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AN INVESTIGATION INTO THE SUSTAINABILITY OF THE CURRENT FUELS USED FOR COOKING IN GHANA TO INFORM FUTURE ENERGY POLICIES

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ABSTRACT

There are sustainability, health and environmental concerns in many developing countries where the use of solid fuels for cooking in poorly ventilated kitchens is a common practice. The utilisation of solid fuels for cooking with inefficient cooking stoves accounts for significant respiratory health issues and deforestation in Ghana. Significant policies and government initiatives in Ghana have been adopted to mitigate household solid fuel consumption, substituting it with increased access to liquefied petroleum gas (LPG). But despite such policies, the consumption of solid biomass fuel, mainly charcoal and firewood, is still prevalent in Ghana. To inform future energy policy, this study investigates the sustainability of cooking fuels utilised in Ghanaian households, to ensure an ecological balance and healthy living circumstances. A two-part survey was conducted between 2013 and 2019 for households in Ghana to identify and investigate factors influencing household cooking fuel preferences. Regression analysis is employed to explore the relationship between the choice of selected fuel and key factors such as fuel cost, availability, region and household size. The findings suggest that fuel cost, availability, geographical location (urban/rural), and household size act significantly as drivers to influence the selection of most Ghanaian cooking fuel, and this was found to be consistent over the studied period.

Keywords: Cooking fuel, deforestation, Ghana, sustainability, accessibility, energy efficiency

1. INTRODUCTION

The global importance of energy cannot be over emphasised, as energy generation and utilisation are an essential prerequisite for the living and survival of the world's citizens, and the growth of many national economies.

This relationship between energy and economic growth has, however, been widely debated for decades, attributable to diverging notions in relation to the precise correlation between energy and economic growth [1]. The underlying rationale for this debate borders on global access to clean and affordable energy and the sustainability of the type of energy resources consumed in any country [2]. As access to clean energy and the sustainable consumption of energy resources is critical for economic growth and in the achievement of the Sustainable Development Goals (SDGs) [3, 4]. However, despite global efforts to ensure adequate access to clean modern energy, many countries still face major challenge of inadequate access to clean modern energy particularly developing countries such as those in sub-Saharan Africa and Asia [5-8]. Approximately, 1 billion people do not have adequate access to modern energy (electricity) while 2.6 billion people lack access to clean cooking fuels and efficient cooking technologies [9]. Therefore, resulting in heavy reliance on solid fuels (firewood and charcoal) for cooking, which consequently results in 2.8 million deaths annually, with women and children mostly affected by the smoke from the combustion of solid fuels used for cooking [4, 5, 10,].

Studies conducted by the Ghanaian Statistical Service [11] and the United Nations Development Programme [3] shows that about 70% of Ghanaian households depend on solid fuels, mainly firewood and charcoal, as the major sources of cooking fuel. This high dependency on firewood and charcoal causes a strain on Ghanaian forestlands and exposure to household air pollution which is responsible for respiratory diseases and over 15000 deaths in Ghana [12]. This negative impact of high solid fuel dependence has led to increased focus on household cooking fuel choices and a call for transition to cleaner cooking fuels.

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Several literatures have investigated household cooking fuel choices in Ghana [13-19]. Many of these studies have investigated the drivers of household fuels choices and its impact on human health which forms a good source of literature for this paper. However, from these articles two main limitations were identified; the sustainability assessment of household cooking fuels in Ghana is very rare and the datasets used in some of these literatures are outdated but makes a valid hypothesis towards cooking fuels, but further investigation is still required to keep up with the current changes in household fuel choices in Ghana.

Using two surveys conducted amongst Ghanaian households in 2013 and 2019, the novelty of this study aims to investigate the sustainability of current household cooking fuel used in Ghana between 2013 and 2019 by examining the sustainability assessment of household cooking fuels in used Ghana and to further investigate the various determinants of household cooking fuel choices in Ghana.

