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Research Article

Understanding the determinants of household cooking-fuel choice in sub-Saharan Africa: evidence from Nigeria

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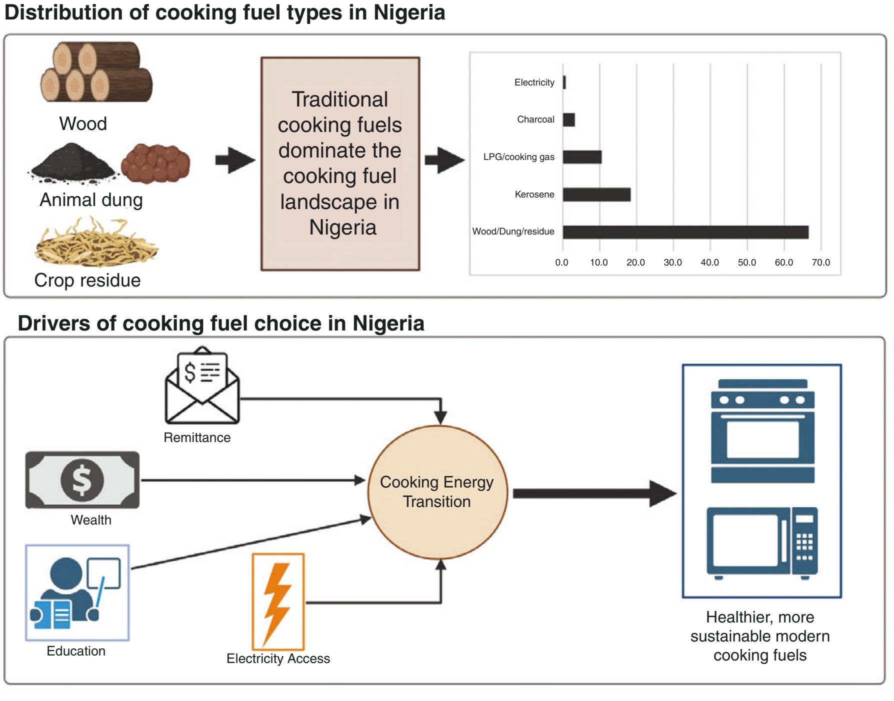
Abstract

Overreliance on traditional cooking fuels by agricultural households poses a significant obstacle to achieving the United Nations Sustainable Development Goal 7 by 2030 in Nigeria. Despite the emerging recognition of remittances as a crucial factor influencing cooking-fuel choices in the energy-transition literature, there is a paucity of studies examining this influence in Nigeria. Using data from 4400 agricultural households sourced from the fourth wave of the Nigerian Living Standard Measurement Survey data sets, this study examined the influence of remittances on cooking-fuel choices, among other factors in Nigeria. Employing descriptive statistics and the multinomial logit regression model, the analysis reveals that traditional cooking fuels, including wood, crop residue and animal dung, continue to dominate the cooking-fuel landscape. The empirical result of the multinomial logit model showed that households that receive remittances are more likely to use modern cooking fuels. Furthermore, wealthier, more educated households with access to electricity are more likely to use modern and transitional cooking fuels than traditional cooking fuels. Based on the findings, the study suggests the incentivization of remittances into the country through the reduction in associated transaction costs and accelerated public infrastructural investment in affordable electricity and good road networks to connect rural areas to gas-supply networks to drive the transition to modern cooking energy. Additionally, educational and awareness campaigns about the health risks associated with traditional cooking energy, particularly indoor air pollution, should be encouraged, especially in rural areas.

Graphical Abstract



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Introduction

By the year 2030, it is expected that no one will be left behind in accessing clean and affordable energy across the globe. This assertion is canonized by the United Nations Sustainable Development Goal (SDG) 7, which seeks universal access to clean and affordable energy by 2030. Specifically, the SDG indicator 7.1.2 focuses on the proportion of the global population relying on clean fuels and technologies for cooking. However, despite various initiatives such as the promotion of investment in solar, wind and thermal power [1] to transition into sustainable energy sources, the successes recorded remain uneven across the globe as the lack of access to clean cooking fuels is more prevalent among developing countries, most especially in the sub-Saharan African (SSA), Southeast Asia and Western Pacific regions [2]. As of 2021, ~2.3 billion people globally lacked access to clean fuels and technologies for cooking, with ~40% in SSA and ~55% in the Asian region [3]. Furthermore, it was reported [4] that household air pollution created by using dirty cooking fuels and technologies resulted in the death of an estimated 3.2 million people globally in 2020, including >230 000 deaths of children <5 years old. Thus, closing households' clean energy gap globally and ensuring adequate access to reliable clean and modern cooking fuels is one of the priorities of the UN as encapsulated in SDG 7.

The SSA region is perceived to be taking a backseat regarding progress towards achieving the set target for SDG 7 by 2030. Available statistics show that the region accounted for ~19% and ~40% of the global population without access to clean cooking fuels and technologies in 2010 and 2021, respectively [3, 5]. This implies that people without access to clean cooking fuels increased from 750 million in 2010 to 900 million in 2021 [5]. This trajectory was attributed to the differentials in the population growth rate (2.5% per annum) and the rate of change in the population with access to clean fuels, which was <0.3% [6]. Another report [5] further emphasized that, if the current trend continues, >1.9 billion people will remain without clean energy by 2030, with sub-Saharan Africa accounting for 57.89% (1.1 billion) of this number. The region's lack of access to clean and efficient cooking energy exacerbates the existing high poverty level, food and nutrition insecurity, environmental degradation and air pollution, ultimately contributing to the negative consequences of climate change [6]. The reliance on dirty cooking fuels puts the greatest health burden on women and children by exposing them and other household members to non-communicable diseases, including stroke, ischaemic heart disease and eye itching [4]. In 2019, an estimated 1.1 million (16.3%) deaths in Africa were caused by air pollution [7], thereby making air pollution the second-largest cause of death in Africa [8] after AIDS.

Nigeria has the largest population and remains the biggest economy in Africa. Since the inception of this millennium, the Nigerian economy has enjoyed a rapid growth rate up to 2014 at an average of ~6% per annum [9]. Despite this performance, the benefit of economic growth on the livelihood and well-being of Nigerians remained uncertain. About 62.9% (133 million) of the Nigerian population are multidimensionally poor, with 7 out of 10 people living in rural areas being multidimensionally poor [10]. Also, Nigeria is geographically bequeathed with ample energy sources varying from fossil fuels, hydropower, uranium, biomass and other renewable resources such as thermal, wind and solar [11]. Nigeria is the top producer of crude oil in Africa and has an estimated 187 trillion cubic metres reserve of liquefied natural gas. Yet, only ~16.8% of the population has access to modern cooking-energy technology [12]. Given that Nigeria is one of the countries with the highest population growth rate in the world and is projected to be the third largest by 2050 [13], its role in attaining the 2030 SDG targets in sub-Saharan Africa cannot be overemphasized.

