Research Article

Transition to cleaner cooking energy in Ghana

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Abstract

Progress towards the Sustainable Development Goal 7 and other related goals hinges on increased access to clean energy alternatives for all people irrespective of where they live. However, most developing countries including Ghana still rely largely on traditional biomass as the main source of household energy as a result of a myriad of challenges. From the foregoing, the present study uses the Ghana Living Standard Survey 7 (GLSS 7) household data and the multinomial logit regression model to analyse the factors that determine the transition to cleaner cooking energy in Ghana. The analysis shows that the main determinants of household energy choice in Ghana are education, household dwelling type, household size, employment and income group. Whereas education, modern housing, paid employment and higher income increase the adoption of cleaner energy, a higher dependency ratio and employment in the informal sector increase the likelihood of using unclean energy. Increased access to education and the adoption of policies to improve housing conditions, employment and incomes are recommended to encourage the adoption of cleaner energy alternatives.

Graphical Abstract

Keywords: cleaner cooking energy; Ghana; households; renewable energy; Sustainable Development Goals; transition

Introduction

Energy is indispensable in human lives and has a critical need both in industrial use and in subsistence consumption. However, the type of energy used could have adverse effects on human health and the sustainability of the natural environment. Paudel et al. [1] observed that the increased adoption of clean cooking-energy alternatives is crucial in meeting the Sustainable Development Goal—SDG13 (Climate Action) and its associated development objectives, particularly in enhancing the socio-economic well-being of women and children in developing countries. In most developing countries, access to clean and modern energy such as liquefied petroleum gas (LPG), electricity and renewables is limited as a result of a myriad of factors such as bottlenecks in supply, affordability issues and preference, among others. A large number of households therefore rely on biomass fuels (wood, leaves, twigs, animal dung, charcoal and crop waste) for all energy needs [2]. According to the International Energy...
Agency [3], while the use of traditional biomass fuel is more pronounced among rural households than urban households in developing countries, more than half of households in the urban areas of sub-Saharan Africa still depend on fuel wood, charcoal or wood waste as the main source of household energy. With high population growth and increasing urbanization over time, the demand for cheap urban household energy has increased significantly in the developing world, thereby contributing to deforestation, forest degradation and climate change. Lohan and Blakers [4] and Yao et al. [5] estimated that ~2.7 billion people around the globe rely on traditional biomass including animal dung, fuel wood, agricultural waste and charcoal for cooking and heating purposes. This situation poses a huge challenge to the quest to achieve Sustainable Development Goals 7 (SDG7) (clean and affordable energy for all) and 13 (climate action) by 2030 aside from the severe environmental and health problems it causes. It is estimated that ~1.3 million people in the world die prematurely every year as a result of exposure to indoor air pollution from biomass. Armah et al. [6] and Muller et al. [7] observed that the burning of biomass fuels significantly contributes to indoor air pollution, which is associated with particulate matter, sulphur dioxide, carbon monoxide and nitrogen dioxide. These pollutants are known causes of cardiovascular mortality and respiratory diseases in general. The authors further argue that the use of biomass fuels, which reduces carbon sink via deforestation, have an indirect effect on human health by causing the release of carbon dioxide into the atmosphere. More so, climate change adversely affects agricultural output and as a result threatens the nutritional health of human beings. Han et al. [8] and Twumasi et al. [9] posit that, aside from the adverse health effects in the use of solid fuel (biomass and coal), there are associated productivity losses as a result of poor health as well as the labour hours spent in gathering firewood, animal dung and other traditional fuels at the expense of engaging in productive income-earning activities to improve the economic well-being of households.

The choice of energy for subsistence consumption has been observed not to be uniform across different communities and households, as it is influenced by several factors including income, price, reliability in supply of LPG and employment types. Three studies [10–12] observed that households’ fuel preference changes with improvement in income levels and the availability of modern and cleaner fuels. Households’ fuel choices and substitution are influenced by the desire for more convenience and cleanliness, which, in the view of Leach [13], becomes more apparent with rising income levels. With improvement in income levels, people are able to afford modern household appliances such as electric and gas cooking stoves, electric irons, refrigerators, radios and televisions, among others, and hence they move up on the energy ladder [14]. By implication, the ownership of modern household appliances and the likelihood of using cleaner and modern energy alternatives have a very strong correlation with income [15]. By extension, it can be deduced that the pattern of household energy consumption is an indication of the level of economic well-being of households/individuals and the level of economic development of a given country [16]. Thus, the unavailability of safe, clean, reliable and environmentally friendly energy for a large segment of households is a strong bane to human development.

