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Factors influencing household's charcoal consumption in Montserrado County, Liberia

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Abstract

In sub-Saharan African Countries, charcoal is still preferred as the main source of energy use by the majority, and its importance is not only as a source of energy but also for generating employment and income among its producers. The current study intends to look into factors related to household charcoal consumption in Montserrado County, Liberia. Specifically, the study aims to assess socio-economic factors affecting household charcoal consumption and to identify the challenges associated with charcoal consumption. The study adopted a cross-sectional research design whereby data were collected once from 386 respondents who are charcoal consumers in Montserrado County. Quantitative data retrieved from the questionnaires were analyzed by using SPSS version 20 in which descriptive and inferential statistics were determined. Results from the multiple linear regression analysis showed that factors such as education level, number of meals, price of charcoal and household size were statistically significantly associated with household charcoal consumption in the study area. Furthermore, the high price of charcoal, low quality of charcoal and dirtiness of homes were the top three challenges affecting charcoal consumption in the study area. The study recommends the government formulate policies for improving accessibility to other alternative energy sources such as gas and electricity affordably and reliably to encourage inter-energy switching among households to ensure sustainable per capita consumption of charcoal.

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Introduction

The majority of households in developing nations depend largely on wood fuel as their main energy source. Clean and efficient energy such as gas, electricity and kerosene are considered to be among the main drivers for sustained economic growth and development. Hence, their unaffordability in terms of price, inaccessibility, unreliability in supply and unavailability have constrained households to consume traditional fuel known as charcoal for cooking, boiling, and ironing (Suliman, 2013). Since the beginning of time, charcoal has been used for a variety of reasons, including medicine and art, but by far its most significant usage has been as fuel for metallurgy, cooking, industry, and automobiles. When high heat is required, charcoal is used as a standard fuel. It may be ground up to produce carbon black for use in chemical processes, and it was crucial to the development of early chemistry (Abdolahi, 2014). The energy balance is dominated by biomass-based fuels, primarily charcoal and firewood are the primary sources of energy in both urban and rural regions due to the extremely restricted access to electricity and other renewable energy sources (Nyoni, 2014).

Almost one-third of the world's population still uses wood as their primary source of fuel for cooking, and many small businesses rely heavily on fuelwood and charcoal as their primary energy sources for tasks like baking, processing tea, and manufacturing bricks. Around the world, wood harvested from forests is utilized to make charcoal and fuelwood at a rate of 50% (Dam *et al.* 2017). Notwithstanding, limited access to cleaner energy services has prompted about two and a half billion of the world's population to use traditional biofuel (charcoal) for cooking, boiling, and ironing (Kowsari and Zerriffi, 2011).

In Africa, about 80% of urban cities are engaged in biomass combustion for cooking (Zulu and Richardson, 2013). The estimated use of wood fuel and charcoal in Africa is 90% (East Africa 94%, North Africa 96%, Central Africa 87%, South Africa 49%, and West Africa 92%). According to official figures, Africa produced 30.6 million tons of charcoal in 2012, which was sold for between USD 6.1-24.5 billion.

African continent with the fastest population growth at 2.45% in 2021, the continent's yearly population growth rate is exceptionally high and is expected to stay over 2% for the ensuing 20 years (UN, 2021). The consumption of charcoal is being influenced not only by projected high population growth and urbanization but also by other factors such as economic, social and environmental factors (Masera *et al.,* 2003). Charcoal and firewood are the two major sources of biomass energy in Liberia. Charcoal trade as a livelihood economic activity in Liberia has helped in poverty alleviation for the Forest Dependent Community (FDC) and contributed immensely to about 10% of the country's GDP (World Bank, 2018). The per annum demand for charcoal since 2018 is estimated at 337,000 metric tons and about 75% is consumed by residents of Monrovia (World Bank, 2019). Currently, charcoal and firewood is the preferred energy source for cooking in Montserrado County. However, increasing demand is more likely due to the lack of affordable, available and reliable clean energy sources and the rate of urbanization. This energy deficit has influenced the high increase in household consumption of the forest-based product mainly charcoal which is adversely affecting the environment due to households' financial incapability to purchase modern energy conversion technologies (Elias and Victor, 2005). Studies conducted in Liberia have estimated that more than half of the total population residing in Montserrado County are experiencing limited access to electricity and other cleaner energy sources like gas, and kerosene (MCDA, 2012). Studies by Goll *et al.* (2014); Brieland, (2015); Oladeji *et al.,* (2018) and World Bank, (2019) have stressed the need for capacity enhancement programs, Law enforcements programs, and a more economically competitive economic model for a realistic analysis of the factors influencing the progressive increase in household's charcoal consumption in Liberia. It is estimated that the annual growth rate of the urban population is 3.4% and it is expected that the demand for charcoal