2. METHODOLOGY

As one of the emerging economies in sub-Saharan Africa, Ghana is located in western Africa, along the Gulf of Guinea in the south, bordering between Burkina Faso to the North, Togo to the East and The Ivory Coast to the West, covering a total land area of 238,533km^2 and a population of approximately 29.6 million people in 2018 [20]. The country's location in the region makes it a major economic hub for businesses and foreign investment, coupled with the recent discovery of oil resources and a Gross Domestic Product (GDP) of US $65.558 billion in 2018 [21].

This study adopts a mixed method approach comprising questionnaire survey, review and analysis of relevant literature in relation to cooking fuels in Ghana and direct observation in the field, including pictorial excerpts on the type of cooking stoves used in most rural villages in Ghana, to obtain the required data.

The questionnaire for this study was designed to investigate the sustainability of household cooking fuels in Ghana and to ascertain the main drivers of Ghanaian household cooking fuel choices. A combination of open and closed questions was asked, where respondents had the freedom to provide their answers based on personal experiences and knowledge. The two-stage survey of this study covered 295 households across the 10 regions of Ghana. In line with the objectives of the study, the questionnaires were distributed to randomly selected households in two clusters, namely urban centres and rural areas, to capture an in-depth insight into cooking fuel trends in the various regions of Ghana. The questionnaires were all distributed twice in August 2013 and December 2019.

The main focus of the questionnaire was to address the following research questions: What are the main sources of cooking fuel used in households? What quantity of fuel is used for cooking? What are the factors that influence household cooking fuel choices in Ghana? What is the likelihood of households adopting solar energy as a cooking fuel source? Questions on the socio-economic background of households were included in order to ascertain current household perception of the factors influencing their decision to choose a particular fuel. Additionally, a stratified random sampling technique was utilised to ensure no overlapping between sampling groups.

2.1 Sample Distribution

The sample distribution for this study targeted households living in both urban and rural areas in Ghana. The sampling stratum was divided into two sub-strata: urban households and rural households. Households were then randomly selected in each stratum based on the location of their home within the 10 regions of Ghana. Five hypotheses will be tested in this study:

- Hypothesis H1: Fuel price is significantly associated with type of cooking fuel.
- Hypothesis H2: Fuel availability is significantly associated with type of cooking fuel.
- Hypothesis H3: Location (Urban/Rural) is significantly associated with type of cooking fuel.
- Hypothesis H4: Location (Region) is significantly associated with type of cooking fuel.
- Hypothesis H5: Household size is significantly associated with type of cooking fuel.

In addition, a series of t-tests were performed to examine whether significant differences exist between the responses from 2013 and 2019. Combining the outcomes of the two-phased sampling yielded a total of 288 households for this study, of which 288 responses were considered valid (n=288). For the first stage of the survey (n=245), the distribution of the questionnaire is shown in Fig. 1. For a sample of n=245 for a population 28 million this indicates a margin of error in the sampling process of ±6% with a confidence interval of higher than 95%; for the second stage of the survey (n=43) this indicates a margin of error in the sampling process of

±15% with a confidence interval of higher than 95%. Confidence interval is the probability that the sample accurately reflects the attitude of the population while margin of error is the extent to which the population's response may deviate from the response of the sample, reflected as a percentage [55]. For the combined two-stages, (n=288), the margin of error in the sampling process was ±6% with a confidence interval of higher than 95% for the whole period.

3. RESULTS AND DISSCUSSION

3.1 Statistical Analysis

3.1.1 Determinants of Energy Source Types

This study hypothesized that the type of energy used by Ghanaians for heating and cooking is determined by a number of key factors such as price, availability, geographical location, supply-side factors and accessibility. Regression analysis was employed to explore the relationship between cooking, heating energy choice and the above factors, examining the hypotheses that will test for this study.

Descriptive statistics and intercorrelations for study variables are presented in Table 4. All correlation coefficients (except for the "Region") were significant, supporting the study's hypotheses (except H4). There was no evidence of multicollinearity among the four predictors (significant r < .502).