This research is carried out to examine the factors influencing cooking-fuel choices among agricultural households in Nigeria. This has become necessary because of the need to shift to cleaner or modern cooking energy to achieve SDG 7 in Nigeria. We focus on agricultural households because agricultural households constitute most of the national labour force and are identified as one of the most vulnerable to vagaries of climate impacts, food insecurity and multidimensional energy poverty in Nigeria [14–16]. Building on previous studies that have explored the factors influencing cooking-fuel preferences in Nigeria, such as income, wealth, household socio-demographic characteristics such as education and household size, among others [17–19], and cooking-fuel accessibility [11], this study contributes to the existing literature on two main fronts.

First, using the most recent nationally representative agricultural household data, this study examines the influence of remittances on cooking-fuel choice in Nigeria. As defined by the International Monetary Fund (IMF) [20], remittances are 'household income from foreign economies arising mainly from the temporary or permanent movement of people to those economies'. Official estimates show that Nigeria is the largest recipient of remittances in sub-Saharan Africa, averaging $21 billion yearly between 2018 and 2022, and accounting for about a third of total inflows into the region [21, 22]. Literature suggests that these remittances are important as economic support for consumption and investment (including but not limited to cooking-fuel expenditure) for households that receive them [23]. However, while remittances are emerging as a crucial factor influencing cooking-fuel choices in the energy-transition literature [24, 25], there is a paucity of studies examining this influence specifically in the context of Nigeria. Considering the significant role of remittances in Nigeria's development context, it has become imperative to examine its role in household cooking-fuel choices.

Secondly, this study departs from the existing studies on cooking-energy preference in Nigeria [11, 26, 27], sub-Saharan Africa and other developing countries [28–31] that focused on analysing the specific types of fuels used, such as kerosene, liquefied petroleum gas (LPG), biomass, charcoal and firewood, among others. This study advanced the analysis by categorizing the types of fuels into traditional, transitional and modern fuels, consistently with the energy-ladder hypothesis [32, 33]. This is important because the goal of policy is to cause a shift from undesirable and unsustainable traditional cooking fuels towards healthier, more sustainable modern fuels. Thus, it is important to understand the factors influencing household choices in each category and craft policies that effectively drive the desired transition.

The findings of this study will be of particular interest to various stakeholders, including the Nigerian government, policymakers, donor agencies and civil societies working towards achieving SDG 7 by 2030 in Nigeria. Specifically, this study seeks to provide answers to the following research questions:

- Does remittance influence households' choice of cooking fuel?
- What other factors drive households' choice of cooking energy (traditional fuels, transitional and modern fuels)?

The rest of the paper is organized into four sections. The next section presents a review of relevant theories on the determinants of household cooking-fuel choices. Section 2 describes the data used for the study, the methods employed to analyse the data and summary statistics. Section 3 discusses the main empirical results. The last section concludes and provides recommendations.

1 Literature review

The economic theories underpinning this research work are the theories of household energy fuel choice and consumer behaviour. The household energy fuel choice theory is based on the energy-ladder model and energy fuel-stacking model. The energy-ladder model argues that households' choice of cooking fuel is primarily influenced by household wealth or income in a unidirectional manner [11]—that is, as household wealth increases, households tend to linearly switch from the use of traditional fuels (biomass) to transitional fuels (kerosene, coal and charcoal) and then to modern fuels (LPG, electricity and natural gas) [28, 34, 35]. However, the core assumption of the energy-ladder model, which is about the complete switch from traditional fuels to modern fuels as household income or wealth increases, has come under criticism, leading to the energy fuel-stacking model [11, 36].

The fuel-stacking model, on the other hand, argues that households may use a combination of fuels and partly switch to other fuels rather than making a complete switch [36]. Importantly, it emphasizes the role of other factors, such as cultural, social and environmental issues, in addition to household wealth or income, in explaining household choice of cooking energy. This is corroborated by findings from existing works which show that energy choice may be a function of factors such as distance to market, access to electricity, geographical location and rural–urban migration, amongst others [29, 31, 34, 37, 38]. This suggests that factors other than income or wealth should be considered when determining the factors influencing households' cooking fuels.

The cooking-fuel preference of households is generally modelled to follow the seminal works of [39, 40] on consumer theory, which posit that consumers derive utility from the attributes embedded in a good rather than the consumption of the good itself. Inferring from this and literature including [26, 32], we deduce that economic and non-economic constraints influence households' preference for a cooking fuel over alternative options. Examples of economic constraints include factors such as the price of cooking fuel, households' income and expenditure, whilst the non-economic factors, on the other hand, include factors such as identified household location and rural–urban migration. We discuss the formulation of the consumer utility model under the section on the theoretical framework.

2 Theoretical framework

As highlighted in the preceding section, this study hypothesizes that households' cooking-energy preference follows the energy-ladder model, i.e. households switch from traditional to transitional and finally to modern fuels as household income increases. However, the influence of other factors, as emphasized in the energy-stacking model, is also investigated. Following [26], this study modelled the household cooking fuels under the general theory of the consumer behaviour framework. This theory is based on the assumption of consumer utility function, which emphasizes that consumers are faced with alternative commodities with independent utility content [41]. The theory further assumes that consumers are rational and choose the alternative with maximum utility [11, 26]. Suppose that a household choice of cooking fuels depends on a choice made from a set of j types of fuels (where $j = 1, 2, \ldots, n$). The household is assumed to derive a given level of utility from choosing any alternative type of fuel. The utility derived is not directly observed, but indirectly observed through a set of attributes of the chosen fuel type. The utility derived can be decomposed into two parts—deterministic v_i and random e_i, represented as follows:

$$\mathbf{U_i} = \boldsymbol{v}_\mathbf{i}(\mathbf{Z_j},\mathbf{S_i}) + \boldsymbol{e}_\mathbf{i}(\mathbf{Z_jS_i}) \tag{1}$$

where Z is a set of attributes of the fuel type and S represents other factors such as socio-demographic, cultural and geographical characteristics affecting household decisions. The choice of a particular fuel type over an array of alternatives is driven by the probability that the utility from the chosen fuel type is higher than the utility associated with the alternate fuel types. The probability P_{ij} for the chosen fuel type over the alternative fuel type is given as:

$$\boldsymbol{P}_\mathbf{ij} = \boldsymbol{prob}\ \left(\mathbf{U_{ij}} > \mathbf{U_{ia}}\right); \boldsymbol{a} = 1,\ 2,\ 3, \ldots, \boldsymbol{j}; \boldsymbol{a} \neq \boldsymbol{j} \tag{2}$$

where $U_{ij} > U_{ia}$ implies that, if the i-th household selects fuel type j, then U_{ij} is the highest utility obtainable from among the j possible choices.

2.1 Empirical review

The empirical review of previous works examining the link between cooking-fuel choices, socio-demographic profiles and geographical factors in Nigeria, sub-Saharan Africa and other developing regions is summarized in this section.

There is a rich menu list of empirical studies [11, 26, 27, 29, 31] on determinants of cooking fuels and energy transition in developing countries. Many of these empirical studies built the foundation of their work on two main principles (energy ladder and fuel stacking) of cooking-fuel choices, which have been widely applied in the literature. However, the debate on the most suitable principle in studying household cooking-fuel choices remains inconclusive [11, 34, 36]. For instance, there is evidence in the literature that household income or wealth, which is argued to be the main factor in the energy-ladder model [28, 34, 35], is not the only determinant of energy transition among households, most especially in developing countries (including Nigeria). Other scholarly work found socio-economic, demographic and geographic factors as determinants of energy transition among households [29, 31, 34, 37, 38].

