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Determinants of cooking fuel choice in southwestern Benin

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Abstract

This study examines the factors determining the choice of cooking fuels in southwestern Benin. The data were generated by a survey of 558 households in southwestern Benin in 2020. The analysis method was based on the Chi-square dependence test and multinomial logit regression model. The survey revealed a contrast level of fuel used among households: butane gas 0.36%, firewood 48.57%, charcoal 7.89% and combinaison of agricultural residues and firewood 43.19%. There is a significant effect between the household's choice of cooking energy and various factors. These include the head of household's gender, religion, profession, and education level, as well as their spouse's education, the household's district, home ownership, residential area, basic needs coverage, size, tenure in the locality, and dwelling type. These findings suggest several measures to increase clean energy use by households. First, improving their economic status, particularly income, is crucial. Second, promoting widespread education and access to modern fuel markets is important. Finally, raising awareness among household heads about the harmful effects of solid fuels through religious leaders can also be effective.

Keywords: Cooking Fuels; Diet; Livelihoods; Firewood; Charcoal; Gaz; Driving factors

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1. Introduction

Since several decades, the destruction of the ozone layer has been a worrying issue that has mobilised environmental activists. Echoing this trend, two targets are included in the Sustainable Development Goal (SDG 7) aiming at eradicating energy poverty: access to electricity and access to clean cooking technologies and fuels for all by 2030 (Aziz and Chowdhury, 2022). The challenge of this sustainable development objective is to meet the significant energy needs of the world's population, while ensuring that the energy used is sustainable. Worldwide, more than 1.5 billion people do not have access to electricity and 2.8 billion people rely on traditional biomass (firewood, crop residues, animal dung, etc.) for cooking (Gaede and Meadowcroft, 2016). The global population's dependence on traditional biomass is growing all the time, given population growth and the difficulties of accessing clean, environmentally-friendly energy. The number of people relying on biomass fuels (such as firewood, charcoal, agricultural residues, and animal dung) for cooking is estimated to reach nearly 3.0 billion worldwide in 2022 (Pangaribowo and Iskandar, 2022). In sub-Saharan Africa, it is estimated that more than 700 million people rely on traditional biomass energy sources for cooking - fuelwood, charcoal, dung and agricultural residues (Yadav and Devi, 2018; Amoah, 2019). The use of biomass is at the root of a number of health, climate and environmental problems observed in developing countries in recent years.

Health risks are linked to indoor pollution. Particulates from biomass combustion, when inhaled, can affect the well-being of the population by causing simple irritation of the respiratory tract and serious disorders such as respiratory infections, bronchitis, risk of asthma, cancer and premature death (Yadav and Devi, 2018). Their use is thus associated with high levels of all-cause morbidity and mortality in both children and adults (Desalu et al., 2012). Women are generally the most affected since they are usually the people most involved in cooking activities (Pangaribowo and Iskandar, 2022). The work of Parikh (2011), revealed that the use of biomass exposes women to discomforts such as neck and back pain, bruising and headaches from collecting and transporting fuel, and causes a great deal of dammage. Domestic cooking with biomass is responsible for 3.5 million premature deaths worldwide, according to the work of Lim et al. (2012) and Imran and Ozcatalbas (2020). The work of Bonjour et al. (2013) and Adeyemi and Adereleye (2016) also shows that 5% of female deaths are due to the use of biomass in developing countries. Li (2020) found that household members with solid (i.e. dirty) fuels are particularly susceptible to many health risks. Among them: poor self-rated health status, lower life satisfaction, higher incidence rate of chronic-lung diseases, heart-problems, hypertension and lower cognitive function, higher chance to be overweight. Using solid fuels affects daily activities.

In environmental terms, the consequences are deforestation and desertification, with obvious implications in terms of loss of land fertility, conflicts over natural resources and negative greenhouse effects. Danlami et al. (2017), Ravindra et al. (2019) and Pangaribowo and Iskandar (2022) have highlighted the harmful consequences of biomass use on the environment. For these authors, the use of solid fuels leads to an increase in greenhouse gas emissions, deforestation, the advance of deserts, environmental degradation through soil erosion and drought. In this way, it is responsible for the destruction of forests and the destabilisation of the habitats of several plants and animal creatures (Yadav and Devi, 2018). For example, worldwide, mangrove forests are disappearing at an average rate of close to 1% per year (Atwood et al., 2017; Hamilton and Friess, 2018; Van Vinh et al., 2019), and in some countries this rate can reach 8% per year (Van Vinh et al., 2019). Similarly, between 2000 and 2012, around 2.3 million km2 of forest were destroyed worldwide, resulting in carbon stock losses (Vafaei et al., 2018).