Table 1 Descriptive statistics and correlations for all regression model variables

Variable	1	2	3	4	5	6
1.Cooking Fuel						
2. Fuel cost	-.119*					
3. Availability	-.513**	.031				
4. Area	-.382**	.001	.502**			
5. Region	-.011	-.020	.080	.097		
6.Household Size	.228**	-.069	.061	-.058	.090	
Mean	3.50	2.73	.79	.72	6.72	.01
SD	1.308	2.118	.408	.450	2.685	.118

Note: Pearson correlations: *p < .05; **p < .01; n=286.

The dependent variable (Cooking Fuel) was regressed on the independent variables three times using 2013 data and 2019 data then using both data. The results of the three models were similar, with the data regression results presented in Table 2 below.

According to these regression results, the research hypotheses H2 and H5 are accepted at P<0.01 and H3 and H1 are accepted at P<0.05 and P<0.1, respectively, suggesting that fuel cost/price, availability, geographical location (urban/rural) and household size act as drivers to influence the choice of Ghanaian household cooking fuel. However, H4 is rejected, suggesting that the region is not a significant predictor of the type of cooking fuel. Hence, regardless of the region, the use of fuel is based on rural vs urban location.

Table 2 Results of the regression model

Variable	*β*	*t-value*	*t*-significance (P)
Constant	5.011	22.724	.000
Fuel Cost	-.088*	-1.822	.070
Availability	-.456***	-8.144	.000
Area	-.141**	-2.509	.013
Region	.015	.312	.755
Household Size	.240***	4.928	.000

Adjusted R^2= .341, Model-significance = .000.
*Significant at 10%.
*Significant at 5%.
***Significant at 1%

3.1.2 Change in attitude over 6 years

A series of t-tests were performed to examine whether significant differences exist between the responses of 2013 and 2019; these revealed no significant differences between the two years in term of the types of energy sources used for cooking (all P values >0.1). However, there were significant differences between the two years with regards to respondents' perspectives regarding the impact of firewood and charcoal smoke on the environment, considering adopting solar energy, and its importance as the future energy source in Ghana (t=-.823, P<.1; t=-.631, P<.01 and t=-3.036, P<.01, respectively). The means suggest that 2019 responses reflected higher awareness of the impact of firewood and charcoal smoke on the environment and human health, more willingness to adopt solar energy for household cooking and more respondents considering renewable energy such as solar energy as a future source of energy in Ghana when compared to 2013.

3.2 Composition of Fuel use in households

Based on analysis of the responses to the survey, various observations were made, revealing that LPG, charcoal and firewood constitute the dominant cooking fuels utilised in most Ghanaian households. Fig. 2 shows the gross percentage fuel use indicating

the gross percentage fuel use, indicating that overall, 97.6% of respondents use either LPG, charcoal or firewood as the main cooking fuel. Further, 69.4% of respondents were using LPG as their main cooking fuel, while 17.6% used charcoal and 10.6% firewood for cooking, with 2.4% of respondents using either plant residue or animal manure.