Furthermore, a considerable amount of literature [11, 31, 42–44] modelled the household decision to switch from one cooking fuel to another based on the perceived utility derived from each of the cooking fuels following the consumer behaviour framework. In terms of the econometric model, different models have been employed to determine the factors influencing the cooking-fuel choices among households. However, it was observed that the choice of econometric methods employed in previous literature was largely driven by how the dependent variables are measured and data availability. The studies [29, 30, 35, 45] operationalized their dependent variables as dichotomous and thus employed binary regression models (such as probit and logit regressions) while [11, 26, 33, 46, 47] used models such as multinomial logit regression and multivariate regression [38, 42] to examine the determinants of cooking fuels options simultaneously. In this study, we employed a multinomial regression model.

With respect to the drivers or factors influencing the cooking-fuel choices among households, we observed that there is a long list of factors comprising gender, age of household head, household size, marital status, household head education and income [11, 26, 31, 35, 44], access to electricity [31, 44, 46], access to credit [38, 42], household geographical location [28, 38, 42], distance to the road [11, 38], distance to the market [38], wealth index [28, 45, 46] and ownership of dwellings [37, 48].

This review of empirical studies shows that some of the determinants of cooking-fuel choices are similar across the various study settings, and the various study objectives drove the differences in the econometric models employed. However, we found that most of the studies suffered from variable bias as none of the reviewed studies considered examining the influence of remittance on cooking-fuel choices among households. Our study, therefore, took a step further to close the gap and contribute to the existing literature by examining the influence of remittance on the choice of cooking fuels in Nigeria.

2.2 Materials and methods

2.2.1 *Data*

We used data from Wave 4 (2018/19) of the Nigeria General Household Survey (GHS) panel for this study. This is a nationally representative survey of agricultural households collected across the six geopolitical zones and 36 states of Nigeria (see Fig. 1). Data were collected from 4976 households across 519 Enumeration Areas. The GHS-Panel is a project conducted in partnership with the World Bank's Living Standards Measurement Study team within the Integrated Surveys on Agriculture programme. The data cover different areas that are relevant to households' well-being, main cooking energy, agriculture and community, including socio-economic characteristics, education, credit, household assets, remittances, non-farm enterprises and income-generating activities, among others. For our study, we extracted data on fuels used by households and other relevant variables. However, due to incomplete data, we utilized 4400 households for the analysis.

2.2.2 *Variables used in the study*

We describe the variables used in this article under this subsection. Frequency distributions, percentages, means, standard deviations, and minimum and maximum values are used to describe the variables.

Dependent variable.

The dependent variable is households' cooking-energy choice obtained by asking households to state their cooking-energy preference. It consists of 13 unordered cooking-energy options (see Table 1), categorized into traditional (wood, animal waste, sawdust and coal briquette), transitional (kerosene, coal and charcoal) and modern (LPG gas, piped natural gas, biogas and electricity) energy sources consistently with energy-ladder literature [32, 33].

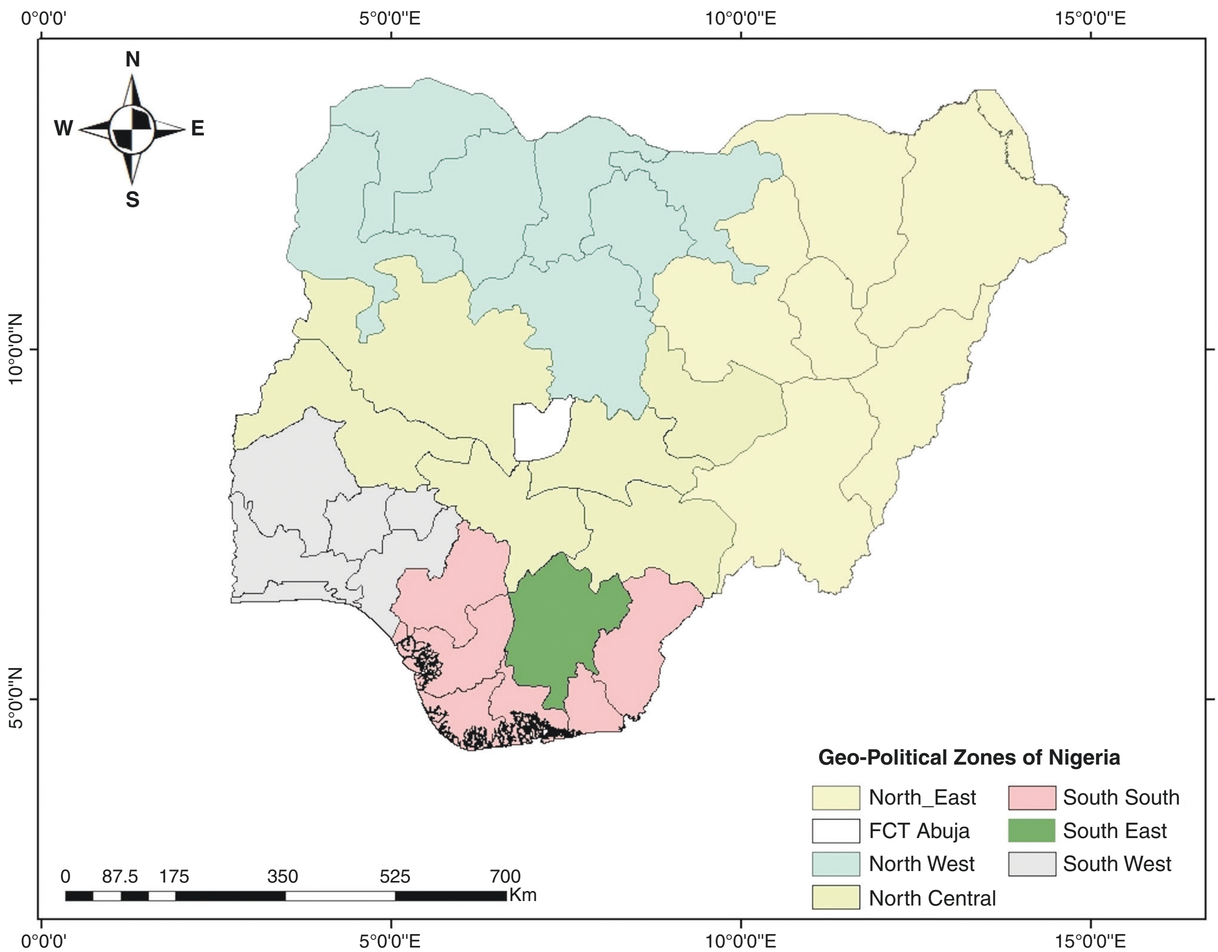

Fig 1: Map of Nigeria with geopolitical zones

Table 1: Distribution of cooking fuels used by households

Cooking fuels	Frequency	Percentage
1. Kerosene[b]	807	18.34
2. Coal/lignite[b]	3	0.07
3. Charcoal[b]	142	3.23
4. Wood[a]	2922	66.41
5. Animal waste/dung[a]	7	0.16
6. Crop residue/plant biomass[a]	4	0.09
7. Sawdust[a]	2	0.05
8. Coal briquette[a]	1	0.02
9. Processed biomass (pellets)/woodchips[a]	1	0.02
10. Biogas[c]	10	0.23
11. LPG/cooking gas[c]	463	10.52
12. Piped natural gas[c]	4	0.09
13. Electricity[c]	34	0.77
Total	4400	100.00

[a]Traditional; [b]transitional; [c]modern.