in the next 20 years may exceed 500,000 by 2030 (World Bank, 2019). Montserrado County has witnessed over the years an unprecedented increase in the number of households (MCDA, 2012). Liberia's National Energy Policy has estimated that about 95% of Liberia's population relies on biomass energy for cooking (MCDA, 2012). Hence, to bridge this gap, non-economic factors need to be incorporated into the model to test the statistical significance of these variables to household charcoal consumption. Therefore the current study intends to look into factors related to household charcoal consumption in Montserrado County, Liberia. The current study should help to understand the factors influencing charcoal consumption among households in the study area. Moreover, the findings of this study are consistent with the twelfth goal among the 17 Sustainable Development Goals which is responsible consumption and production, to achieve sustainable management and efficient use of natural resources by 2030 (UN, 2015). Furthermore, the findings of this study are in line with the Liberia Forest Sector Project (2016 – 2023) whose key issue is to produce and consume charcoal from sustainably managed community forests (World Bank, 2016). The results of the study also offer suggestions to the policy formulation organs on adequately forest sustainability.

Objective of the study

Main objective

To evaluate factors related to household charcoal consumption in Montserrado County, Liberia

Specific objectives

To assess socio-economic factors related to household charcoal consumption. To assess the challenges associated with household charcoal consumption.

Methodology

Description of the study area

Montserrado County (Fig. 1) is the oldest county in the country, almost as old as the Republic of Liberia itself. Montserrado County is a county in the northwestern portion of the West African nation of Liberia containing its national capital, Bensonville.

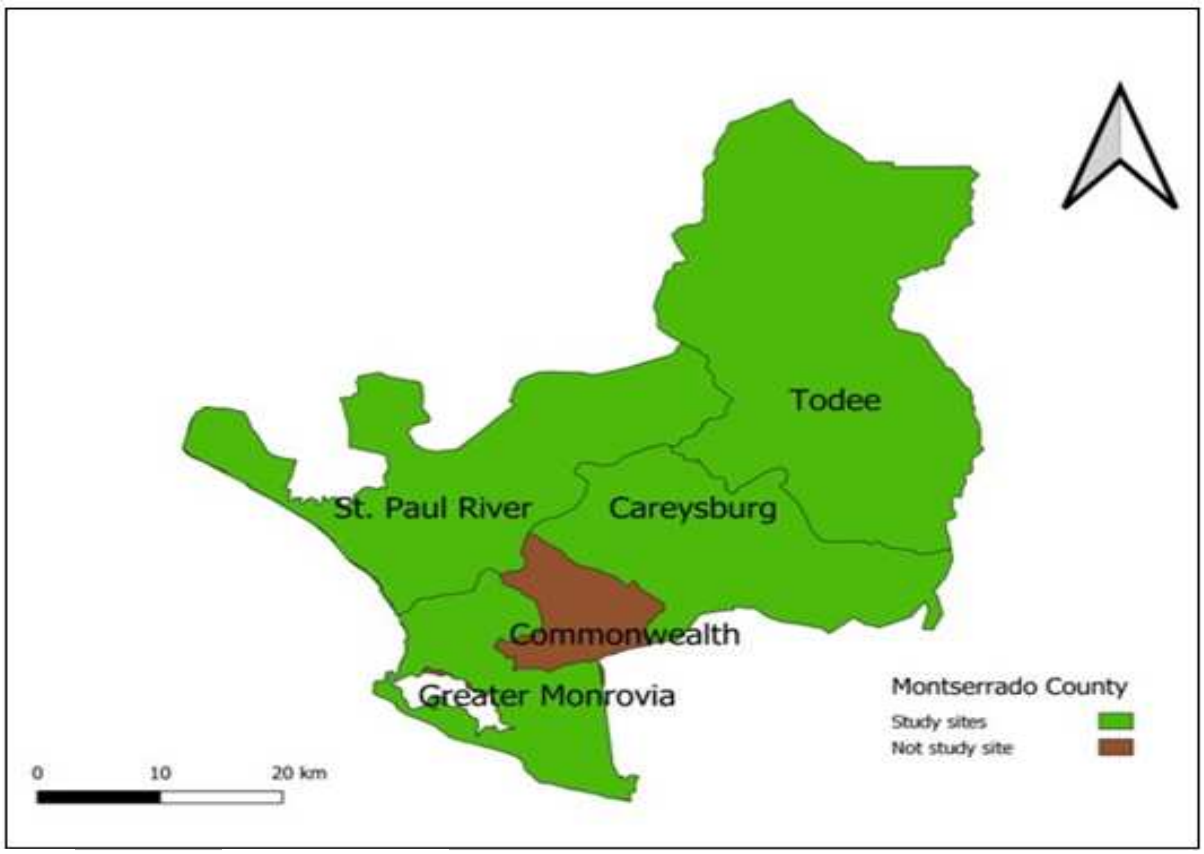

Fig. 1. Map showing Montserrado County.