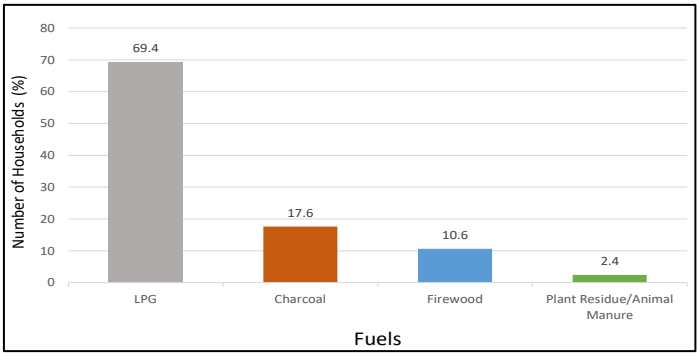

Fig. 1 Percentage fuel use in households

The high percentage value of LPG usage reflects the impact of government efforts, as highlighted in [11] in promoting LPG utilisation as the cooking fuel of choice, over charcoal and firewood which cause negative environmental effects, health impacts and deforestation. However, despite this encouraging LPG percentage, the use of charcoal is still very much prevalent in Ghanaian household cooking fuel mix, as presented in Fig. 2. These results corroborate the findings of Mensah & Adu [17] which suggested that despite governmental efforts, Ghanaian households still rely on charcoal as their main source of cooking fuel. Specifically, they found unsustainability concerns associated with charcoal use in terms of its non-renewable nature, environmental and health impacts attributable to deforestation, particulate matter ($PM_{2.5}$) emissions and respiratory illnesses. The observed trend in Fig. 2 suggests that there are factors acting as principal drivers influencing household choice of cooking fuel, as discussed in the next section.

3.3 Drivers of Ghanaian household fuel choices

The results from the survey indicated that reasons for the trend seen in Fig. 4 are attributable to the dependability of cooking fuels on certain variables, such as, accessibility, availability and affordability (pricing) as shown in Table 3 below. Previous research has identified changes in technology, economic changes and the taste of food as factors that could influence household cooking fuel choice.

Retrospectively, accessibility to LPG in Ghana has been a challenge, due to reoccurring supply deficiencies, cost of LPG and the use of LPG canisters with their associated hazards of transportation and storage, therefore, driving households to move from LPG usage to charcoal and firewood, irrespective of the sustainability concerns linked with solid fuel use for cooking. Nevertheless, the results from the survey revealed that the likelihood of households adopting any type of cooking fuel based on accessibility tends to be in favour of LPG with 55.2% of respondents confirming LPG as their preferred choice of cooking fuel on the grounds of ease of accessibility.

Table 3. Reasons for Household Choice of Cooking Fuel

Variable (%)	Accessibility	Affordability	Availability
LPG	55.2	15.9	3.5
Charcoal	16.7	18.0	18.0
Firewood	4.2	4.6	6.3

Access to LPG is largely dependent on the proximity of energy consumers to LPG supply outlets and LPG availability, implying that geographical factors and the availability of fuel play a pivotal role in influencing household cooking fuel preferences. Therefore, from Table 3 above, it is evident that there exist some variations in relation to the variables that may influence household's cooking fuel choices. A higher percentage of respondents preferred using charcoal because it is affordable and readily available for use when compared to LPG. Hence, the decision reflects to prioritise cost over sustainability concerns that such high reliance on charcoal for cooking brings, including the aforementioned forest depletion and associated increased release of particulate matter ($PM_{2.5}$) to the atmosphere, alongside increasing the rate of exposure to emissions from the combustion of charcoal for women and children, as the main people involved in cooking activities in most households in developing countries

In addition, results from the survey showed that the price factor is influencing household cooking fuel preferences. Table 2 illustrates the significance of affordability (cost or pricing) as a major determining factor that largely influences household's choice of cooking fuels. The positive effect of price on charcoal is attributable to the reduced capital investment associated with charcoal production and its availability on the market. Charcoal is usually sold in small bags and is much easier to transport and store when compared to LPG' canisters, hence, increasing the probability of households in Ghana choosing charcoal over LPG.

3.4 Sustainability assessment of household cooking fuel

In order to attain the sustainability assessment of the cooking fuels used in Ghanaian households, the individual sustainability assessment of each cooking fuel

