Woodfuel use in urban environment: analysing variations and predictors in Kampala City

Introduction

Firewood and charcoal are the leading sources of energy for cooking in most of Uganda's households. Although the use of woodfuel (firewood and charcoal) in urban areas may be less prevalent in comparison with rural areas, the level is quite high even in Kampala City, the nation's Capital and largest commercial centre.

Affordable and reliable energy is vital for meeting basic human needs and can be a corner-stone of development. Having access to modern energy sources such as electricity or liquefied petroleum gas can impact human wellbeing by reducing health and safety risks often associated with traditional energy use (Kowsari & Zerriffi, 2011). Modern energy sources can also translate into decreasing time budget constraints on household members, particularly women and children who usually take substantial time and effort in cooking and collecting firewood (Barnes & Floor, 1996). When households move up along the energy ladder and use less of woodfuel, emissions of greenhouse gases tend to decrease (Holdren et al., 2000).

Charcoal and firewood dominate the sources of energy used for cooking in developing countries (Knight & Rosa, 2012). Over 2 billion people in developing countries are reported to rely on traditional biomass fuels including wood, agricultural residues and dung for their daily energy needs (van der Kroon, Brouwer, & Van Beukering, 2013). In 2014, firewood and charcoal contributed 71.2% and 22.7% respectively to the sources of energy for cooking in Uganda (UBOS, 2014).

High level combustion of biomass including woodfuel is a matter of concern for environmentalists considering that combustion is one of the major sources of greenhouse gases (Namaalwa, Hofstad, & Sankhayan, 2009). Effects of smoke arising from burning woodfuel is one of the predisposing factors to acute respiratory infections (ARI) in young children (Mishra, Smith, & Retherford, 2005). The reliance on biomass for cooking and heating purposes exposes many women and young children in developing countries to high levels of indoor air pollution. To manage these challenges, United Nations has continued to advocate for affordable and clean energy. Goal 7 of the Sustainable Development Goals (SDGs) aims to ensure access to affordable, reliable, sustainable and modern energy (UNDP, 2015).

Researchers have been exploring dimensions of household energy use in order to design and implement strategies required for providing secure access to energy services. Understanding household energy dynamics would also facilitate the transition to modern fuels, scale down energy poverty, address environmental concerns and mitigate greenhouse gas emissions (van der Kroon et al., 2013). Yet despite elaborate research on the subject, the understanding of variables associated with energy use patterns and the variables associated with household energy use remains limited, particularly with reference to the developing countries such as Uganda.

Several studies in Uganda have examined household woodfuel consumption and energy insecurity (Agea, Kirangwa, Waiswa, & Okia, 2010; Mukwaya, 2016). Although these have shed light on energy dynamics, the factors associated with using woodfuel for cooking in the urban environment remains unknown. The high prevalence of traditional energy sources for household cooking despite rising coverage of electricity supply in Kampala City requires deeper understanding. This paper contributes to existing literature on fuel choices through understanding energy dynamics in an urban environment. The main objective of the study is to analyse socio-demographic predictors of woodfuel use in Kampala City, Uganda.

Theoretical & conceptual framework

The energy ladder model

The paper is informed by previous work on the energy ladder model and the hypothesized determinants of household energy choice (Kowsari & Zerriffi, 2011). The energy ladder model, which was developed based on the correlation between income and uptake of non-solid sources of energy such as electricity, describes a pattern of fuel substitution as a household's economic situation changes (Hosier & Dowd, 1987). The model ranks fuels based on efficiency, cleanliness and convenience of storage and usage (Kowsari & Zerriffi, 2011). Consequently broad categories are suggested namely traditional fuels (animal waste, agricultural waste, firewood), transition fuels (charcoal, kerosene, coal) and advanced fuels (biofuels, LPG and electricity) (van der Kroon et al., 2013). Traditional fuels are at the bottom of the ladder while the advanced fuels are at the apex (Figure 1).

The model presupposes that households switch from traditional energy systems to modern energy systems up the ladder depending on factors such as household income, fuel and equipment costs, availability and accessibility of fuels, reliability of modern fuel distribution and relative fuel prices (Masera, Saatkamp, & Kammen, 2000).