The county is bounded South by the Atlantic Ocean, Bong County on the North, Bomi County on the West and Margibi County on the East. Montserrado County is susceptible to a massive exodus of people seeking government jobs, and successful business because it is the commercial hub, and a place dominated by almost all 16 tribes of Liberia. It has two main climatic conditions, the rainy season from May to November and the Dry season between December to February. The average temperature ranges between 21 and 36°C with an annual average rainfall of about 1905mm (MDA, 2012).

Montserrado is the smallest county by size, but the largest in a population comprising approximately 33% of Liberia's total population. The primary reason for choosing Montserrado County as the study area is because of the high population and per capita charcoal consumption. The county accounts for about (65%) of the total demand for charcoal (LFSP, 2019). Hence, the demand is more than ten times greater than in any other county in Liberia.

Research design

The cross-sectional research approach was used in the current study as it allowed for the collection of comparable data from family households who use charcoal for cooking at once (Neuman, 2014). The design was chosen because it is affordability, relatively quick to conduct and permits significantly faster data collection without compromising data quality (Setia, 2016).

Sampling techniques and sample size

A combination of multi-stage sampling and purposive sampling was used. At stage one, Montserrado County was purposively selected.

At stage two, Specific household heads from the four selected districts of Montserrado County (Table 1) were selected through purposive sampling so as to get a specific household who are charcoal users. The sample size was determined according to Boyd *et al.* (1981) where the intensity of 10% from every sampling frame.

Data collection

Primary data were collected from respondents using a pre-structured questionnaire with both open and closed-ended questions. Further, ten focus group discussions (FGD) were conducted, the FGDs involved 15 participants comprising elders, community leaders, student representatives, women, and youth leaders. A total of 150 participants were involved in these discussions. To ensure the validity and reliability of the collected data, the data-gathering tools were pre-tested in the study area, before the actual data collection to guarantee familiarity and clarity. Collected data during the piloting the data collection tool were not included in the study's final analysis.

Data analysis

Quantitative data collected through the questionnaires were analyzed using the Statistical Package for Social Sciences (SPSS version 20) whereby both descriptive (frequencies and percentages) were determined. A multiple linear regression model was used to estimate the correlational relationship between household charcoal consumption, and socio-economic factors. Differences or associations between variables were considered statistically significant if the p-value was ≤0.05. For the case of qualitative data that was collected through FGDs, content analysis was used, whereby the answers from the members were categorized into meaningful themes.

Results and discussion

Respondent's demographic and socio-economic characteristics

Demographic and socio-economic characteristics of the respondents show that majority of the respondents (57%) were males while (43%) were females (Table 2). Farsi *et al.* (2007) indicated that female-headed households are statistically significant due to the fact that charcoal utilization and daily household food preparations are in the preview of women. These studies were consistent with Mekonnen and Kohlin (2009) who postulated that the probability of female-headed households

consuming either charcoal or a mix of solid and non-solid fuel was high. Charcoal consumption could experience a downward consumption trend if alternative energy sources were available, accessible and reliable in Montserrado County. Results showed that respondents with ages between 36-60 years were active groups constituting about 57% of charcoal actors. This was followed by ages ranging between 0 - 34 years consisting of about (35%) of charcoal users and lastly the group of ages above 60 years which constituted 8.8% of the charcoal users. This shows that most of the charcoal consumers were in middle age consistent with Liberia's demographic dividend as enshrined in the National Development Agenda (PAPD, 2018) where about (53%) of the population are between the ages 15 – 64 years constituting the working age. These are income earners who have the financial capability to purchase at will.will power to the energy market system.

Table 1. Sampling frame and sample size.