Explanatory variables.

Based on the review of the literature [11, 31, 32, 42, 49, 50] on the determinants of cooking-fuel choices in Nigeria and other developing countries and data availability in the data sets, we selected 22 household socio-economic and demographic variables, which are included in the analysis. The variables included are remittance, gender, age of household head, household size, marital status, household head education, access to electricity, access to credit, household location, distance to road, distance to market, wealth index, ownership of dwelling and the number of income-generating activities (see Table 2). These variables were operationalized differently. Variables such as remittance, gender, marital status, access to electricity, access to credit, household location, ownership of dwelling and geopolitical zone were operationalized as categorical variables, while household head education, average household education, distance to road, distance to market, dependency ratio and wealth index are continuous (see Table 2).

2.3 Analytical techniques

This section provides information on the methods employed in the study, descriptive statistics used and the econometric models adopted.

2.3.1 *Descriptive statistics*

Households' demographic information is described under the categorized set of cooking-energy choices in Table 2 using mean and standard deviation.

2.3.2 *Econometric models*

We applied a multinomial logistics (MNL) regression model to analyse the determinants of households' cooking-energy choices in Nigeria, given that the response variable has more than two measurement levels. As seen in Section 2 of this article, the underlying rationale for a household's cooking-energy preference over alternative options is to maximize households' utility. Following [31], we hypothesize that the utility a household i derives from selecting an alternative cooking-energy option j takes the linear form:

$$\mathbf{U_{ij}} = \mathbf{x_{ij}} \boldsymbol{b_j} + \mathbf{e_{ij}} \tag{3}$$

where U_{ij} is the utility of energy preference ($j = 1\ldots\ldots n$) for a household ($i = 1\ldots\ldots N$), x_{ij} is the matrix of explanatory variables that remains constant across the energy alternatives, b_j is the coefficients of regression and e_{ij} is the error term and unobserved attributes of the cooking-energy options.

For a dependent variable with multiple measurement levels (j), the j-th cooking-energy option that the i-th household selects to maximize its utility takes the value 1 if the household selects the j-th energy option and 0 if otherwise.

The probability that a household chooses an energy option given its socio-economic and demographic characteristics (x_i) is modelled as:

$$\mathbf{P}\,[\mathbf{y} = \boldsymbol{j}] = \frac{\mathbf{exp}\left(\boldsymbol{b_j'}\mathbf{X_i}\right)}{\mathbf{1} + \sum_{j=0}^{J} \mathbf{exp}\left(\boldsymbol{b_j'}\ \mathbf{X_i}\right)} \tag{4}$$

where $P\,[y = j]$ is the likelihood that a household chooses either of the three energy options, with the traditional energy option arbitrarily set as the reference category. X_i is a vector of the explanatory variables and b_j is the coefficient of the vector of the explanatory variables.

Equation (4) can be rewritten as:

$$\mathbf{P}\,[\mathbf{y} = \mathbf{j}] = \frac{\mathbf{exp}\left(\boldsymbol{\beta_0} + \boldsymbol{\beta_1}\mathbf{x_1} + \boldsymbol{\beta_2}\mathbf{x_2} + \ldots \boldsymbol{\beta_n}\mathbf{x_n}\right)}{1 + \boldsymbol{e}xp\left(\boldsymbol{\beta}_0 + \boldsymbol{\beta}_1\mathbf{x}_1 + \boldsymbol{\beta}_2\mathbf{x}_2 + \ldots \boldsymbol{\beta}_n\mathbf{x}_n\right)} \tag{5}$$

Equation (5) is linearly parameterized as follows:

$$\boldsymbol{MNL}(\mathbf{y}_j) = \mathbf{log}\left(\frac{\mathbf{P_i}}{\mathbf{1{-}P_i}}\right) = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1\mathbf{x}_1 + \boldsymbol{\beta}_2\mathbf{x}_2 + \ldots \boldsymbol{\beta}_n\mathbf{x}_n + \boldsymbol{e} \tag{6}$$

where $\mathbf{y}$ = cooking-fuel type ($\boldsymbol{j}$ = 1 traditional fuel, $\boldsymbol{j}$ = 2 transitional and $\boldsymbol{j}$ = 3 modern fuel), β is the vector of coefficients, X_i is the vector of independent variables defined in Table 2 and e is the error term.

We attempt to understand households' cooking-energy switching patterns given a change in any of the socio-economic and demographic characteristics of the households by computing the marginal effect. The marginal effect is computed by taking the first difference of Equation (4) following [51].

3 Results and discussion

3.1 Descriptive statistics

Table 1 presents the summary statistics of the cooking-energy options available to the 4400 households. The results show that most of the households (66.67%) use traditional cooking fuel, whereas 21.64% and 11.61% use transitional and modern cooking-fuel sources, respectively. Fuelwood is the dominant energy option (66.4%) for most households. This heavy reliance on fuelwood may be attributed to the fact that agricultural households often have access to forest areas where fuelwood is sourced. Secondly, fuelwood is comparatively cheap compared with most other energy fuels, which could make it a preferred option for agricultural households who constitute most of the poor in Nigeria, as in other developing countries. Other dominant cooking fuels used by the households are kerosene (18.23%), LPG (10.52%) and charcoal (3.23%).

Table 2 presents the description and summary statistics of the explanatory variables used for this study. The summary statistics show that about a third (30.5%) of the households receive remittance from migrant household member(s); most (85.2%) of the households are headed by males; >79% of the household heads are married, aged 48.6 years on average and their highest educational attainment is a junior high school certificate. The

Table 2: Data description for selected variables (N = 4400)