In Ghana, there has been a decline in the usage of traditional biomass in the last three decades. For instance, the report from the Ghana Statistical Service (GSS) in 2019 shows that fuel wood usage by households, which was 69% in 1990, decreased to 46.48% in 2016/17. This reduction could be as a result of the general rising income levels and policy initiatives such as the national electrification project, LPG-promotion program and the West African Gas Pipeline project undertaken by the government in recent years. The government of Ghana has made significant strides since the 1980s to connect a large number of rural communities to the national electricity grid as well as providing subsidies on LPG in a bid to minimize the dependence on traditional biomass (fuel wood and charcoal) so as to preserve the natural vegetation. However, empirical evidence suggests that the efforts of the government to promote the adoption of cleaner energy alternatives by households have not yielded the expected results, as traditional biomass (fuel wood and charcoal) still remains the primary source of household energy in both rural and urban areas of Ghana [17]. The report from the seventh round of the Ghana Living Standard Survey (GLSS 7), conducted in 2016/17, revealed that with regard to the choice of cooking energy, 46.48%, 28.16%, 18.37% and 0.21% of Ghanaian households use wood, charcoal, gas and electricity, respectively. This means that despite all the interventions by the government to promote the adoption of cleaner energy alternatives for cooking, a whopping 74.64% of Ghanaian households still depend on traditional biomass (wood and charcoal) as their main source of cooking fuel. The breakdown shows that 12.55%, 44.22%, 34.85% and 0.23% of urban households use wood, charcoal, gas and electricity, respectively, as their main cooking energy, and 72.03%, 16.07%, 5.96% and 0.2%, respectively, for rural households. These statistics undermine the government’s efforts towards promoting the use of modern and cleaner fuels in order to protect the environment for a more sustainable development.

Motivated by recent concerns about the adverse impacts of dirty cooking energy on the environment, health and progress towards the SDGs, the issue of household-fuel transition in developing countries has received significant attention in the literature [9–11]. However, no study in the literature has applied the GLSS 7 data set to examine Ghana’s transition to cleaner cooking energy, which makes this study very unique and relevant in filling the time gap in the literature. Another significant contribution of this study to the literature is the inclusion of variables such as house ownership and dwelling type, which have been identified as important determinants of the transition to cleaner cooking energy in the literature [7, 14, 18]. All previous studies in Ghana have omitted these important variables, which could affect the robustness of their findings. More so, among the few studies on the subject in Ghana, only [11] included the economic activity of the household head (employment type) in their model and, surprisingly, they reported a negative effect of formal employment on the adoption of LPG as cooking fuel contrary to a priori expectations. This finding could be as a result of the relatively smaller sample size used in their study. The present study uses the recent GLSS 7 survey data, which are nationally representative, to provide a more robust analysis of key factors influencing cooking-fuel choice in Ghana.

Next in this paper, we present a review of literature on the determinants of the choice of cooking energy by households followed by a detailed explanation of the econometric techniques and data employed in the study. Presentation of findings and discussion of results precede the conclusions and policy recommendations emanating from the study.

1 Review of related literature
1.1 Theoretical literature
A number of theories in the literature have focused on explaining the determinants of households’ choice of energy. Notable among them are: the energy-ladder theory/model and the fuel-stacking
theory. The ‘energy-ladder model’ is often used to explain households’ choice of fuel in developing countries. The model shows the process through which households move from traditional fuels (e.g. firewood) to intermediate fuels (kerosene, coal) and then adopt modern fuels (LPG, electricity), as household income rises [19, 20]. In this model, households that use traditional energy sources are found at the lower end of the energy ladder. As households begin to adopt modern and cleaner energy alternatives, they move up the energy ladder. At the apex of the ladder are households that have fully adopted cleaner energy alternatives. A key point of the model is that economic development and rising income levels propel households to move up on the energy ladder [21]. Thus, as household income rises, they substitute dirty energy sources (firewood, charcoal, coal, etc.) with cleaner energy options such as LPG, electricity and renewables.