County	District	Study population (Sampling frame)	Sample size (n)
Montserrado	Greater Monrovia	1500	150
	Careysburg District	900	90
	Todee District	900	90
	St. Paul River District	560	56
	Total		386

Results further indicate that majority (42%) of the respondents were married. These homes were better organized and optimistic about improving their energy strategies if electricity was affordable and reliable. On the other hand, about (29%) of the respondents have attained a college-level education. These respondents are literate (Venance *et al*., 2016). Literate charcoal actors are assumed to have a better understanding of sustainable practices on charcoal consumption (Emana *et al*., 2017) and can easily adopt new, efficient and modern environmental cooking technologies contrary to those without any formal education who are less informed and less likely to adopt new cooking technologies.

Household size was also a major socio-economic factor. Results show that the majority of the respondents (48%) had a household size of more than 6 people. This implies that households in the study areas comprised more people, hence, the per capita charcoal consumption is likely to be higher than in other counties. This is consistent with the study done by Venance *et al.* (2016) who reported that the higher the household size the more likely the source of energy is consumed. Furthermore, the descriptive analysis shows that about (40%) of the respondents were not employed (Table 2). This suggests that the majority of the household in the study area have low or no income at all and hence adopting an alternative source of energy apart from charcoal is a bit challenging for them. Notwithstanding, household heads with comparatively high incomes engaged in inter-fuel stacking.

Factors influencing household charcoal consumption

A multiple linear regression model was used to determine factors influencing household charcoal consumption. Explanatory variables included age of household, marital status, education level, income, household size, number of meals and the price of charcoal. The actual estimates of causal effects were obtained by using these control variables (Hunermund and Louw, 2020). Results in (Table 3) show that no variables had a tolerance value (>1) and VIF value (> 10). This observation confirms that there was no violation of the multicollinearity assumption in this current study as stipulated by Pallant (2011). In addition, the Durbin-Watson's d tests were used to test for auto-correlations. The results showed that the Durbin-Watson's is 1.78 for the full which falls within the values of $1.5 < d < 2.5$, implying that there is no auto-correlation (Kutner *et al.* 2005). Hence, there is no auto-correlation in the multiple linear regression data. The coefficient of determination (R^2) in the regression model for the full sample was 77.1% (Table 1.3).

Table 1. Respondents Demographic and Socio-economic Characteristics (n = 386).

Characteristic		Frequency	Percentage
Sex	Male	220	57
	Female	166	43
Age	0 – 35 years	134	34.7
	36 – 60 years	218	56.5
	Above 60 years	34	8.8
Marital status	Single	153	39.6
	Married	161	41.7
	Divorced	24	6.2
	Widow	43	11.1
	Cohabitation	5	1.3
Education Level	Illiterate	85	22
	Elementary	33	8.5
	Junior high	54	14
	College	113	29.3
	University	95	24.6
	Post graduate	6	1.6
Household size	Less than 3	57	14.8
	Between 3 – 6	144	37.3
	Above 6	185	47.9
Occupation	Not employed	152	39.4
	Employed	137	35.5
	Entrepreneur	97	25.1

The linear regression results in (Table 3) show that on average, the price of charcoal was statistically significant ($p < 0.001$) with household's charcoal consumption. However, it had a negative beta coefficient of 0.14. A one-unit increase in price will decrease households' consumption of charcoal by 0.14kilograms ceteris paribus, consistent with the demand theory of consumption. However, the nature of the product and its significant role in residential energy use in Montserrado County, households still consume charcoal irrespective of the increase in price. This implies that if there are alternative energy sources that are cost-effective and maximize consumers' satisfaction domestically, the probability of linear switching is likely by households. This will reduce the consumption of charcoal, thus saving the environment and the tropical forest. However, it was not statistically significant in the sub-samples representing the districts separately. The finding is consistent with the finding by Nyembe, (2011) who reported in his findings that the price of charcoal was negatively related to household's charcoal consumption that is when the price of charcoal rises majority of the households' switches to other energy sources which are cheaper and affordable than using the same energy source at a higher price. A similar finding was reported by Babaola and Opii (2022), Mekonnen and Kohlin (2008) and Nur, (2021).

Table 3. Regression results of full sample and the four districts.

