables/bioenergy/

Joshi, J., & Bohara, A. K. (2017). Household preferences for cooking fuels and inter-fuel substitutions: Unlocking the modern fuels in the Nepalese household. *Energy Policy*, *107*, 507–523. DOI: 10.1016/j.enpol.2017.05.031

KNBS. (2015). *Narok County statistical abstract*. Kenya National Bureau of Statistics. Retrived from https://www.knbs.or.ke/download/narok/

KNBS. (2018). *2015/16 Kenya Integrated Household Budget Survey (KIHBS)* (No.

978-9966-102-03–4). Kenya National Bureau of Statistics. retrieved from https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/KNBS_-_Basic_Report.pdf

KNBS & SID. (2013). *Exploring Kenya's inequality: Pulling apart or pooling together?* (No. 978-9966-029-19–5). Nairobi, KE: Kenya National Bureau of Statistics & Society for International Development–East Africa. Retrieved from http://inequalities.sidint.net/kenya/wp-content/uploads/sites/3/2013/10/SID%20Abridged%20Small%20Version%20Final%20Download%20Report.pdf.

Kovacevic, M. (2010). *Measurement of Inequality in Human Development: A Review*. Human Development Research Paper 2010/35. United Nations Development Programme. Retrieved from http://hdr.undp.org/sites/default/files/hdrp_2010_35.pdf

Muller, C., & Yan, H. (2016). Household fuel use in developing countries: Review of theory and evidence. *Energy Economics*, *70*, 429-439.

Ogwumike, F. O., Ozughalu, U. M., & Abiona, G. A. (2014). Household energy use and determinants: Evidence from Nigeria. *International Journal of Energy Economics and Policy*, *4*(2), 248.

Ouedraogo, B. (2006). Household energy preferences for cooking in urban Ouagadougou, Burkina Faso. *Energy Policy*, *34*(18), 3787–3795. DOI: 10.1016/j.enpol.2005.09.006

Rahut, D. B., Behera, B., & Ali, A. (2017). Factors determining household use of clean and renewable energy sources for lighting in Sub-Saharan Africa. *Renewable and Sustainable Energy Reviews*,

72(Supplement C), 661–672. DOI: 10.1016/j.rser.2017.01.080

Rahut, D. B., Das, S., De Groote, H., & Behera, B. (2014). Determinants of household energy use in Bhutan. *Energy*, *69*(Supplement C), 661–672. DOI: 10.1016/j.energy.2014.03.062

Sathaye, J., & Tyler, S. (1991). Transitions in household energy use in urban China, India, the Philippines, Thailand, and Hong Kong. *Annual Review of Energy and the Environment*, *16*(1), 295–335. DOI: 10.1146/annurev.eg.16.110191.001455

Song, C., Bilsborrow, R., Jagger, P., Zhang, Q., Chen, X., & Huang, Q. (2018). Rural Household Energy Use and Its Determinants in China: How Important Are Influences of Payment for Ecosystem Services vs. Other Factors? *Ecological Economics*, *145*, 148–159. DOI: 10.1016/j.ecolecon.2017.08.028

Wakeford, J. J. (2017). *The Water – Energy – Food Nexus in a Climate—Vulnerable, Frontier Economy: The Case of Kenya*. Sustainability Institute, South Africa. https://assets.publishing.service.gov.uk/med ia/58e27db9ed915d06ac0000b2/Water-energy-food_nexus_in_Kenya_2017.pdf

World Health Organisation. (2017). *WHO|Household air pollution and health*. WHO. http://www.who.int/mediacentre/fact sheets/fs292/en/

Wrigley, E. A. (2013). Energy and the English industrial revolution. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371*(1986), 20110568. DOI: 10.1098/rsta.2011.0568