Masera et al. [14] asserted that the energy-ladder theory does not adequately explain the dynamics of households’ fuel choices. Instead, they proposed the fuel-stacking theory, which relates to multiple-fuel-use patterns, whereby households opt for a combination of fuels from both the lower end and upper end of the energy ladder. The theory suggests that modern fuels only serve as partial, but not perfect, substitutes for traditional fuels and that multiple-fuel use is necessitated by varying reasons, such as: the occasional shortages of modern fuels, high cost of modern fuels, fluctuations in the prices of commercial fuel and preferences that make it unlikely that households will fully adopt modern fuels [14].

Goldemberg [22] opined that developing countries have the opportunity to ‘leapfrog’ over investment in traditional sources of energy (i.e. biomass, coal and fossil fuels) and rather focus on developing renewable forms of energy that are more sustainable. The idea is that through leapfrogging, a developing country like Ghana can avoid environmentally destructive stages of development in order not to take the polluting development path of developed countries. Noordeh [23] asserted that energy leapfrogging is not only beneficial for the environment, but will also give economic advantages to developing countries. For example, South Africa has been able to add >4000 MW of renewable power to its national grid within 4 years, whereas it would have taken several decades to build a coal-fired power station to generate the same amount of energy. Developing countries do not have adequate energy infrastructure to meet their ever-increasing demand, and this provides a good opportunity to invest in renewable-energy technology without opposition from existing energy producers. More so, developing countries have the support of developed nations to develop renewable-energy solutions with the pledge of $100 billion per annum by developed nations to assist developing nations in implementing clean-energy technologies through the Green Climate Fund [24].

1.2 Empirical literature

Motivated by the propositions of the theoretical literature, the determinants of fuel use that have been often considered in the existing empirical studies are: income level, price, household preferences, education, economic activity of household heads and energy-supply factors, among others [7]. A number of studies in the literature have focused on investigating the elements that drive the transition to cleaner fuels in developing countries in the past three decades. Most of these studies used simple descriptive statistics in their analysis but, in recent times, there has been the emergence of the application of econometric methods such as logit and probit regressions to analyse the determinants of household-fuel use [7].

Nguyen et al. [25], in a study on Vietnam, investigated energy transition, energy inequality and energy poverty using time-series data on the residential energy expenditure of >9000 households from 2004 to 2016. The authors found that there was a transition from traditional energy to modern energy in Vietnam, with variations resulting from different regions, ethnic and welfare groups, and between rural and urban populations. An important revelation of the study is the finding that ethnic minority households and the poor largely depended on traditional energy sources (coal and biomass) for cooking. In a study on Nepal, Acharya and Marhold [26] applied the multiple discrete continuous extreme value model with data from the Annual Household Survey in Nepal to examine the determinants of the choice of fuel by households. The results revealed that lower educational qualification of household head and house ownership had a positive link with the use of firewood and kerosene, whereas ownership of Information and Communications Technology devices and access to renewable-energy alternatives positively influenced the use of more modern and cleaner fuels by households.

Zhang and Hassen [27] applied the correlated random-effects generalized ordered probit model and household survey data spanning two decades to examine the determinants of household-fuel use in urban China. The authors reported that household-fuel use in urban China was influenced by fuel prices, households’ economic status, household size, educational level and gender of the household head. This finding suggests that improved income level, reduced price advantage of dirty fuels (e.g. taxing coal) and empowering the female members of households are crucial in promoting the use of clean energy alternatives in urban areas.

Gyamfi et al. [28], using a multinomial logistic-regression model and data from surveys carried out in 14 off-grid rural communities in the Rio Negro and Amazonas states in Brazil, reported that the age of the household head, household size, number of daily meals, the community, the educational level of the household head and the income level of the household were important determinants of fuel choice. Specifically, the authors found that, as the income level rises, households become less likely to add firewood to their fuel mix. More so, as the household size and the number of people at meals rises, households become more likely to adopt firewood as the main fuel for cooking. In addition, Démurger and Fournier [29], in their study in China, brought to light that rural households respond to increasing income levels by substituting coal for firewood.