Variable	Description	Mean	Standard deviation	Minimum	Maximum
Gender (x_1)	Dummy for gender of household head (male = 1)	0.852	0.355	0	1
Age of household head (x_2)	Age of household head (years)	48.624	14.446	17	99
Household size (x_3)	Number of household members	6.133	3.552	1	31
Marital status (x_4)	Marital status of household head, 1 if married and 0 otherwise	0.796	0.403	0	1
Access to electricity (x_5)	Dummy for access to electricity by the household, 1 if yes and 0 if otherwise	0.548	0.498	0	1
Access to credit (x_6)	Dummy for access to credit by the household, 1 if yes and 0 if otherwise	0.158	0.365	0	1
Household location (x_7)	Location of the household, 1 if urban and 0 if otherwise	0.322	0.467	0	1
Dependency ratio (x_8)	A measure of the number of dependents aged 0–14 and >65 years compared with the total population aged 15–64 years	98.869	85.259	0	800
Distance to road (x_9)	Distance to the nearest all-weathered road (km)	4.94	6.744	0	59.3
Distance to market (x_{10})	Distance to the nearest major market (km)	66.868	47.952	.4	227
Household head education (years) (x_{11})	Number of years of schooling of household head	7.858	5.598	0	20
Average household education (years) (x_{12})	Average years of schooling of household	5.951	3.845	0	20
Remittance (x_{13})	Dummy for whether household receives remittance (Yes = 1)	0.305	0.461	0	1
Wealth index (x_{14})	A list of non-productive assets owned by the household, such as a television, radio and lamp, among others (index)	0.125	0.147	0	1
Ownership of dwelling (x_{15})	Dummy for ownership of dwelling by the household, 1 if yes and 0 if otherwise	0.631	0.483	0	1
Number of income activities (x_{16})	Number of income activities engaged by the households	4.619	1.304	0	8
North-Central (based category)	Geopolitical zone of household, 1 if North-Central and 0 otherwise	0.169	0.374	0	1
Northeast (x_{17})	Geopolitical zone of household, 1 if Northeast and 0 otherwise	0.173	0.379	0	1
Northwest (x_{18})	Geopolitical zone of household, 1 if Northwest and 0 otherwise	0.178	0.382	0	1
Southeast (x_{19})	Geopolitical zone of household, 1 if Southeast and 0 otherwise	0.16	0.366	0	1
South-South (x_{20})	Geopolitical zone of household, 1 if South-South and 0 otherwise	0.163	0.369	0	1
Southwest (x_{21})	Geopolitical zone of household, 1 if Southwest and 0 otherwise	0.158	0.365	0	1

average household's highest educational attainment is primary school and the majority of households own their places of dwelling (63.1%). The average household size is six persons, with one working-age person taking up the burden of two dependants in a household (the average dependency ratio is 98.89%) and at least a working-age person is engaged in four income-generating activities.

The demographic information of the surveyed households conforms with the work of [52], which reports that >81% of surveyed households from the 2018 Nigerian Demographic Health Survey are male-headed, with the average age of male-headed households being 44.4 years. The average distance from the households' place of dwelling to the nearest all-weather road is 4.94 km, and households travel almost 67 km to access the nearest market. The distance to the market is a disincentive for households to source cleaner cooking energy, and this perhaps explains why the large distribution of households relies on agriculture and forest-based products for cooking. Over 54.8% of households have access to electricity, <16% have access to credit, 30.5% of households receive remittance and only 12.5% of households own non-productive assets.

Further, the geographical location of the households shows that >67% of households live in rural Nigeria, with households almost evenly distributed across the six states of Nigeria. The 4400 households consist of 16.9% from North-Central, 17.3% from Northeast, 17.8% from Northwest, 16% from Southeast, 15.8% from Southwest and 16% from South-South.

The distribution of energy used by households based on socio-economic characteristics is displayed in Table 3. Traditional energy fuels were the most commonly used energy fuels across the households' socio-economic characteristics. Specifically, traditional energy was the predominantly used cooking energy among rural households (84.1%), while transition energy was more common among urban households. This might be because of rural households' access to cheap and affordable traditional cooking fuels biomass such as wood, crop residues and coals compared with urban dwellers. Usage of efficient and environmentally friendly modern and clean energy was higher among urban households (28.7%) compared with rural areas, where it was used by <5% of households. The implication of this is that rural dwellers rely heavily on unclean traditional energy, which threatens environmental sustainability compared with urban dwellers. This suggests that policymakers and government should make more effort (policies and programmes) to increase households' access to affordable clean energy and increase awareness about the environmental effects of unclean traditional energy, especially in rural areas.

Similarly, traditional fuel usage was relatively higher among male-headed and married households and households who

Table 3: Distribution of energy groups by household socio-economic and demographic characteristics

Variable	Traditional	Transition	Modern
Household location			
Urban	424	583	405
	30.03	41.29	28.68
Rural	2513	369	106
	84.10	12.35	3.55
Gender			
Female	419	166	65
	64.46	25.54	10.00
Male	2518	786	446
	67.15	20.96	11.89
Marital status			
Single	517	277	105
	57.51	30.81	11.68
Married	2420	675	406
	69.12	19.28	11.60
Recipient of remittance			
No	2121	646	290
	69.38	21.13	9.49
Yes	816	306	221
	60.76	22.78	16.46
Ownership of dwelling			
Not owned	632	647	345
	38.92	39.84	21.24
Owned	2305	305	166
	83.03	10.99	5.98
Zone			
North-Central	519	144	79
	69.95	19.41	10.65
Northeast	701	52	10
	91.87	6.82	1.31
Northwest	677	72	33
	86.57	9.21	4.22
Southeast	452	209	41
	64.39	29.77	5.84
South-South	372	228	115
	52.03	31.89	16.08
Southwest	216	247	233
	31.03	35.49	33.48

The first row has 'frequencies' and the second row has 'row percentages'.

owned their dwelling, while that of transition energy was higher among female-headed, single households and households that lived in rented apartments. Modern energy usage was low (~10% of households) irrespective of the gender and marital status of the household head. However, it is worth noting that its usage was higher among households who do not own their dwelling, where it is being used by >20% of households. The level of usage of traditional energy was high in almost all the geopolitical zones of Nigeria, where it is being used by >50% of households except in the Southwest (~31.0%). Generally, the usage of traditional energy was higher among the geopolitical zones in the northern region. The highest usage was reported in the Northeast and Northwest, while the Southwest had the lowest usage, followed by the South-South.

To ensure that no serious multicollinearity exists among the explanatory variables, we subjected the variables to a pairwise correlation diagnostic test. Literature suggests that multicollinearity likely exists if the absolute value of the correlation coefficient is ~0.8 or more [11, 53]. The result of the pairwise correlation diagnostic in Table S1 in the online Supplementary Data shows that multicollinearity does not exist among the explanatory used in this study.

3.2 Determinants of household cooking-energy choice

The empirical analysis regarding the determinants of household cooking-energy choice was done using a multinomial logit model. The dependent variables are the three cooking-energy sources as classified in the energy-ladder hypothesis, i.e. traditional energy sources (wood, dung and residues), which is the base category; transition energy sources (kerosene, coal and charcoal); and modern energy sources (electricity, LPG and biogas) [44]. The estimated coefficients (Betas) and marginal effects are presented in Tables 4 and 5, respectively.

Table 4: Multinomial logit estimation result

Variables	Transition	Modern
Household size	−0.099***	−0.106***
	(0.021)	(0.033)
Gender	0.541***	0.336
	(0.186)	(0.278)
Age of household head	−0.003	−0.022***
	(0.004)	(0.007)
Marital status	−0.541***	−0.334
	(0.175)	(0.254)
Access to electricity	0.917***	0.865***
	(0.131)	(0.265)
Access to credit	0.044	0.067
	(0.133)	(0.194)
Household location	1.246***	1.299***
	(0.112)	(0.178)
Dependency ratio	−0.000	0.003**
	(0.001)	(0.001)
Distance to road (km)	−0.015*	−0.014
	(0.008)	(0.011)
Distance to market (km)	0.004***	0.004**
	(0.001)	(0.002)
Household head education (years)	0.028*	0.059**
	(0.015)	(0.024)
Average household education (years)	0.023	0.161***
	(0.024)	(0.038)
Remittance	−0.052	0.439***
	(0.111)	(0.162)
Ownership of dwelling	6.863***	14.801***
	(0.640)	(0.847)
Wealth index	0.995***	0.956***
	(0.113)	(0.181)
Number of income activities	0.325***	0.411***
	(0.042)	(0.062)
Northeast	−0.261	−1.024**
	(0.213)	(0.453)
Northwest	−0.170	−0.233
	(0.201)	(0.329)
Southeast	0.608***	−0.429
	(0.171)	(0.304)
South-South	0.567***	0.728***
	(0.163)	(0.246)
Southwest	0.730***	1.718***
	(0.177)	(0.250)
Constant	−4.103***	−8.484***
	(0.382)	(0.642)
Observations	4400	4400

Standard errors in parentheses.
***P < 0.01; **P < 0.05; *P < 0.1.