Despite the New York Declaration on Forestry to reduce deforestation by 50% by 2020 and the United Nations Sustainable Development Goals to halt deforestation by the same deadline, tropical deforestation continues inexorably (NYDF Assessment Partners, 2019; Di Sacco et al., 2021). In the humid tropics, an average of 4.3 million hectares of old-growth forest were destroyed each year between 2014 and 2018 (NYDF Assessment Partners, 2019). It should also be noted that the loss of natural forests is not offset by reforestation (Brancalion et al., 2017; Meli et al., 2017; Wheeler et al., 2016), nor by forest protection or restoration (Gann et al., 2019).

In view of the above, it is worth looking more closely at the factors that determine the choice of cooking energy sources among households in developing countries, with a view to reducing the health and environmental consequences of the use of traditional fuels. The existing literature on the subject reveals that several factors are behind the high level of biomass use in developing countries. These include economic factors (Behera et al., 2015; Rahut et al., 2017), social factors (Mensah and Adu, 2015), demographic factors (Rahut et al., 2017), geographical and local factors (Rahut et al., 2016; Hou et al., 2017), and institutional factors (Imran and Ozcatalbas, 2020).

1.1. Literature review

The emerging literature on the issue of household energy choice can be classified into two broad categories, namely: the energy ladder model (Amoah, 2019) and the portfolio choice model Heltberg (2003). The energy ladder model emphasizes the role of economic factors (household income) in determining and explaining the fuel choice transition. This model visualizes an energy transition process in three stages: (i) universal dependence on biomass, (ii) households switching to fuels such as coal and charcoal in response to higher incomes and factors such as deforestation and urbanization, and (iii) switching to "modern" fuels such as LPG, natural gas or electricity. For Amoah (2019), this model suggests that the main factor influencing energy scaling is household income and relative fuel prices. With regard to the second category, the literature considers household energy choice as a portfolio choice. According to Heltberg (2003), household energy portfolios focus on household size, composition and diversification. For Heltberg, the household economic model allows for the integration of opportunity costs, which are influenced by education and the availability of labor and natural resources. Thus, several factors are cited as determining households' choice of cooking energy source. These include socio-economic factors, household demographics, geographical factors, housing characteristics and institutional factors.

1.1.1. Socio-economic factors

The economic factors that determine the choice of cooking energy source by households refer to variables that measure their economic situation. These variables generally include household income, affordability, occupation of the head of household, level of education and fuel costs. Several studies have shown that these variables play an essential role in the choice of household cooking energy sources. For Imran and Ozcatalbas (2020) education and income have a significant influence on the choice of cooking fuel in rural Pakistan. These authors demonstrated that wealthy households have a positive and significant influence on their choice of cooking fuel, and that increases their ability to acquire modern fuels, particularly gas. In the same vein, Aziz and Chowdhury (2022) have shown that household income is positively associated with the choice of household cooking energy source. A few years earlier, Pandey and Chaubal (2011) proved that the presence of an economically active person in the household increases the probability of choosing clean cooking fuel over other cooking sources. In the other hands, education level is an important factor delaying the adoption of clean fuels (Suliman, 2010).

1.1.2. Demographic factors

Household demographic characteristics influence his cooking energy source choice. These demographic factors are notably: marital status, gender, age of household head, household composition and household size. For many authors, larger households use less modern fuels than smaller ones. Desalu et al. (2012) addressed the demographic aspect of household fuel choice. They found that using solid fuels was strongly associated with larger household size in urban areas. Similar findings were obtained by Imran and Ozcatalbas (2020) on rural Pakistani households and by Aziz and Chowdhury (2022) in Bangladesh. For Aziz and Chowdhury (2022), larger households use less modern fuels. The influence of head of household's marital status, gender, and age were highlighted in the work of Danlami et al. (2017). Thus, households tend to adopt clean energy when the head of household is 1female (Mensah and Adu, 2013; Danlami et al., 2017).

1.1.3. Geographical factors

Household demographic factors also influence household cooking fuel switching and consumption behavior. Ifegbesan et al. (2016) proved that in Nigeria, the residence area and the geographical region have a significant positive influence on the behavior of Nigerian households in terms of choice of cooking energy source. For these authors, solid fuels are heavily used by households residing in rural areas compared to those in urban areas. Desalu et al. (2012), Mensah and Adu (2013), justify this preponderance of solid fuel use in rural areas by the income level of rural households and the proximity or access to modern fuels in these areas.