Pundo and Fraser [30] analysed the determinants of household cooking-fuel choice in rural Kenya using the multinomial logit (MNL) model and primary data collected from the Kisumu District of Kenya. The authors reported in their empirical analysis that the educational level of household heads, type of food mostly cooked, ownership of dwelling unit and the type of dwelling unit (traditional or modern) were the main factors that influenced the choice of household cooking fuel. Megbowon et al. [31] applied a multivariate probit analyses to investigate the factors that influence households’ choice of cooking fuels using data derived from Nigeria’s Malaria Indicator Survey of 2015. Their analysis revealed that kerosene and wood were the main fuels used mostly by Nigerian households for cooking. The authors found that higher levels of education and wealth increased the likelihood of a household using LPG as the main fuel for cooking but reduced the likelihood of using charcoal, kerosene and/or firewood as the main fuels for cooking. Household size and rural dwelling were found to have a significant positive influence on the use of firewood as the main cooking fuel in Nigeria. Ouedraogo [32], in a study using household data from Burkina Faso, observed that rising
income levels induced households in urban areas of the country to opt for natural gas over kerosene for cooking. Baiyegunhi and Hassan [33], in their study, reported that the transition from fuel wood to kerosene, natural gas and electricity occurred in response to rising income levels in rural Nigeria. Lay et al. [20] show in Kenya that rising expenditure induced households to choose electricity and solar energy over wood and kerosene.

A few studies have been conducted in Ghana on the subject of household cooking-fuel use and progress towards the adoption of cleaner energy by households. Kwakwa et al. [11] applied a logit regression model with data collected from 507 households in the tropical forest zone (Koforidua, Kumasi, Tarkwa, Ho and surrounding rural communities) and the savannah zone (Tamale, Wa and their rural communities) to analyse the choice of fuels by Ghanaian households. The authors reported that electricity, charcoal and firewood constituted the three key energy types used by Ghanaian households. With regard to the determinants of the choice of fuel, the study brought to light that income and education had a negative influence on the use of kerosene, charcoal and firewood as the main household fuel for cooking. Household size increased the likelihood of using dirty fuels such as firewood and charcoal. Contrary to a priori expectations, the study revealed that households with heads employed in the formal sector were less likely to use LPG as their source of energy. Thus, the study showed a negative relationship between employment and better fuel choices, which contradicts studies in other places that found a positive effect of employment on clean energy alternatives. This unexpected finding could be as a result of the small sample size used in the study. Mensah and Adu [10], using data from the fifth and sixth rounds of the Ghana Living Standards Survey (GLSS 2005/6 and 2012/2013), analysed the dynamics in cooking-fuel use by households in Ghana and identified the main forces that drive households’ cooking-fuel choices. The results of the study revealed that there was a significant transition from the use of firewood towards the use of LPG from 2005/06 to 2012/13. The authors further reported that price, income level, reliability in supply of LPG and other household attributes were important variables that drove the choice of cooking energy in Ghana. The study revealed that while price had a reducing effect on the use of LPG as the main fuel for cooking, income level and reliability in supply had a positive influence on households’ adoption of LPG as the main fuel for cooking in Ghana. Karimu et al. [34], using the GLSS 5 and GLSS 6 surveys and a flexible semi-parametric specification, analysed the factors that determine the probability of adopting LPG as the main cooking fuel in Ghana. The authors uncovered that socio-economic and demographic factors such as income, education, access to urban infrastructure and household location were key determinants of households’ choice of LPG as the main cooking-energy option. The evidence of the study further revealed that urban households with superior socio-economic and demographic factors had a greater likelihood of adopting LPG as the main cooking fuel relative to households in rural areas and urban households with poor socio-economic and demographic conditions. The findings of most of the studies reviewed seem to give credence to the energy-ladder model, which emphasizes income and socio-economic conditions in general, in explaining the transition from dirty and ‘inferior’ traditional fuels to clean and ‘normal’ modern fuels. LPG is generally acknowledged as a superior cooking fuel because it is cleaner, faster and more convenient to use compared to firewood [35]. It is expected that as the income of households increase, they would prefer LPG despite the fact that it is relatively costly. Nnaji et al. [36], in line with the assertion of Heltberg [35], reiterate that as the household income level rises, the likelihood of switching to fuel wood alternatives increases owing to the inconvenience of using firewood relative to cleaner alternatives. Manyo-Plange [37] also observed that household heads prefer gas for cooking because the firewood stove emits smoke that has adverse health implications, unlike LPG. From the foregoing, this study seeks to analyse Ghana’s progress towards cleaner and more sustainable cooking-energy alternatives and also to examine the determinants of the choice of cooking fuel by households, using the recently released Ghana Living Standards Survey 7 (GLSS 2016/17). Data from this survey provide us with the opportunity to present recent evidence on the issues from a Ghanaian perspective. This is critical in filling the time gap, as findings from the current study will be more relevant or closer to the present situation compared to previous evidence given the continuous and significant changes in government policies, initiatives and plans over the years. In addition, although variables such as house ownership and dwelling type have been identified in the literature as important determinants of household-fuel choice (see [7, 14, 18]), none of the few studies in Ghana has included these variables in their model. In this paper, we have factored in these variables alongside other relevant variables to examine the determinants of household choice of cooking energy in Ghana.