The model suggests further that as families gain improved socio-economic status, they abandon first-stage technologies that are inefficient, less costly and more polluting. Rather, the pattern gradually shifts towards second phase transition fuels and ultimately to the higher-order fuels (LPG and electricity) in the third phase. While higher-order fuels may be costly, they are considered more efficient and may require less labour and produce less pollution per unit of fuel (Masera et al., 2000).

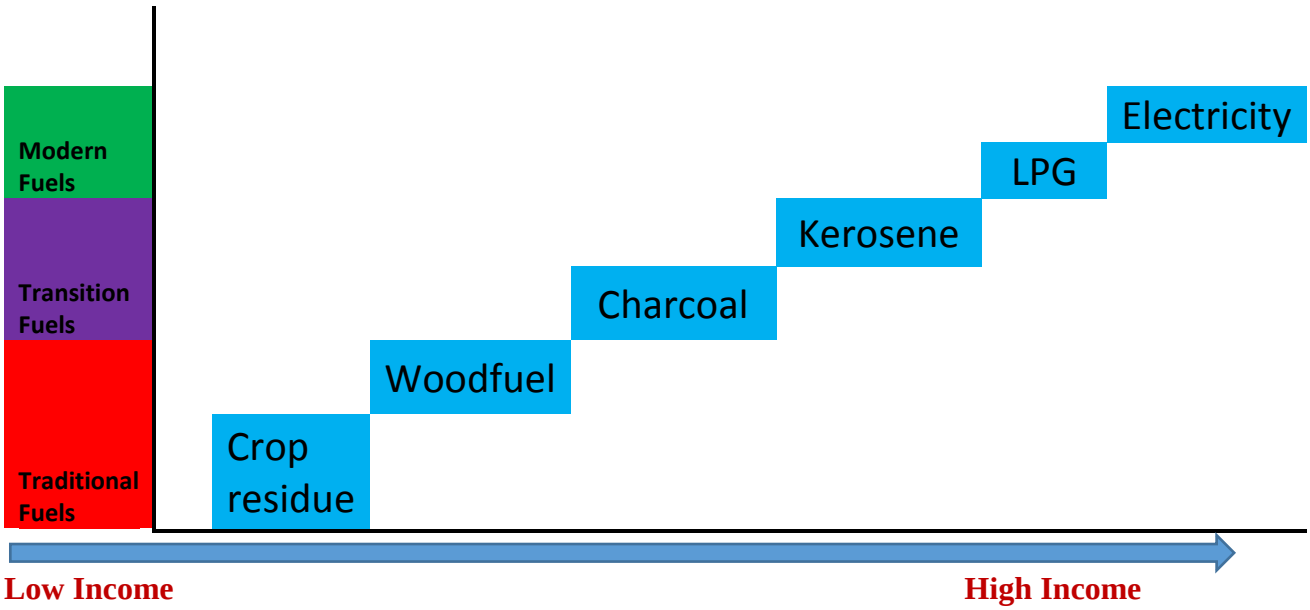

Figure 1: The energy ladder: Adapted from: Kowsari & Zerrifi (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. Energy Policy. Elservier

Factors determining household energy choice

The conceptual framework used in the paper is informed by previous work on factors determining household energy choice (**Kowsari & Zerrifi, 2011).** Household energy choice is hypothesized to depend on household decisions based on a complex interaction between endogenous (household) factors and Exogenous factors (external factors). The endogenous factors comprise of economic, socio-demographic and behavioural characteristics (Figure 2). The exogenous economic factors comprise physical environment, energy policies and supply and energy device characteristics. These factors are closely interrelated and tend to operate in conjunction rather than in isolation.