Variables	Full sample (n = 386)		Greater Monrovia (n = 150)		St. Paul River (n = 56)		Careysburg (n = 90)		Todee (n = 90)	
	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B
Age	0.391	0.37	0.905	0.007	0.939	-0.011	0.563	0.077	0.958	0.007
Marital status	0.486	-0.04	0.907	-0.04	0.328	0.090	0.107	-0.122	0.417	0.063
Household size	0.04*	0.103	0.114	-0.71	0.156	0.216	0.002***	0.411	0.000***	0.606
Price of charcoal	0.000***	-0.14	0.370	-1.38	0.950	0.014	0.062	0.266	0.062	-0.274
Monthly income	0.208	-0.04	0.013*	0.667	0.096*	-0.012	0.007***	-0.03	0.851	0.0128
Education level	0.004***	-0.20	0.000****	-293	0.126	-149	0.432	-0.57	0.801	0.015
Number of meals per day	0.002***	0.123	0.541	0.047	0.030*	-328	0.000***	0.387	0.001***	0.426
R^2	0.771		0.56		0.42		0.33		0.4	

However, the energy deficit scenario in Liberia has constrained households to perpetually consume charcoal at a higher price due to scarcity of the alternative energy sources. With the current situation in Montserrado County and on a per-district level, consumers are not exposed to alternative energy sources where the market system allows them to freely choose at an optimal level at minimum cost.

Household size was statistically significant with charcoal consumption and also exhibit a positive relationship with a coefficient of 0.103kilograms. This implies that a one-unit increase in the size of the household results in an increase in the household's charcoal consumption by 0.103kilograms. Moreover, the size of the family determines the quantity of food cooked and the quantity of charcoal to be used. Earlier stated, Montserrado County is the official set of National government that continues to experience an increase in population which has affected household size. This implies that if proper decentralization of major economic activities is initiated by the Central government, household size will be at a minimum level, thus affecting charcoal consumption negatively. Comparatively, similar results were also observed in the two sub-samples districts of Todee and Careysburg while the remaining two districts had different results. Greater Monrovia exhibited a positive relationship even though it wasn't statistically significant. St. Paul River district results on household size were neither significant nor had a positive relationship. Similar findings to the full sample were reported by Hetberg (2003) and Mekonnen and Kohlin (2009). They found out that households with large family sizes were more likely to consume charcoal and wood and less likely to consume kerosene, gases and other alternative sources of energy. Furthermore, the findings by Kyrereh *et al.* (2019) reported that households with a greater number of males are considered to be active members and can produce more volume of charcoal than households with fewer numbers. Household size is a crucial factor in determining the consumption of charcoal since the increase in household size affects the ability of households to move to cleaner fuels.

Results on the number of meals (Table 3) are statistically significant with household's charcoal consumption and it shows a positive relationship. Results from the analysis show that households' charcoal demand sensitivity to changes in the number of meals per day are positively correlated.

A one-unit increase in the number of meals per day leads to an increase of 0.123 kilograms of charcoal in a specific household. Comparing the results of the full sample to the sub-samples of the district it can be observed that results are similar with the exception of the Greater Monrovia district which the number of meals was not statistically significant but similarly had a positive relationship. Similar results were reported by Sabuhungu *et al.* (2015) and Babalola and Opii (2013) that the number of meals per day increases charcoal consumption. Greater Monrovia district has comparatively better infrastructure as compared to the other districts. Moreover, the socio-economic and demographic characteristics of household heads in Greater Monrovia district are fairly good as compared to the other districts. Household heads have better market information and are exposed to other alternative energy sources as compared to the other districts.

Table 4. Challenges on charcoal consumption.

Challenge experienced	Frequency	Percentage
High price	252	22.7
Low quality	239	21.6
Dirtiness of homes	233	21
Limited supply	218	19.7
Long distance	166	15

Further results on education level (Table 3) show that it is statistically significant with household's charcoal consumption, but however results from the analysis show a negative relationship between education level with charcoal consumption. This implies that when a household head advances in education by one unit, household charcoal consumption declines by 0.2kilograms holding all other factors constant. Hence the more educated household heads the more the awareness of using environmentally friendly energy sources therefore the less charcoal consumption. However, only Monrovia District had similar results to the general sample while the remaining districts had insignificant results on education level. The finding is consistent with the findings by Yusuf *et al.* (2021), Paudel *et al.* (2016) and Dagnachew *et al.* (2019) that level of education knowledge has an impact on charcoal consumption, household heads with higher education are more likely to be economically capable and less likely to consume of charcoal. Conversely, household heads with no formal education are more likely to consume traditional fuel and less likely to adopt energy-efficient technology. This implies that education has the ability to influence fuel choices thus making the energy transition process from inferior energy to superior and clean energy easy. However, findings by Zulu and Richardson, (2013) argued that access to a high level of education with poor income yet has no impact on charcoal consumption. Therefore, for energy security, most households practice a fuel-stacking strategy in the wake of uncertainties.