2 Methodology

2.1 Theoretical framework and the model

Similar to [38], this study is theoretically underpinned by the ‘utility-theory’ approach, which posits that users of energy have preferences and their choice of energy type (cooking fuel) depends on those preferences. If $X$ represents a set of possible choices, we consider a consumer-choice model of the form $x \in \mathbb{R}^n$ , which suggests that there are $n$ different energy choices (clean energy, charcoal and wood). In addition, we assume that $x \in X$ so that $\mathbf{x} = (x_1, ..., x_n)$, where $x_\text{clean}$ and $x_\text{other}$ represent clean energy and other energy types (i.e. wood and charcoal). Thus, the utility function for the household choice of cooking fuel is defined as follows:

$$V_{ij} = B_jx_i + u_i$$

(1)

where $V_i$ denotes the indirect utility function of household $i$ for cooking fuel $j$, $x_i$ stands as the vector of individual, household and other characteristics that influence a household’s choice of fuel, $B_j$ is a vector of coefficients of explanatory variables, measuring the average probability/likelihood that a household chooses a particular cooking-fuel type; and $u_i$ is the stochastic component that captures the unobserved utility. In view of the foregoing, the empirical model of this study follows the structure of the MNL model to estimate the determinants of household choice of cooking fuel. The choice of the MNL model structure is premised on the fact that the dependent variable has more than two outcomes [38, 39]. Thus, we assume that every household attaches some level of satisfaction or utility to different cooking-fuel types and chooses the alternative with the highest utility conditional on their characteristics. This is stated as a probability such that the probability ($P_j$) that household $i$ chooses a particular cooking-fuel type or category $j$ over $k$, given their characteristics ($X$) is specified as follows:

$$P_j = P_j(V_{ij} > V_{ik}) = P_j(B_jX_i + u_i > B_kX_i + u_k) \text{, for all } i \neq k$$

(2)

For the purpose of this study, three categories of household cooking fuels are used. Thus, $j$ is defined as follows: clean energy (0), charcoal (1) and wood (2). In this case, the clean-energy category combines natural gas and electricity, while charcoal and wood are each considered an unclear energy source. Each category
represents the main cooking fuel used by a typical household. Following this, the probability function in Equation 2 can be re-specified as follows:

\[ p_{ij} = \frac{\exp(B_j X_i)}{\sum_{j=0}^{J \infty} \exp(B_j X_i)} \]  

(3)

where clean energy is set as the reference category by normalizing its coefficients to 0. With this, we can easily compare the use of clean energy (i.e. gas and electricity) to each use of unclean energy (i.e. wood and charcoal). Note that setting a reference category satisfies the assumption of the Equivalent Difference Property of the MNL model, which ensures that a change in the reference class does not affect the quality and interpretation of the outcome [38]. Other assumptions of the MNL model include the Independence of Irrelevant Alternative, according to which, during the time of decision-making, the choice between two alternatives is independent of any third alternative. Thus, the error component of the utility function in Equation 1 is assumed to be identically and independently distributed across alternatives and households.

Generally, the initial estimates from an MNL model are interpreted in terms of their signs (or directions) and significance levels. Hence, to estimate the extent of the effect of a factor on the dependent variable, the study provides estimates for the relative risk ratio (or odds ratio). This is obtained by finding the ratio between the probabilities of a chosen category and the reference category in the form:

\[ \frac{p_r(y = j|x)}{p_r(y = 0)} = \exp(B_j X_i) \]  

(4)

With the relative risk ratio, the coefficients are interpreted in terms of magnitude and significance level. So, all variables with coefficients of >1 favour the chosen category (e.g. wood) relative to the reference category or class (which is clean energy, i.e. gas and electricity). Similarly, all variables with coefficients of <1 favour the reference class relative to the chosen class. Intuitively, an inverse of the coefficient gives the direct and explicit effect of variables for the reference class (clean energy).