1.1.4. Housing characteristics

In terms of housing characteristics, the location of the house, the house structure, the number of rooms in the house and the dwelling sharing have a significant influence on household fuel consumption. As illustrated by Couture et al. (2012), Laureti and Secondi (2012) and Danlami et al. (2017), being owner or renting a house influences the choice of cooking fuel source. Through their work, Couture et al. (2012), Laureti and Secondi (2012) and Danlami et al. (2017) demonstrated families living in their own house adopt clean cooking fuel sources. Desalu et al. (2012) showed that heads of tenant households living in rural areas tend to adopt solid fuels. Upon an empirical study, (Adeyemi and Adereleye, 2016) "home ownership" has negative and statistically significant coefficients for kerosene and cooking gas. This implies households that own their housing unit tend less to use these alternatives to firewood. Aziz and Chowdhury (2022) concluded in Bangladesh that houses with more ventilation facilities tended to use less clean fuels and more primitive forms of stoves, while rented houses used cleaner fuels and technologies.

1.1.5. Institutional ecosystem

Regarding institutional environment, Danlami et al. (2017), Imran and Ozcatalbas (2020) highlighted how modern fuels choice is affected by government policies (energy regulation), their availability and accessibility.

For these authors, the level of organization and development of the fuel market, and a country's strategic choice in the fight against deforestation influence behavior in terms of choice of cooking energy source. In addition, the availability of a particular fuel source influences household fuel-switching behaviour.

This study aims to examine the factors influencing households' choice or adoption of cooking energy. Clean energy for cooking fuels is essential to reduce the high levels of indoor and outdoor pollution that developing countries are facing in order to achieve the 2063 Sustainable Development Goals. Lack of access to safe and environmentally friendly energy is also an additional constraint on human development and the reduction of disease and child mortality. The main goal of this study is to contribute to the fight against deforestation, the degradation of biodiversity, the acceleration of soil erosion and the loss of agricultural productivity. It documents the health risks resulting from the use of biomass through an analysis of factors determining the choice of cooking fuel by households in the southwestern region of Benin. To reach that goal, appropriate data and methodological approach were used.

2. Data source and methods

2.1. Data source

The data used were extracted from the databases of a survey carried out by Applied Anthropology Research Group, whose empirical data collection took place from 20 November to 11 December 2020, in 40 villages in the commune of Bopa, in the Mono department in southwestern Benin. Data were collected from 558 heads of household, representative of the commune. Households were selected from a two-stage cluster random sample. In the first stage, 40 clusters (villages) were selected at random from all the villages in the commune. In the second stage, 17 households were randomly selected per cluster (village). At the end of the survey, the total number of households interviewed was 558, including 137 in urban areas and 421 in rural areas. In the overall sample, 82.97% of the heads of household were men and 17.03% were women.

2.2. Method

In this paper, the dependent variable is an unordered category variable with 3 possible categories or choices (0- Résidus agricoles+ bois de chauffage; 1- Bois de chauffage; 2- charbon de bois). The literature teaches us that the generalization of binomial models (logit, probit) to discrete variables with more than two modalities is done using multinomial models (several modalities). In the dichotomous logit model, only one parameter vector β was needed in order to determine the two probabilities, since Pr (yi = 0) + Pr (yi = 1) = 1. In the multinomial case, one needs a different parameter vector βj for each alternative. In general, for a multinomial logit model with m+1 modalities one estimates m probabilities:

$$P_j = \Pr(y = j|X) = \frac{\exp(X\beta j)}{1+\sum_{k=1}^{m}\exp(X\beta_k)}$$

for j = 1,2, to m and a reference probability p

$$P_o = \mathbf{Pr}\,(\mathbf{y} = \mathbf{m}+\mathbf{1}|\mathbf{X}) = \frac{1}{1+\sum_{k=1}^{m}\exp(X\beta_k)} \text{ with } \sum_{j=0}^{m} p_j = 1$$

Another fundamental characteristic of the multinomial logit is the independence from other events of the ratio of the two probabilities associated with two possibilities j and i

$$\frac{P_j}{P_i} = \frac{Pr\,(y = j|X)}{Pr\,(y = i|X)} = \exp\,(X(\beta j - \beta i))$$