Other factors such as the age of the household, marital status and income were not statistically significant in the household's charcoal consumption. But compared with the district level separately, three Districts of Greater Monrovia, and Careysburg for the aspect of income were statistically significant with positive and negative relationships. In general, considering the full sample, results (Table 3) on income show a negative relationship with charcoal consumption. That is to say, a one-unit increase in household disposable income declines the consumption of charcoal by 0.039kilograms.

This implies that those households with higher incomes will automatically gravitate to the available superior energy sources. Although the finding was not statistically significant they are consistent with the energy ladder hypothesis that household income influences their ability to purchase superior energy sources (Van der Kroon and Van Beukering, 2013). Furthermore, different studies have reported similar findings Baland *et al.* (2018) and Mperejekumana *et al.* (2021) that household income affects the readiness to adopt and use modern cooking technologies.

This implies that this result, like other studies, discounts the energy ladder theory and thus considering other factors in the model will help in understanding those relevant influencing variables that are affecting household charcoal consumption in Montserrado County, especially with income in disposable income.

The age of the head of household had a positive relationship with charcoal consumption but was not statistically significant in the model. As the age of the head of household increases the consumption of charcoal increases by 0.37kilograms. The marital status of the respondents was not statistically significant and had a negative relationship. Meaning that marital status had no influence on charcoal consumption.

Challenges in consuming charcoal

Multiple response analysis results show different challenges experienced by charcoal users (Table 4). The first reported challenge that was common for the majority of the respondents was the high price of charcoal which accounted for nearly a quarter (22.7%) of the respondents. Findings in a study by Nabukalu and Giere (2019) showed that charcoal pricing depends on better quality and origin. Charcoal from different areas comes with different prices and hence, better quality charcoal is compromised with a higher price in the study area. Notably, there are those consumers who prefer soft charcoal due to its lower price and the fast rate at which it burns while others prefer hard charcoal because they consider it more economical with a slower burning rate. However, the Norconsult Tanzania Limited report of 2002 revealed that the cost of charcoal varies slightly depending on the particular season, during the rainy season price of charcoal is higher and it lowers during the dry season. Furthermore, the study by Sankhayan and Hofstad, (2000) on production and spatial price differences for charcoal revealed that there is no statistical evidence of price increase or decrease with distance. Therefore, the price of charcoal is not only influenced by one factor but the price fluctuates depending on various reasons as explained by the previous studies explained above. Low quality of charcoal was the second mentioned challenge with accounted (for 21.6%) of the respondents, whereby low quality of charcoal was seen as an obstacle in the consumption of charcoal for daily uses (Table 4). Findings by Nabukalu and Giere, (2019) show that the quality of charcoal depends on the price used to purchase charcoal. Lower prices result in low quality however, due to some topographical aspects there may be some charcoal wood varieties that are of low quality in nature. Moreover, the limited supply of charcoal was another challenge due to the natural and artificial scarcity of charcoal. Some producers engage in hoarding in order to create artificial scarcity, thus increasing prices arbitrarily for their own financial gains. Nabukalu and Giere (2019) believe that scarcity of charcoal arises sometimes due to some ecological reasons such as exceeded deforestation which prohibits charcoal producers from cutting down trees over a period of time hence resulting in inadequate supply. However, Branch and Tiitmamer, (2022) reported in the literature that charcoal production will cease due to the ongoing global effort to ensure reliable and sustainable energy for all meeting the 7th Sustainable Development Goal. Similarly, literature by Tippayawong *et al.* (2020) reveals that charcoal production is likely to degrade the environment hence, production should cease and the introduction of a better source of reliable energy of smokeless charcoal from plant residues which is more environmentally friendly as compared to wood charcoal. Furthermore, long distances and the dirtiness of homes as among other challenges facing the consumption of charcoal.

Conclusions and Recommendations

Based on the study findings and the discussions presented, it is concluded that education level, number of meals, price of charcoal and household size were statistically significant associated with household charcoal consumption in Montserrado County**.** Education level plays a significant role in the consumption of charcoal. Most households prefer charcoal as compared to alternative energy sources due to its affordability, reliability and accessibility. Households with a higher level of education, income and better social status tend to engage in energy stacking strategy compared to those of lower socioeconomic status in Montserrado County. Household size largely influenced the quantity of charcoal to be used. Further, the high price of charcoal, low quality of charcoal and dirtiness of homes were the top three challenges affecting charcoal consumption in the study area. Due to urbanization, population expansion and non-economic factors, household charcoal consumption may rise further if programs to enhance sustainability are not initiated and enforced. Charcoal usage directly contributes to deforestation and forest degradation. This research recommends that national government institute policies the will promote, support and enforce the use of alternative energy sources like gas,

solar and coal briquettes which are clean and low-carbon emitters than charcoal and introduce customized programs for sustainable production and consumption of charcoal.