### Summary of definitions of variables

#### Table 1: Summary of definitions of variables

| Variables       | Definitions                                                                 |
|-----------------|-----------------------------------------------------------------------------|
| Cooking fuel    | This is the dependent variable: a categorical (outcome) variable for household’s main cooking fuel: clean energy (gas and electricity), wood and charcoal. Clean energy is set as the reference category/class |
| Female          | This is a dummy variable with a value of 1 if the household head is a female and 0 if a male |
| Age             | This is a continuous variable for head’s age in years                        |
| Age square      | This is a continuous variable measuring the square of the age variable in years |
| Education       | This is a categorical variable for the highest educational qualification of head: none, basic, secondary and tertiary education. None (thus, no education) is set as the reference group |
| Employment status| This is a categorical variable for head’s employment status: paid employee, agricultural self-employed, non-agricultural self-employed, unemployed and economically inactive. Paid employee is set as the reference group |
| Dependency ratio| This is a continuous variable measuring the dependency ratio of the household |
| Household size  | This is a continuous variable measuring the number of members in the household |
| House ownership | This is a categorical variable for house ownership: houseowner, renting, others (rent-free, squatting, perching). Houseowner is set as the reference group |
| Dwelling type   | This is a categorical variable for household dwelling type: separate house, semi-detached house, flat apartment, compound house, huts/buildings in the same compound and others (kiosk, tent, improvised home and uncompleted building). Separate house is set as the reference group |
| Income quintile/status | This is a categorical variable for first to fifth income quintiles. First quintile (lowest income status) is set as the reference group |
| Urban           | This is a dummy variable with a value of 1 if household lives in an urban area and 0 otherwise (rural) |
| Ecological zone | This is a categorical variable for the ecological location of the household: forest, coastal, savannah and Accra |

### Results and discussion

#### 3.1 Some descriptive analysis of variables

Table 2 presents some descriptive explanations of the variables using frequency distribution. As shown in Table 2, a significantly higher proportion of male-headed households (52.7%) than females (42.3%) use wood as the cooking fuel while a higher proportion of female-headed households (38%) than males (26.3%) use charcoal. The use of cleaner energy is significantly higher among households headed by educated persons, particularly for those with secondary and tertiary education, while the use of unclean energy is highest among the uneducated and less-educated ones. The use of cleaner energy is significantly higher among paid employees but lowest for other employment types, particularly for the unemployed. Further, renting households significantly use cleaner energy (44.8%) compared to houseowners (10%) and other renting statuses including rent-free and squatting (21.8%). Also, about one-third and two-fifths of houseowners and others significantly use wood and charcoal, respectively. Similarly, cleaner energy use is reported...
to be highest among households with modern structures. Thus, the sample data show that cleaner-fuel usage is significantly higher among households in flat apartments (71.2%) followed by semi-detached houses (34.1%). Regarding the use of cooking fuel by income groups, statistics show that higher-income households significantly use cleaner energy than their counterparts from relatively lower-income households, where the use of wood and charcoal dominates. Expectedly, the proportion of urban households (39%) that use cleaner energy is significantly higher than their rural counterparts (6.8%). The use of wood and charcoal as a cooking fuel dominate in rural and urban areas, respectively. Very similarly, a significantly higher proportion of households in Accra use cleaner energy (58.8%) and charcoal (40.7%) compared to other ecological zones.

### 3.2 The MNL model estimation results and discussion

Table 3 presents estimates from the MNL model of the factors influencing a household’s choice of main sources of cooking fuel. A common challenge with cross-sectional data is the issue of heteroscedasticity. To deal with this, the study applied the robust command in Stata to estimate the robust standard errors, which are reported in parentheses. Also, a further test shows that the model does not suffer from multicollinearity, as no two regressors are correlated to a higher degree. This is indicated in the Variance Inflation Factor, whose value is <5 compared to the rule of thumb of 10. The estimates are provided for both the coefficients (which are interpreted in terms of signs and significance levels) and the relative risk ratios (or odds ratios), which signify the extent of...
Table 3: Factors influencing household’s choice of cooking fuel