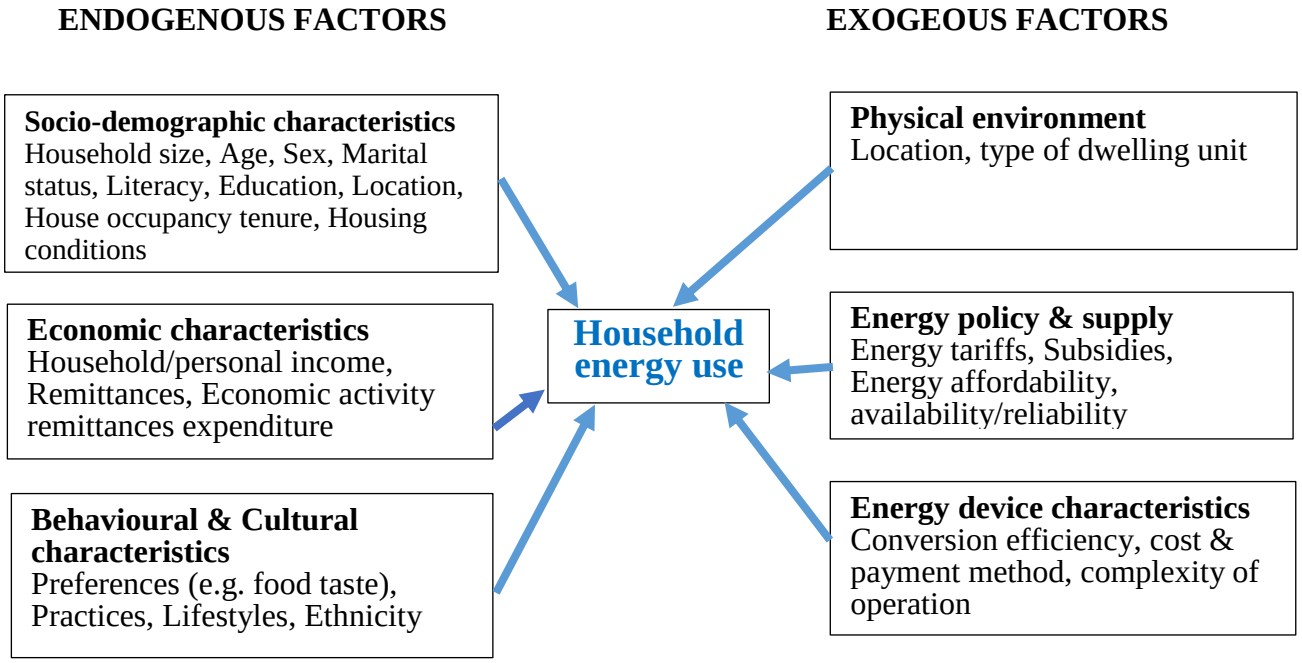

Figure 2. Conceptual framework of factors determining household energy choice
Adapted from: Kowsari & Zerrifi (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. Energy Policy. Elservier

Data and methods

This paper uses secondary data collected in the 2014 Uganda National Population and Housing Census. Household data for Kampala City was extracted from the main national data set. The total number of households was 41,525. The census asked questions about the type of energy used for household lighting and cooking. The question that sought information on cooking was: "What source of energy does this household mainly use for cooking?" During analysis, the various sources of energy used for cooking were dichotomized into woodfuel (firewood and charcoal) and non woodfuel (electricity, gas, kerosene and others). Owing to the binary nature of the outcome variable (woodfuel and non woodfuel), Chi-square technique was used to assess the association between woodfuel use and various sociodemographic and economic factors. Binary logistic regression model was employed to assess the predictors of woodfuel use among the urban households.

The logistic model takes on the form:

$$\text{logit}\,[p(X)] = \log\left[\frac{p(X)}{1-p(X)}\right] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots + \beta_x x_k.$$

Where:
α is the intercept,
$\beta_1, \beta_2, \beta_3 \ldots \beta_k$, are the regression coefficients of x_1, x_2, $x_{3\ldots.}$ x_k,
$x_1 \ldots x_k$ are the independent variables.

The independent variables were age, sex, education, marital status, location, school attendance, livelihood, economic activity, house occupancy tenure, dwelling unit and housing material.