The results show that access to remittance has the propensity to induce households' preference for modern energy. Specifically, households that receive remittances are 0.7% more likely to use modern cooking fuels relative to traditional cooking fuels. This is plausible, given that remittances provide additional household income (usually from migrant members) that can be deployed to invest in cleaner, healthier and more efficient cooking-energy technologies. This conforms with recent evidence from the relationship between remittances and energy transition in developing countries [54–56]. Additionally, wealth is a crucial factor in determining household choice of cooking energy; a 1% increase in the wealth index reduces the probability of using traditional cooking-energy sources such as fuelwood and animal dung by 15.9% and increases the probability of using transition and modern fuels by 14.8% and 1.1%, respectively.

Similarly, the number of income activities has a positive influence on household cooking-energy choices. Households with more income sources are more likely to utilize transition and modern cooking energy relative to traditional energy. This conforms to the energy-ladder hypothesis that, as households become wealthier, they tend to shift from lower rungs of the energy ladder (traditional or unclean energy such as wood, crop residues and animal dung) to higher rungs with modern, cleaner and more efficient energy sources [44, 57]. This is intuitive, given that wealthier households have greater financial resources, enabling them to afford cleaner cooking technologies, which often come with higher upfront costs but are healthier, more energy-efficient and more environmentally friendly in the long run [58].

The effect of human capital on the household choice of cooking energy was controlled for using the household head's number of years of schooling and the average household years of schooling. The results show that education is negatively associated with traditional cooking-energy sources and positively associated with transition and modern energy sources. Specifically, a 1% increase in the household head education reduces the probability of using traditional energy sources by 0.5% and increases the probability of using transition and modern energy for cooking by 0.4% and 0.1%, respectively. In addition, a 1% increase in the average household years of education increases the probability of using modern cooking-energy sources by 0.2%. Several reasons are advanced in the literature about this relationship between education and cooking-energy choice [59, 60]. First, educated households tend to be more aware and have a greater understanding of the health risks and pollution associated with traditional cooking-energy sources, as well as the health benefits of using cleaner energy sources, which can motivate them to prioritize cleaner cooking-energy options. Furthermore, education increases individuals' (and households') income-earning potential, which can enable them to invest in cleaner cooking technologies and energy sources [58].

Furthermore, infrastructural access influences household cooking-energy choice. For instance, access to electricity reduces households' likelihood of using traditional cooking-energy sources by 14.3% and increases transition and modern cooking energy by 13.3% and 1.0%, respectively. Likewise, a 1% increase in the distance to the road increased the probability of using traditional cooking energy by 0.2% and reduced the probability of using transition cooking energy by the same magnitude. Electricity access is crucial to using electrical cooking technologies, and good roads are important in supplying modern cooking-energy equipment and consumables (such as cooking gas, gas cylinders, etc.). This suggests that the provision of modern infrastructure is important

Table 5: Results of the marginal effects

Variables	Traditional	Transition	Modern
Household size	0.016***	–0.015***	–0.001**
	(0.003)	(0.003)	(0.000)
Gender	–0.075***	0.072***	0.003
	(0.023)	(0.022)	(0.003)
Age of household head	0.001	–0.000	–0.000***
	(0.001)	(0.001)	(0.000)
Marital status	0.092***	–0.089***	–0.003
	(0.033)	(0.031)	(0.004)
Access to electricity	–0.143***	0.133***	0.010***
	(0.019)	(0.018)	(0.003)
Access to credit	–0.007	0.007	0.001
	(0.021)	(0.020)	(0.003)
Region	–0.225***	0.208***	0.018***
	(0.022)	(0.021)	(0.004)
Dependency ratio	–0.000	–0.000	0.000**
	(0.000)	(0.000)	(0.000)
Distance to road (km)	0.002*	–0.002*	–0.000
	(0.001)	(0.001)	(0.000)
Distance to market (km)	–0.001***	0.001***	0.000**
	(0.000)	(0.000)	(0.000)
Household head education (years)	–0.005**	0.004*	0.001**
	(0.002)	(0.002)	(0.000)
Average household education (years)	–0.005	0.003	0.002***
	(0.004)	(0.004)	(0.001)
Remittance	0.002	–0.009	0.007**
	(0.017)	(0.016)	(0.003)
Ownership of dwelling	–1.194***	0.996***	0.198***
	(0.111)	(0.105)	(0.032)
Wealth index	–0.159***	0.148***	0.011***
	(0.018)	(0.017)	(0.003)
Number of income activities	–0.053***	0.048***	0.005***
	(0.007)	(0.006)	(0.001)
Northeast	0.046	–0.035	–0.011***
	(0.030)	(0.029)	(0.004)
Northwest	0.027	–0.024	–0.003
	(0.029)	(0.028)	(0.004)
Southeast	–0.098***	0.105***	–0.007**
	(0.033)	(0.032)	(0.003)
South-South	–0.104***	0.093***	0.011**
	(0.031)	(0.030)	(0.005)
Southwest	–0.156***	0.115***	0.041***
	(0.037)	(0.033)	(0.011)
Observations	4400	4400	4400

Standard errors in parentheses.
$^{***}P < 0.01$;
$^{**}P < 0.05$;
$^{*}P < 0.1$.

in driving the transition from traditional unclean cooking energy to modern, clean cooking energy. This result is corroborated by the findings of [31] and [44] in Afghanistan and Ghana, respectively.

The results also indicate that there is a disparity between urban and rural households in their choice of cooking energy; rural households are more likely to use traditional cooking energy, while urban households are more likely to use transition and modern cooking energy [32, 50]. Specifically, urban households are 22.5% less likely to use traditional cooking energy and 1.8% more likely to use modern cooking energy relative to rural households. This could be because urban households tend to have more access to infrastructure, e.g. electricity access, which is more prevalent in urban areas, as well as cooking gas-supply networks. Conversely, traditional cooking-energy sources (animal dung, fuelwood and crop residue) tend to be more available in rural areas where more agricultural production and forest resources are available. Household cooking-energy choice is also influenced by various household characteristics. Households with large families and those who are married are more likely to use traditional cooking energy and less likely to use transition and modern cooking energy. This is consistent with previous findings in the literature, especially in developing countries [31, 59, 60]. Large households typically consume more cooking energy and are likely to reduce their share in household expenditure by using the less expensive traditional options (wood, dung and crop residue). Age also negatively influences the probability of using modern cooking energy. However, the results show that male-headed households are less likely to use traditional cooking energy and more likely to use transition cooking energy. This does not support the findings of some studies in the literature [58, 61] which suggest that female-headed households tend to utilize cleaner cooking-energy sources relative to male-headed households because women are mostly responsible for cooking activities and therefore choose the cooking-energy fuel that gives them the most utility (ease of use, health concerns, etc.).