| Variables                     | Coefficient | Wood   | Charcoal | Odds ratios |
|-------------------------------|-------------|--------|----------|-------------|
|                               |             |        |          |             |
|                               |             | Wood   | Charcoal |             |
| Head’s characteristics        |             |        |          |             |
| Female                        | 0.27***     | 0.27***| 1.31     | 1.31        |
|                               | (0.09)      | (0.07) |          |             |
| Age                           | −0.03*      | −0.03**| 0.97     | 0.97        |
|                               | (0.02)      | (0.02) |          |             |
| Age square/100                | 0.05***     | 0.05***| 1.05     | 1.05        |
|                               | (0.02)      | (0.02) |          |             |
| Basic education               | −1.09***    | −0.76***| 0.34     | 0.47        |
|                               | (0.10)      | (0.08) |          |             |
| Secondary education           | −1.82***    | −1.37***| 0.16     | 0.25        |
|                               | (0.15)      | (0.10) |          |             |
| Tertiary education            | −2.67***    | −2.10***| 0.07     | 0.12        |
|                               | (0.15)      | (0.10) |          |             |
| Non-agricultural self-employed| 0.27**      | 0.11   | 1.31     | 1.11        |
|                               | (0.11)      | (0.08) |          |             |
| Agricultural self-employed    | 2.25***     | 0.65***| 9.46     | 1.92        |
|                               | (0.14)      | (0.13) |          |             |
| Unemployed                    | 0.42**      | 0.02   | 1.52     | 1.02        |
|                               | (0.15)      | (0.12) |          |             |
| Economically inactive         | 0.14        | −0.30**| 1.15     | 0.74        |
|                               | (0.15)      | (0.13) |          |             |
| Household characteristics     |             |        |          |             |
| Dependency ratio              | 0.06        | 0.05   | 1.07     | 1.05        |
|                               | (0.06)      | (0.05) |          |             |
| Household size                | 0.07***     | 0.03*  | 1.07     | 1.03        |
|                               | (0.02)      | (0.02) |          |             |
| Renter                        | −1.43***    | −0.26***| 0.24     | 0.77        |
|                               | (0.12)      | (0.09) |          |             |
| Other (e.g. rent-free, squatting) | −0.12   | 0.26***| 0.89     | 1.30        |
|                               | (0.10)      | (0.09) |          |             |
| Observations                  | 12,431      | 12,431 | 12,431   | 12,431      |

Robust standard errors in parentheses. ***P < 0.01; **P < 0.05; *P < 0.1.

The study further reveals that an increase in the level of educational achievement is associated with a higher chance of using a cleaner energy relative to using unclean energy. For instance, relative to no education, a household whose head has a basic, secondary and tertiary education is ~2.9, ~6.3 and ~14.3 times more likely to use cleaner energy relative to using wood. A similar pattern of educational effect is observed when considering choosing between the use of cleaner energy and charcoal. This finding is in line with the general observation that higher education increases the capacity to earn more and to have a better understanding of the health impacts of unclean energy and a stronger desire for a clean environment including quality air.

In the case of employment status, the findings show that self-employment and unemployment increase the likelihood of using wood as cooking fuel compared to paid employment (that is mostly formal in nature), which increases the usage of cleaner energy. For instance, being agriculturally self-employed increases the chance of using wood for cooking by ~9.5 times compared with paid employment, which increases the adoption of cleaner energy. In the case of charcoal, the findings are mixed. Relative to paid employment, being agriculturally self-employed and economically inactive, respectively, increase and decrease the use of charcoal compared to using cleaner energy. This finding is a direct contradiction to the findings of Kwakwa et al. [11], who surprisingly reported a negative effect of formal employment on the adoption of LPG as cooking fuel in Ghana. However, the unexpected findings of Kwakwa et al. [11] could have been biased by the relatively small sample size used in their study.

3.4 Household characteristics

Both the dependency ratio and household size increase the likelihood of using unclean energy (wood and charcoal). This finding is consistent with anecdotal and theoretical expectations, as relatively larger households usually opt for firewood or charcoal because they are comparatively more affordable when cooking for more people. Compared to being a houseowner, households that live in rented houses are ~0.24 and ~0.77 times less likely to use wood and charcoal, respectively, compared to using cleaner energy. By implication, being a renter relative to being a houseowner increases the use of cleaner energy by ~1.3 and ~1.7 times compared to using wood and charcoal, respectively. Other ownership statuses (i.e. rent-free, perching and squatting) relative to being a houseowner rather increases the use of charcoal by 1.3 times compared to using cleaner cooking fuel.