Results

a) Energy choices

Findings indicate that 8 in 10 of the households in Kampala City use woodfuel for cooking (Figure 3). Results further show that while less than 1 in 10 (8.1%) of the households use electricity for cooking, over 83% use the same energy source for lighting (Figure 4). This suggests that the low use of electricity for cooking is not necessarily due to limited electricity supply since about 8 in 10 of the households are able to light their homes using electricity.

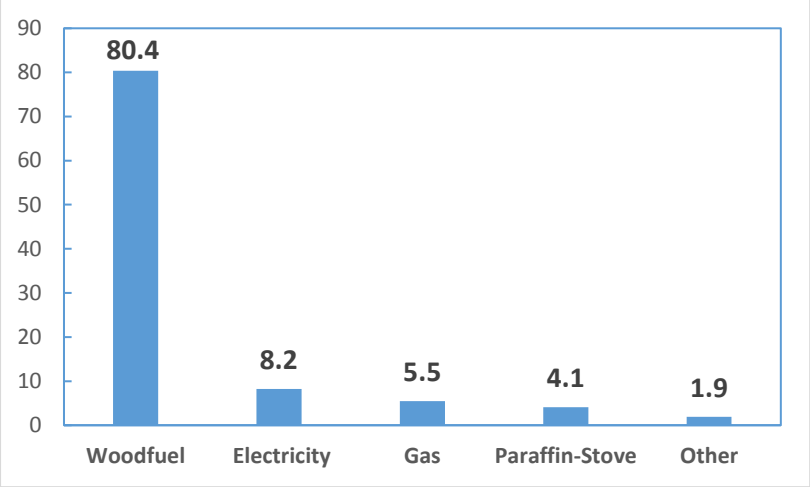

Figure 3 Percent of households by source of energy for cooking

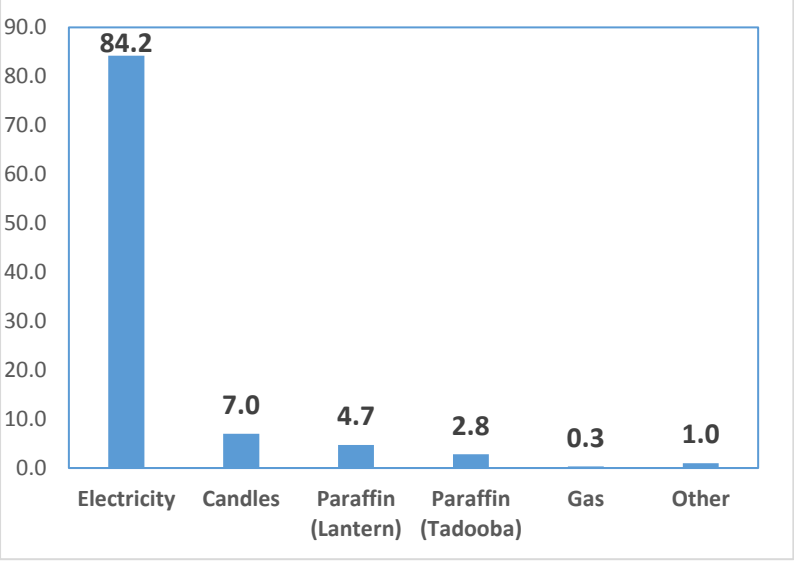

Figure 4. Percent of households by source of energy for lighting

b) Variations in woodfuel for cooking in Kampala City households

Woodfuel use in cooking varied by socio-demographic characteristics About 8 in 10 of household heads aged 15-29 belonged to households using woodfuel for cooking and the proportion increased with age (Table 1). While 75% of household heads aged 15-29 used woodfuel, the corresponding percentage among those aged 60 and older was 85%. The proportion of woodfuel use was higher among females (84%) than males (79%). Regarding school attendance the proportion using woodfuel was higher among those who had never attended school (89%) than those who had ever attended (80%). The highest percentage was among household heads residing in Rubaga and Kawempe divisions (85% & 82% respectively) while Central Division had the lowest (70%).