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References

Abdollahi M, **Hossein A**. 2014. Charcoal. Encyclopedia of Toxicology, Third Edition, 2014, 779–781**,** visited on 16/08/22. http://dx.doi.org/10.1016/B978-0-12-386454-3.00685-0

Amugune IM. 2020. Technological factors influencing the quality and quantity of charcoal produced in western Mau forest. Unpublished Dissertation for Award of Degree of Doctor of Philosophy at Africa Nazarene University, Kericho County. Kenya 1 - 60.

Babalola F, Opii EE. 2022. Factors influencing consumption of charcoal as household energy in Benue State, Nigeria. *I*nternational Journal of Organic Research and Development **6(1),** 68-81, visited on 16/08/22 https://www.researchgate.net/publication/282152027

Baland J, Bardhan P, Bowles S. 2018. Cooperation and Enviromental Sustainability. Princeton University Press, Princeston, NJ, USA, 246 – 273

Branch A, Tiitmamer N. 2022. From crisis to context: Reviewing the future of sustainable charcoal in Africa. Energy Research and Social Science **87,** 12.

Dagnachew AG, Hof AF, Lucas P, Van Vuuren DP. 2019. Scenario analysis for promoting clean cooking in sub-Saharan Africa: Costs and benefits. Energy, 192. http://dx.doi.org/10.1016/j.energy.2019.116641

Dam JV, Eijck J, Schure V, Zuzhang X. 2017. The Charcoal Transition: Greening the Charcoal Value Chain to mitigate Climate Change and Improve Local livelihoods, FAO, Rome, Italy, 184.

Emana B, Afari-Sefa V, Nenguwo N, Ayana A, Kebede D Mohammed H. 2017. Characterization of pre-and postharvest losses of tomato supply chain in Ethiopia. Agriculture and Food Security **6,** 1-11.

Flias RJ, Victor DG. 2005. Energy Transitions in Developing Countries: A Review for assessing household energy use. Energy for Sustainable Development **17,** 127-137, visited 14/08/22. https://www.mdpi.com/2571-8797/1/1/6/pdf

Goll II, Nick B, Li J, McKay J, John S. 2014. Analysis on the Causes of Deforestation and Forest Degradation in Liberia. Research Journal of Agriculture and Forestry Sciences **2,** 20-30, visited 14/08/22. www.isca.me

Hunermund P, Louw B. 2020. On the Nuisance of Control Variables in Regression Analysis. Available at visited on 12/08/2022. https://arxiv.org/pdf/2005.10314.pdf

Kowsari R, Zerriffi H. 2011. Three-dimensional energy profile: A conceptual framework, visited 16/08/22. https://doi.org/10.1016/j.enpol.2011.06.030

Kyrereh B, Hansen CP, Pouliot M, Brobbey K. 2019. Factors influencing participation and income from charcoal production and trade in Ghana. Energy for Sustainable Development **50,** 69-81, Liberia. 239, visited 20/09/22.
https://doi.org/10.1016/j.esd.2019.03.003

LFSP 2019. Liberia Forest Sector Project. Opportunities for Charcoal and Sustainable Forest Management. World Bank. 40, visited 12/06/22.
http://documents.worldbank.org/curated/en/145661549384956090/Opportunities-for-Charcoal-and-Sustainable-Forest-Management

MCDA, 2012. Monsterado County Development Agenda. Economic Affairs.

Mperejekumana P, Li H, Wu R, Lu J, Tursunov O, Elshareef H, Gaballah MS, Nepo N.J, Zhou Y, Dong R. 2021. Determinants of household energy choice for cooking in Northen Sudan: visited 28/09/22.
https://doi.org/10.3390/ijerph182111480

Nabukalu C, Giere R. 2019. Charcoal as an energy resource: Global trade production and socio-economic practices observed in Uganda. Resources, **8(183),** 1 – 27, visited 18/08/22.
https://www.mdpi.com

NTL 2002. The true cost of charcoal: A rapid appraisal of the potential economic and environmental benefits of substituting LPG for charcoal as an urban fuel in Tanzania, 56 p, visited 18/08/22.
http://coastalforests.tfcg.org/pubs/NORConsult_charcoal_vs_LPG.pdf

Nur AA. 2021. Factors influencing on charcoal production in lower Shabelle region of Somalia. Global Scientific Journals **9(6),** 1371- 1386.