Lastly, the results indicate that there are significant differences in the choice of cooking energy among households based on the region they are domiciled in. Households in the Southwest and South-South are more likely to use transition and modern cooking energy relative to those in the North-Central region (base category), while those in the Northeast have a lower probability of using modern cooking energy compared with households in the North-Central region.

4 Conclusions and policy implications

This study was carried out to understand the factors influencing household choice of cooking energy using the most recent nationally representative Living Standards Measurement Survey covering 4400 agricultural households in Nigeria. Traditional cooking fuels (wood, crop residue and animal dung), which are harmful to human health, remain the dominant cooking fuels among households. The results of the multinomial logit model estimation show that households who receive remittances are more likely to use modern cooking fuels. Similarly, wealthier households are more likely to use modern and transitional cooking fuel rather than traditional cooking fuel, which conforms to the energy-ladder hypothesis. Educated households who live in urban areas are more likely to use modern and transitional cooking fuel relative to traditional cooking fuel. Furthermore, infrastructural access (electricity access, distance to market) plays a key role in households' cooking-energy choices, showing that factors other than affordability are important in households' cooking-fuel choices.

Based on these findings, the study recommends the incentivization of remittances into the country through the reduction in associated transaction costs and accelerated public infrastructural investment in affordable electricity and good road networks to connect rural areas to gas-supply networks to drive the transition to modern cooking energy. Furthermore, to encourage households to switch from traditional to modern cooking fuels, the attention of the policymakers has to be directed to the socio-economic and demographic factors identified from this study as barriers to household utility of modern fuels. A specific interest in schemes aimed at promoting modern cooking fuels, such as the Sustainable Energy for All and Global Alliance for Cookstoves Nigeria, should be directed at scaling up the provision of modern cooking appliances to rural Nigeria, particularly to households located in the Northeast and Northwest areas of Nigeria and among aged female-headed households where modern cooking-fuel use is inadequate.

In addition, we recommend the implementation of pro-poor policies that improve households' financial capacity to purchase modern, efficient cooking fuels. This can include social insurance schemes that remit targeted poor households and income-generating opportunities that propel wealth building. Lastly, we recommend that stakeholders support both formal and informal education in creating awareness about the health risks associated with traditional cooking fuels, especially in rural areas of Nigeria.

4.1 Limitations of the study

There are some limitations to this study. First, due to the use of secondary data, this study is constrained concerning the scope of information contained in the data set. We are unable to include variables such as the cooking-fuel prices and quantity of fuels used by the households, and cannot model households' switching between cooking fuels due to lack of information. The study therefore recommends the inclusion of these variables in future research. Despite these limitations, our study contributes to the existing literature by providing evidence of the effect of remittances and other factors on household cooking-fuel choice in Nigeria.

Supplementary data

Supplementary data is available at *Clean Energy* online.

Conflict of interest statement

None declared.

Data Availability

The data underlying this article are available in Mendeley Data, at https://dx.doi.org/10.17632/nk3k3rdv7v.1. The data sets were derived from sources in the public domain: World Bank Microdata Library, https://doi.org/10.48529/1hgw-dq47.

References

[1] UNDP. *Goal 7: Affordable and Clean Energy*. https://www.undp.org/sustainable-development-goals/affordable-and-clean-energy (22 September 2023, date last accessed).

[2] WHO/IEA/GACC/UNDP/WB. *Achieving Universal Access to Clean and Modern Cooking Fuels and Technologies*. Washington, DC: United Nations, 2018.

[3] International Energy Agency. World Energy Outlook 2022. In: *International Energy Agency/World Energy Outlook 2022*. Paris: International Energy Agency, 2022.

[4] WHO. *Household Air Pollution*. https://bit.ly/4b1pplx (11 August 2023, date last accessed).

[5] United Nations. *The Sustainable Development Goals Report 2023: Special Edition*. New York: United Nations, 2023.

[6] IEA/IRENA/UNSD/WB/WHO. *Tracking SDG 7: The Energy Progress Report 2019*. Washington, DC: World Bank, 2019.