Woodfuel use was highest in households whose main source of livelihood was business enterprise (85%) and lowest in those whose source was family/relatives/friends (68%). Charcoal and firewood use was predominant in households that did not receive remittances (83%) and less in those that received remittances (73%). Household heads who were *own account workers* (87%) used woodfuel more than those who were *paid employees* (79%). Regarding house occupancy tenure, *owner occupiers* (85%) used woodfuel more than those who rented (81%). The lowest was among those whose status was 'others' (60%).

Woodfuel use was higher in households residing in tenements (85%) in comparison with those staying in detached/semi-detached/semi-detached house (79%), room or rooms in a main house (76%) and flat (36%). Households residing in rammed earth-floored structures comprised the highest percentage of woodfuel users for cooking (86%) while the lowest percentage was among those residing in title/concrete-floored shelters (59%).

Table 1 Prevalence of energy use for cooking by socio-demographic variables

Variable	Woodfuel	Non woodfuel	Number
Age			
15-29	75.0	25.0	15,713
30-44	83.6	16.4	17,295
45-59	83.5	16.5	6,464
60+	84.6	15.4	2,053
Sex			
Male	78.8	21.2	29,069
Female	83.9	16.08	12,456
School attendance			
Ever attended school	80.0	20.0	39,805
Never attended school	88.7	11.3	1,720
Subcounty			
Central	70.0	30.0	2,336
Kawempe	82.1	17.9	9,541
Rubaga	85.2	14.8	10,392
Makindye	80.7	19.3	10,875
Nakawa	74.7	25.3	8,381
Main source of HH livelihood			
Employment income	79.9	20.1	23,986
Business enterprise	85.2	14.8	9,173
Family/relatives/friends	68.3	31.7	3,506

Others	82.5	17.5	4,860
Remittances			
Received money/goods	72.8	27.1	10,037
No money/goods received	82.7	17.3	31,488
Activity status			
Paid employee	78.9	21.1	21,992
Own account worker	86.7	13.3	11,322
Unemployed	79.7	20.3	1,470
others	72.7	27.3	4,493
House occupancy tenure			
Owner occupier	84.6	15.4	8,425
Rented	81.1	18.9	30,122
Others	60.3	39.7	2,978
Dwelling unit			
Tenement/*Muzigo*	85.0	15.0	23,560
Detached/semidetached house	79.0	20.9	13,621
Flat	36.0	64.0	1,546
Room/rooms in main house	**76.6**	**23.4**	**1,470**
Others	67.4	32.6	1,328
Floor material			
Rammed earth	86.4	13.6	2,003
Cement screed	83.0	17.0	34,615
Tiles/concrete	58.7	41.3	4,602
Others	74.1	25.9	305
Total	**80.4**	**19.6**	**41,525**

c) Predictors of urban woodfuel use

Table 2 shows regression analytical results of woodfuel use. It is shown that the likelihood of woodfuel use increased with age. Being aged 30-44 (OR=1.2, CI=1.100-1.261); 45-59 (OR=1.3, CI=1.145-1.384); 60 and older (OR=1.4, CI=1.213-1.647) increased the odds of woodfuel use in comparison with age 15-29. Females were more likely to use woodfuel than their male counterparts (OR=2.1, CI=1.916-2.207). In comparison with male, being female increased the odds of woodfuel use.

The ever married and married persons (OR=2.5, CI=2.267-2.808; OR=3.7, CI=3.461-3.966 respectively) were more likely to use woodfuel than their never married counterparts. Although the Anglicans were less likely to use woodfuel in comparison with Catholics, (OR=0.933, CI=0.871-0.999), the Muslims were more likely to use the fuel (OR=1.2, CI=1.064-1.242). Household members who had never attended school were more likely to use woodfuel than their counterparts who had ever attended (OR=1.410, CI=1.196-1.661).

The location in which households lived predicted woodfuel use. Of the five divisions of Kampala city, the lowest likelihood was for Central Division, the area that houses the City's Central Business District (CBD). The odds of using woodfuel were higher among households staying in Kawempe Division (OR=1.2, CI=1.104-1.409) and Rubaga Division (OR=1.3, CI=1.179-1.507) in comparison with the Central Division,

Households whose main source of livelihood in the last 12 months was business enterprise were more likely to use woodfuel than their counterparts whose livelihood hinged on employment income. The odds of woodfuel use were higher among household heads who were *own account workers* in comparison with those who were paid employees (OR=1.2, CI=1.134-1.319). Results in Table 2 further show that woodfuel use was associated with remittances. Persons who never received money and goods from persons abroad were more likely to be woodfuel users than their counterparts who received remittances (OR=1.4, CI=1.320-1.520).