Nyembe M. 2011. An econometric analysis factors determining charcoal consumption by urban households: The case of Zambia. Thesis for award of MSc. degree at Swedish University of Agricultural Sciences. 92 p, visited 14/08/22.
https://stud.epsilon.slu.se/2274/1/nyembe_m_110214.pdf

Nyoni J. 2014. Knowledge, Attitude and Perception Study of the Biomass Energy Sector. Final report submitted to the Swiss Agency for Development and Cooperation Swiss Cooperation Office, Dar es Salaam, Tanzania. 132 p, visited 10/07/22.
https://www.ajol.info/index.php/tjfnc/article/view/140809/130545

Oladeji S, O Ologunwa, OP, Tonkollie BT. 2018. Socio-economic impact of traditional technology of charcoal production in Kpaai District-Bong County Liberia. Environmental Management and Sustainable Development **7(2),** 86, visited 18/08/22.
https://www.macrothink.org/journal/index.php/emsd/article/view/11770

Pallant J. 2011. SPSS survival manual: A step by step guide to data analysis using the SPSS program. 4th Edition, Allen & Unwin, Berkshire.

Paudel U, Khatri U, Pant KP. 2018. Understanding determinants of household cooking fuel choice in Afghanistan: A multinomial logit estimation. Energy **156**, 55-62, visited 27/09/22.
https://ideas.repec.org/a/eee/energy/v156y2018icp55-62.html

Pussinen A, De Jong BHJ, Mohren GMJ. 2003. Modeling carbon sequestration, visited 18/08/22.
https://www.sciencedirect.com/science/article/abs/pii/S0304380002004192

Sabuhungu EG, Ndimanya P, Lebailly P. 2015. An analysis of the urban consumption of charcoal by household: The case of the city of Bujumbura in Burundi. International Review of Research and Emerging Markets and the Global Economy **1(3),** 430-442, visited 17/08/22.
http://globalbizresearch.org/files/6017_irrem_sabuhungu-emery-gaspard_ndimanya-patrice_lebailly-philippe-154348.pdf

Sankhayan PL, Hofstad O. 2000. Production and Spatial Price Differences for Charcoal in Uganda. Journal of Forest Research **5,** 117-121, visited 10/08/22.
https://www.tandfonline.com/doi/abs/10.1007/BF02762389

Suliman KM. 2010. Factors affecting the choice of households' primary cooking fuel in Sudan. In Research Report Presented to the Economic Research Forum, visited 10/08/22. https://erf.org.eg/programs/factors-affecting-the-choice-of-households-primary-cooking-fuel-in-sudan/

Tippayawong KY, Panyakom S, Suriyanarakorn C, Wiratkasem K. 2020. Supply chain analysis of smokeless charcoal from maize residues. Energy Reports **6**, 60 – 66, visited 15/08/22. https://www.econstor.eu/bitstream/10419/243858/1/169316955X.pdf

UN. 2015. The Millennium Development Goals Report. 73pp. Available at visited on 16/08/2022. https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf

UN. 2021. World Population Prospects 2019. Available at accessed on 15/08/2022. https://statisticstimes.com/demographics/africapopulation.php#:~:text=Africa%20has%20been%20the%20fastest,annual%20growth%20rate%20of%202.87%25

Van der Kroon B, Van Beukering PJH. 2013. The energy ladder: Theoretical myth or empirical truth? Results from meta-analysis. Renewable and Sustainable Energy Reviews **20(12),** 504-513.

World Bank. 2016. Liberia Forest Sector Project. Available at visited on 16/08/2022. https://projects.worldbank.org/en/projects-operations/project-detail/P154114?lang=en)

World Bank. 2018. Liberia: Country Forest Note January 2018 Environment and Natural Resources Global Practice, 59 p.

World Bank. 2019. Liberia Forest Sector Project Opportunities for Charcoal and Sustainable.

Yusuf FA, Kusin MF, Kpalo SY. 2021. Knowledge, attitude and practice regarding charcoal consumption among households in Sanag Province, North-Eastern Somalia. Sustainability **13,** 2084, 1 - 13 p, visited 16/08/22. https://www.mdpi.com/2071-1050/13/4/2084

Zulu LC, Richardson RB. 2013. Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa. Energy for Sustainable Development **17(2),** 127-137, visited 10/08/22. https://www.researchgate.net/publication/257434437_Charcoal_livelihoods_and_poverty_reduction_Evidence_from_sub-Saharan_Africa