Table 4. Sustainability assessment of Household cooking fuels in Ghana

	Affordability	Availability	Accessibility	Environment	Socio-Economic Benefits	Weighted Sustainability Assessment
Cooking Fuels						
LPG	**L**	**M**	**M**	**H**	**H**	**M**
Charcoal	**H**	**H**	**H**	**L**	**L**	**L**
Firewood	**H**	**H**	**H**	**L**	**L**	**L**
Biogas	**L**	**H**	**L**	**H**	**H**	**M**
Solar	**L**	**H**	**M**	**H**	**H**	**H**

was rated on three levels: L (Low), M (Medium) and H (High). Categorisation was completed using respondent's views in relation to assessing the sustainability ratings for each cooking fuel, and, in consideration of the essential key variables in relation to affordability, availability, accessibility, environmental impact and socio-economic benefits. From Table 4 it can be observed that solar energy for cooking represents the most sustainable option for households in Ghana, followed by biogas and LPG. However, charcoal and firewood have the lowest sustainability ratings when compared to other cooking fuels. The low sustainability ratings for charcoal and firewood are linked to the detrimental environmental and socio-economic impacts of these fuels combined with time spent in collecting firewood.

However, despite the low sustainability ratings for charcoal and firewood, the affordability, accessibility and availability ratings for both fuels are appreciably high, due to easy access to charcoal and firewood that comes at a low cost in the market. Therefore, making fuels such as charcoal, evidently the most sought after and utilised cooking fuel in Ghana, irrespective of the willingness of households to spend money on clean modern fuels like LPG and biogas, is still a priority. However, LPG and biogas are often limited in terms of high purchasing cost, supply constraints, lack of awareness and technical knowledge, and, as such, is not readily available for most households in Ghana. In light of the above trends, it can be deduced that the use of charcoal and firewood use as cooking fuels in Ghana is unsustainable due to environmental, health and socio-economic impacts, hence, there is an increasing requirement for the creation of an energy market that will introduce improved access to clean modern cooking fuel and higher incentives and technological improvements for cooking stoves.

4. CONCLUSION

This study has investigated and evaluated the sustainability of cooking fuels in Ghanaian households and discussed the important characteristics of household fuel preferences by critically examining the factors that are central to influencing a household's choice of cooking fuel. Results obtained show LPG and charcoal as the major cooking fuel sources used in most Ghanaian households, accounting for 97.6% of responses, where LPG (69.4%) was the preferred type of cooking fuel. This positive percentage of LPG usage emanates from government incentives aimed at encouraging a transition from solid fuels to the utilisation of modern fuels (LPG). However, further analysis reveals firewood (10.6%) and charcoal (17.6%) as the most prevalent cooking fuels in many Ghanaian households due to supply deficiencies, high cost of LPG and inaccessibility to LPG stations. This results in high consumption of firewood and charcoal which has sustainability challenges as the consumption of firewood and charcoal adversely affects Ghanaian forestlands, environment and health. This research identified pricing, accessibility, availability, geographical location (urban vs rural), and supply factors as pivotal variables that influence household fuel choice in Ghana. As over 67% of respondents identify price, accessibility and availability as major influencers when choosing cooking fuels. However, despite the above drivers of Ghanaian household cooking fuel choice, statistics from this study reveal increased awareness of the health burden of solid fuels and more acceptance of solar cooking fuel amongst responses collected in 2019 when compared to 2013.

Given the results above, this study recommends that increased supply of cleaner fuels like LPG could mitigate reliance on solid fuels in Ghana, although increasing supply of LPG might not suffice in encouraging transition to cleaner fuels especially for rural households who live in remote areas with low income and might not be able to afford LPG. To compliment increased supply of LPG, more investment into the development of solar energy cooking stoves and provision of incentives to make such stoves affordable for households could be beneficial, given that a shift in household attitudes towards better sustainability awareness has already been seen. Moreover, policy goals for the rural areas should be directed towards developing efficient cooking stoves and

construction of proper ventilated kitchens for cooking activities. Further, there is a need for further upscaling of awareness and educating households on the environmental and health effects of solid fuels, since results from the study highlight the relationship between household pollution and acute respiratory infections.

There is therefore an urgency for an increased awareness and education on the health benefits of adopting modern fuels, which may, in-turn, alter the household perception of over-reliance on solid fuels and foster a further shift from conventional fuel use to modern fuels.

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