For dwelling type, the results reveal that households living in semi-detached houses and flat apartments use less wood compared to using cleaner energy, while all other dwelling types (including kiosk, tent, improvised home and uncompleted building) have increased likelihood of adopting wood. The findings are similar to the case for charcoal with the exception of semi-detached houses, which reported an insignificant coefficient. Households living in flat apartments and semi-detached houses are mostly middle-class people who have a relatively higher earning capacity and can therefore afford LPG, electricity and other cleaner energy options even though they are more expensive compared to traditional biomass.

Another stimulating finding of the study is the monotonically increasing effect of income status on the use of clean cooking fuel. This is consistent with the energy-ladder theory which postulates that as households enter the next higher income bracket, their preference for clean energy increases. For instance, being in the first income quintile, households in the fourth and fifth income quintiles increase their likelihood of using clean energy, respectively, by ~3.4 and ~6.3 times compared to using wood and ~3.3 and ~6.3 times compared to using charcoal.

3.5 Geographical areas

The geographical variables suggest that living in relatively developed areas increases the likelihood of the adoption of cleaner energy (see Table 4). Thus, the findings indicate that living in
urban areas relative to living in rural areas decreases the use of wood and charcoal by -0.10 and -0.61 times compared to using clean cooking fuel. In other words, relative to being a rural household, being an urban household increases the likelihood of using cleaner energy by 10 and 1.6 times compared to using wood and charcoal, respectively. This finding is consistent with the fact that average income levels and economic opportunities in urban areas are usually higher than in rural areas. Further, households living in the forest and savannah zones have a higher likelihood of unclean energy usage compared to those living in the coastal zones. This could be explained to mean that fuel wood and charcoal are more accessible and cheaper in forest and savannah areas relative to other ecological zones, thereby making them a more convenient and cost-effective cooking-energy option for people in those areas. The effect of the Accra variable is mixed for wood and charcoal. Thus, relative to using clean energy, households in Accra decrease and increase their usage of wood and charcoal, respectively.

4 Conclusion and policy recommendations

The analysis shows that the main determinants of household energy choice in Ghana are education, household dwelling type, household size (dependency ratio), employment and income level. With regard to education, the results show that higher education increases the adoption of cleaner energy alternatives such as LPG and electricity relative to wood and charcoal. This implies that government policies to promote the use of cleaner energies must integrate access to education, especially at the secondary and tertiary levels. The sustainability of the free senior high school (SHS) policy, for instance, could go a long way to reducing the use of dirtier cooking-energy options in Ghana in the future. For dwelling type, the results brought to light that households living in modern housing structures (semi-detached houses and flat apartments) are more likely to use cleaner energy options relative to households living in less-organized housing units. This means that policies should be aimed at improving the housing conditions of households in the bid to reduce households’ reliance on unclean energy alternatives. The affordable housing scheme initiated by the government should be scaled up, especially in the urban areas of Ghana, to improve the housing conditions of a large number of households in order to enhance the transition to cleaner energy use. Both the dependency ratio and household size increase the likelihood of using unclean energy (wood and charcoal), which implies that policies to reduce population growth could also influence Ghana’s transition to cleaner cooking-energy use. In the case of employment status, the findings show that employment in the formal sector increases the likelihood of using cleaner energy options relative to self-employment and unemployment, which increase the tendency for using wood as cooking fuel. It is, therefore, prudent that government adopt policies to formalize the economy that are mainly informal. One other important finding of the study is the increasing effect of income status on the use of clean cooking fuel in line with most of the existing studies and anecdotal evidence. Suffice to say that scaling up poverty alleviation will go a long way towards facilitating the transition to cleaner cooking energy in Ghana. More so, the findings indicate that living in urban areas relative to living in rural areas decreases the use of wood and charcoal as cooking fuel. This means that policies to enhance urbanization will go a long way towards reducing the pressure on Ghana’s forest cover through the illicit cutting of trees for firewood or charcoal production. An interesting area that is worth exploring in future studies is how flagship policies of the government of Ghana such as free SHS and the One-District–One Factory policy will influence the adoption of cleaner energy options in the country in the long term.

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Conflict of interest statement

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