[7] Fisher S, Bellinger DC, Cropper ML, *et al*. Air pollution and development in Africa: impacts on health, the economy, and human capital. *Lancet Planet Health*, 2021, 5:e681–e688.
[8] Gouda HN, Charlson F, Sorsdahl K, *et al*. Burden of non-communicable diseases in sub-Saharan Africa, 1990–2017: results from the Global Burden of Disease Study 2017. *Lancet Glob Health*, 2019, 7:e1375–e1387.
[9] World Bank. *GDP Growth (Annual %)—Nigeria*. https://bit.ly/4901ktN (22 September 2023, date last accessed).
[10] National Bureau of Statistics. *Nigeria Multidimensional Poverty Index (2022)*. Abuja: National Bureau of Statistics, 2022.
[11] Oyeniran IW, Isola WA. Patterns and determinants of household cooking fuel choice in Nigeria. *Energy*, 2023, 278:127753.
[12] WHO. *Proportion of Population with Primary Reliance on Polluting Fuels and Technologies for Cooking (%)*. https://bit.ly/490bzhJ (19 September 2023, date last accessed).
[13] UNDESA. *The World Population Prospects: 2015 Revision*. https://www.un.org/en/development/desa/publications/world-population-prospects-2015-revision.html (19 August 2022, date last accessed).
[14] Adeyonu AG, Adams SO, Kehinde MO, *et al*. Spatial profiles and determinants of multidimensional energy poverty in rural Nigeria. *Int J Energy Econ Policy*, 2022, 12:373–384.
[15] Aminu RO, Si W, Ibrahim SB, *et al*. Impact of socio and demographic factors on multidimensional poverty profile of smallholder arable crop farmers: evidence from Nigeria. *Int J Soc Econ*, 2022, 49:107–123.
[16] Ibrahim S, Omonitan M, Aminu R, *et al*. Adaptive capacity to climate change and food security among farm households in Southwest Nigeria. *Econ Agric*, 2022, 69:777–791.
[17] Buba A, Abdu M, Adamu I. Socio-economic determinants of households fuel consumption in Nigeria. *Int J Res*, 2017, 5:348–360.
[18] Adetayo OD, Oladehinde GJ, Adeyinka SA, *et al*. Household energy demand in typical Nigerian rural communities. *Eur J Bus Sci Technol*, 2021, 7:165–185.
[19] Oyedele O. Determinants of household cooking energy choice: are such choices influenced by health outcomes? *Int J Energy Econ Policy*, 2023, 13:553–564.
[20] IMF. *Balance of Payments and International Investment Positions*. 6th edn. Washington, DC: International Monetary Fund, 2009.
[21] World Bank/KNOMAD. *Remittances Remain Resilient but Are Slowing*. Washington, DC: World Bank, 2023.
[22] Statista. *Value of Remittance Inflows to Nigeria from 2011 to 2022 (in Billion U.S. Dollars)*. Financial. https://bit.ly/3HnZS8H (20 December 2023, date last accessed).
[23] Nevin AS, Omosomi O. *Strength from Abroad the Economic Power of Nigeria's Diaspora*. Lagos: Pricewater House Coopers Limited, 2023.
[24] Islam MS. Do personal remittances cause environmental pollution? Evidence from the top eight remittance-receiving countries. *Environ Sci Pollut Res Int*, 2022, 29:35768–35779.
[25] Osei-Gyebi S. Does inward remittance influence the choice of households' cooking fuel? *Int J Sustainable Energy*, 2023, 42:1226–1240.
[26] Baiyegunhi LJS, Hassan MB. Rural household fuel energy transition: evidence from Giwa LGA Kaduna State, Nigeria. *Energy Sustain Dev*, 2014, 20:30–35.
[27] Ifegbesan AP, Rampedi IT, Annegarn HJ. Nigerian households' cooking energy use, determinants of choice, and some implications for human health and environmental sustainability. *Habitat Int*, 2016, 55:17–24.
[28] Ahmad TI, Nawaz MA, Kiran K, *et al*. Dirty versus clean fuel for cooking in Pakistan: regional mapping and correlates. *Environ Sci Pollut Res Int*, 2023, 30:26458–26471.
[29] Ali J, Khan W. Factors affecting access to clean cooking fuel among rural households in India during COVID-19 pandemic. *Energy Sustain Dev*, 2022, 67:102–111.
[30] Mottaleb KA, Rahut DB, Ali A. An exploration into the household energy choice and expenditure in Bangladesh. *Energy*, 2017, 135:767–776.
[31] Paudel U, Khatri U, Pant KP. Understanding the determinants of household cooking fuel choice in Afghanistan: a multinomial logit estimation. *Energy*, 2018, 156:55–62.
[32] Katutsi V, Dickson T, Migisha AG. Drivers of fuel choice for cooking among Uganda's households. *Open J Energy Effic*, 2020, 09:111–129.
[33] Lokonon BOK. Household cooking fuel choice: evidence from the Republic of Benin. *African Devel Rev*, 2020, 32:686–698.
[34] Martey E, Etwire PM, Atinga D, *et al*. Household energy choice for cooking among the time and consumption poor in Ghana. *Energy*, 2021, 226:120408.
[35] Dongzagla A, Adams AM. Determinants of urban household choice of cooking fuel in Ghana: do socioeconomic and demographic factors matter? *Energy*, 2022, 256:124613.
[36] Yadav P, Davies PJ, Asumadu-Sarkodie S. Fuel choice and tradition: why fuel stacking and the energy ladder are out of step? *Sol Energy*, 2021, 214:491–501.
[37] Rahut DB, Behera B, Ali A. Patterns and determinants of household use of fuels for cooking: empirical evidence from sub-Saharan Africa. *Energy*, 2016, 117:93–104.
[38] Wassie YT, Rannestad MM, Adaramola MS. Determinants of household energy choices in rural sub-Saharan Africa: an example from southern Ethiopia. *Energy*, 2021, 221:119785.
[39] Lancaster KJ. A new approach to consumer theory. *J Polit Economy*, 1966, 74:132–157.
[40] Rosen S. Hedonic prices and implicit markets: product differentiation in pure competition. *J Polit Economy*, 1974, 82:34–55.
[41] Obayelu AE, Ogunnaike MG, Omotoso FK. Socioeconomic determinants of fruits consumption among students of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. *Int J Fruit Sci*, 2019, 19:211–220.
[42] Twumasi AM, Jiang Y, Addai B, *et al*. Determinants of household choice of cooking energy and the effect of clean cooking energy consumption on household members' health status: the case of rural Ghana. *Sustain Prod Consum*, 2021, 28:484–495.
[43] Baraya AAS, Handoyo RD, Ibrahim KH, *et al*. Determinants of households' energy consumption in Kebbi State Nigeria. *Cogent Econ Finance*, 2023, 11:2242731. https://doi.org/10.1080/23322039.2023.2242731
[44] Karimu A. Cooking fuel preferences among Ghanaian households: an empirical analysis. *Energy Sustain Dev*, 2015, 27:10–17.
[45] Bakhsh K, Sadiqa A, Yasin MA, *et al*. Exploring the nexus between households' choice of cooking fuels, sanitation facilities and access to information in Pakistan. *J Clean Prod*, 2020, 257:120621.
[46] Sana A, Kafando B, Dramaix M, *et al*. Household energy choice for domestic cooking: distribution and factors influencing cooking fuel preference in Ouagadougou. *Environ Sci Pollut Res Int*, 2020, 27:18902–18910.
[47] Sharma V, Dash M. Household energy use pattern in rural India: a path towards sustainable development. *Environ Challenges*, 2022, 6:100404.

[48] Adeyemi PA, Adereleye A. Determinants of household choice of cooking energy in Ondo State, Nigeria. *J Econ Sustain Dev*, 2017, 7:131–142.

[49] Bofah RO, Appiah-Konadu P, Ngwu FN. Transition to cleaner cooking energy in Ghana. *Clean Energy*, 2022, 6:193–201.

[50] Mperejekumana P, Li H, Wu R, *et al*. Determinants of household energy choice for cooking in Northern Sudan: a multinomial logit estimation. *Int J Environ Res Public Health*, 2021, 18:11480.

[51] Greene WH. *Econometric Analysis*. 7th edn. Hoboken, NJ, USA: Pearson, 2012.

[52] Nwaka ID, Uma KE, Nwokike Ike G. Determinants of household fuel choices among Nigerian family heads: are there gender-differentiated impacts? *Environ Sci Pollut Res*, 2020, 27:42656–42669.

[53] Shrestha N. Detecting multicollinearity in regression analysis. *Am J Appl Math*, 2020, 8:39–42.

[54] Abba Yadou B, Ntang PB, Tchio Tchieutsouah R, *et al*. Do remittances align with energy transition in Africa? An approach with the level of income of countries. *Nat Resour Forum*, 2023. https://doi.org/10.1111/1477-8947.12333

[55] Agradi M. Does remittance inflow influence energy poverty? *Appl Energy*, 2023, 335:120668.

[56] Djeunankan R, Njangang H, Tadadjeu S, *et al*. Remittances and energy poverty: fresh evidence from developing countries. *Util Policy*, 2023, 81:101516.

[57] van der Kroon B, Brouwer R, van Beukering PJH. The energy ladder: theoretical myth or empirical truth? Results from a meta-analysis. *Renew Sustain Energy Rev*, 2013, 20:504–513.

[58] Rahut DB, Ali A, Mottaleb KA, *et al*. Wealth, education and cooking-fuel choices among rural households in Pakistan. *Energy Strat Rev*, 2019, 24:236–243.

[59] Kapsalyamova Z, Mishra R, Kerimray A, *et al*. Why energy access is not enough for choosing clean cooking fuels? Evidence from the multinomial logit model. *J Environ Manage*, 2021, 290:112539.

[60] Kitole FA, Tibamanya FY, Sesabo JK. Cooking energy choices in urban areas and its implications on poverty reduction. *Int J Sustainable Energy*, 2023, 42:474–489.

[61] Mensah JT, Adu G. An empirical analysis of household energy choice in Ghana. *Renew Sustain Energy Rev*, 2015, 51:1402–1411.