The odds of woodfuel use were higher for household heads living in rented dwelling units than those who were *owner occupier*s (OR=0.7, CI=0.670-0.793). The type of dwelling unit similarly influenced urban woodfuel use. In comparison with residing in tenement (muzigo), households who stayed in detached/semi-detached house, flat and rooms were less likely to use woodfuel (OR=0.7, CI=0.613-0.703; OR=0.2, CI=0.212-0.777; OR=0.631, CI=0.550-0.730). Findings further indicate that the quality of shelter in which persons resided influenced woodfuel use. In comparison with households who stayed in rammed earth-floored structures, the odds of using woodfuel were lower for those who whose residential shelter floor material was cement screed (OR=0.660, CI=0.569-0.760) and tiles/concrete (OR=0.3, CI=0.416-0.785).

Table 2 Predictors of woodfuel use, Kampala urban environment

Variable	Odds Ratio	Confidence Interval	
Age			
15-29	1.000		
30-44	1.180**	1.100	1.261
45-59	1.259**	1.145	1.384
60+	1.414**	1.213	1.647
Sex			
Male	1.000		
Female	2.057**	1.916	2.207
Marital status			
Never married	1.000		
Married	3.705**	3.461	3.966
Ever married	2.522**	2.267	2.808
Religion			
Catholic	1.000		
Anglican	0.933**	0.871	0.999
Muslim	1.150**	1.064	1.242
Pentecostal/Born again/ Evangelical	0.997	0.916	1.086
Others	0.509**	0.044	0.581
School attendance			
Ever attended school	1.000		
Never attended school	1.410**	1.196	1.661
Subcounty			
Central	1.000		
Kawempe	1.247**	1.104	1.409
Rubaga	1.333**	1.179	1.507

Makindye	1.134	1.006	1.278
Nakawa	0.926	0.820	1.045
Livelihood			
Employment income	1.000		
Business enterprise	1.083**	1.001	1.172
Family/relatives/friends	1.000	0.884	1.136
Others	1.033	0.943	1.132
Economic activity			
Paid employee	1.000		
Own account worker	1.223**	1.134	1.319
Unemployed	0.898	0.797	1.013
others	1.239**	1.063	1.443
Paid employee	0.917	0.827	1.017
Remittances			
Received money/goods	1.000		
No money/goods received	1.416**	1.32	1.520
House occupancy tenure			
Owner occupier	1.000		
Rented	0.729**	0.67	0.793
Others	0.346**	0.309	0.387
Dwelling unit			
Tenement/*Muzigo*	1.000		
Detached/semi-detached house	0.657**	0.613	0.703
Flat	0.242**	0.212	0.277
Room/rooms in main house	0.631**	0.548	0.726
Others	0.633	0.550	0.730
Floor material			
Rammed earth	1.000		
Cement screed	0.660**	0.569	0.760
Tiles/concrete	0.327**	0.277	0.385
Others	0.572**	0.416	0.785

** Statistically significant at 5% significance level

Discussion

The main objective of the study was to analyse the variations and predictors of woodfuel use in Kampala urban environment. Findings indicate that likelihood of woodfuel use increased with age. The trend/pattern may relate to younger persons who probably prefer cooking using modern sources of energy to traditional ones such as firewood and charcoal. It may also be the case that while older household heads use transition and advanced fuels for lighting, they could be more conservative and less adaptive to using such energy sources for cooking. Other studies have shown that older persons restrain to move away from their current practices (van der Kroon et al., 2013). Fuel cost may also be an influencing factor as indicated in a related study on fuel use in Ouagadougou (Ouedraogo, 2006).

The higher likelihood of woodfuel use among females is perhaps expected considering that, in the Ugandan setting, much of the household cooking is done by females, who also mainly collect firewood and charcoal. A large proportion of female-headed households may have

compromised ability to access modern fuels resorting to the comparatively less costly woodfuel sources (Ouedraogo, 2006). The higher likelihood of woodfuel use among the currently married and ever married persons could be explicable in terms of differences in domestic roles and responsibilities. The never married females may also comprise lower proportion of those who are not yet into domestic work such as preparation of household meals.

Results show that woodfuel use varies by religion with the Muslim community being more likely to use woodfuel. The underpinning explanation for this finding is not immediately clear, but the factors could probably be rooted within variations in cooking energy preferences. There could be differences, for example, in preferred fuel for steaming local foodstuffs such as *matooke* (local plantain) where electricity is often less preferred in comparison with charcoal. Other studies have indicated that meals that are traditionally cooked on fire can influence preference for continued use of firewood (van der Kroon et al., 2013).

Findings indicate that woodfuel use varies by the household geographic location. There is higher probability of woodfuel use in the city divisions of Kawempe and Rubaga in comparison with the Central Division. The nature of housing and the possible stringent tenancy contracts could be some of the factors influencing lower prevalence of woodfuel in Central Division - the city's relatively more affluent urban area. Van der Kroon et al., (2013) have similarly argued that the location where a household resides can be a factor in energy choices and cite urbanization as one of the variables linked to energy transitions (Mekonnen & Köhlin, 2009).

The *business enterprise* category of economic activity increased the odds of using woodfuel in comparison with *employment income*. Perhaps the nature and scale of the business operations makes this possible. Kampala City comprises a wide range of business categories: vending, car washing, hairdressing, groceries etc. Operating charcoal stoves is a familiar practice common to many persons in such enterprises.

Findings further indicate lower likelihood of woodfuel use among remittance recipients in comparison with non-recipients. This is perhaps not unusual considering that recipients could probably have more disposable incomes compared to non-recipients. This would enable/make the former better able to afford the relatively higher priced but cleaner fuels and, thus, less reliance on woodfuel in comparison with the non-recipients. Studies elsewhere have similarly indicated that income is an important influencing factor of fuel switching; indicating that households with regular income are better able to use non-solid fuels for their energy needs (Heltberg, 2005; Rao & Reddy, 2007).

House occupancy tenure predicts woodfuel use with persons in rented premises being less likely to use woodfuel than *owner occupiers*. As Mekonnen & Köhlin, (2009) have argued, being the owner of a house does not necessarily imply having higher purchasing power than a tenant. Rather it could mean prevalence of freedom of space management in the house. Tenants are expected to comply with occupancy contracts and regulations which may compromise their leeway in deciding energy options. Some rentiers / landlords can issue guidelines on how rented

property should be used including asking tenants to desist from cooking with charcoal and firewood that may be perceived as materials that soil dwelling units' walls and roofs.

Living in higher quality structure (such as detached/semi-detached house, flat, room in main house) is associated with lower likelihood of using woodfuel for cooking. Similarly, living in cement screed and tile/concrete floor structures is associated with lower odds of using woodfuel in comparison with living in houses with rammed earth floor. These findings suggest that the nature of housing and type of dwelling unit influence woodfuel use. The odds of woodfuel use reduce as housing quality improves. This dovetails with studies elsewhere (van der Kroon et al., 2013) which indicate that house size measured by the number of rooms is associated with a move away from woodfuel towards LPG use. This lends credence to the tendency for wealth to influence energy transition.

Conclusion and implications

Kampala City households are at the lowest end of the energy ladder with firewood and charcoal being the leading sources of energy for cooking. Being older and female increases the odds of cooking using woodfuel. Living in tenements, staying in rammed earth-floor dwelling units, never attended school, and being non-recipient of remittances increases the odds of woodfuel use. Residing in peripheral divisions of the city increases the odds of woodfuel use in comparison with Central division. The findings have several implications including improving household socioeconomic and housing conditions. Policies and programmes specifically targeting urban house occupancy tenure and housing conditions could have particular effect on woodfuel use in the city.

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