This implies that,

$$\frac{P_j}{P_0} = \frac{Pr\,(y = j|X)}{Pr\,(y = 0|X)} = \exp\,(X\beta_j)$$

It is assumed that this ratio is independent of possibilities other than j and i. This assumption is called the Independence of Irrelevant Alternative. The estimation of the parameters of the model is performed using the algorithms of maximization of the log-likelihood function. The values of the coefficients are not directly interpretable in terms of marginal propensity, only the signs of the coefficients indicate whether the variable has a positive or negative effect on the relative probability of choosing j rather than 0. The estimation results are assessed in the same way as for the other models:

- the significance of the coefficients using the z-statistic ratios,
- the overall significance of the fit (the hypothesis: H0: a1 = a2 = a3= . . . = ak = 0) by the statistic LR = -2(Ln(LR) - Ln(LU)) which follows, under the null hypothesis H0, a distribution of a χ2 with k degrees of freedom. The pseudo-R2 is given by: R2 = 1 - Log(Lu) Log(LR).

In the case of this study, the mathematical model takes the form:

SE = f(arr, SC, DRL, RC, NIC, PC, SIZE, COUV, NIE, medium, PM, TL)

Where,

- SE = Cooking energy source
- Arr= Arrondissement of residence of the household
- SC = Sex of head of household
- DRL = Number of years spent in the locality
- RC = Religion of head of household
- NIC = Level of education of head of household
- PC = Profession of head of household
- SIZE= Size of household
- COUV= Coverage rate of household's basic needs
- NIE = Level of education of wife of head of household
- LOCATION = Place of residence
- PM = Household ownership
- TL = Type of dwelling

The material collected and the analysis method used enabled us to generate results.

3. Results

The survey revealed that very few households surveyed use modern sources of cooking energy. Only 0.36% of households surveyed use butane gas as the only cooking fuel in their household. The cooking energy sources of the households surveyed are mostly rudimentary and hostile to the environment: 43.19% of households combine agricultural residues, firewood and charcoal, while 48.57% use only firewood and 7.89% use only charcoal (Fig 1).

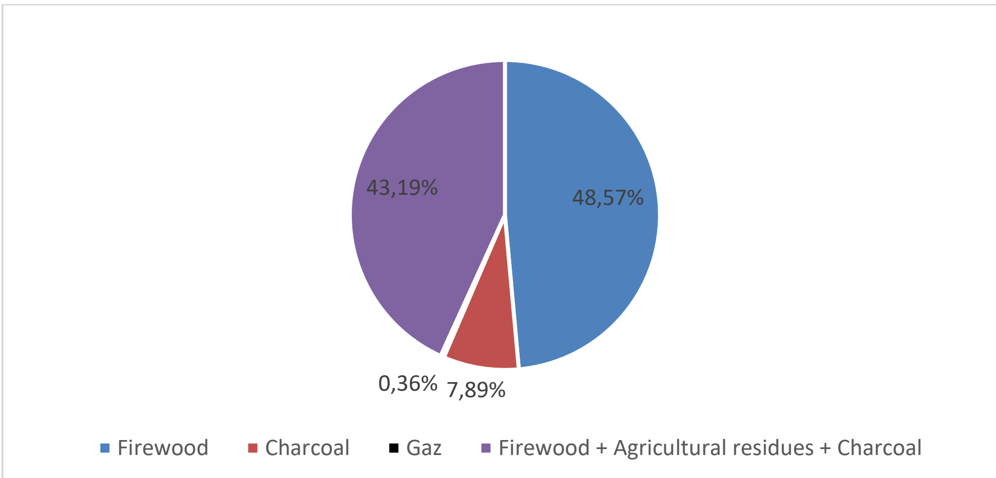

Fig 1. Breakdown of households by sources of cooking energy (Source: NutAumed/GRAnAp survey, December 2020)

The results of the Chi-square test established a relationship of dependence between households' choice of cooking energy source and several independent variables. This dependence is established between the choice of household cooking energy source and the gender of the head of household (Prob = 0.0059), the district in which the household resides (Prob = 0.0000), the type of house ownership (Prob = 0.0069), the religion of the head of household (Prob = 0.0008), the level of education of the head of household (Prob = 0. 0000), occupation of the head of household (Prob = 0.0194), place of residence (Prob = 0.0000), household needs coverage rate (Prob = 0.0001), household size (Prob = 0.0136), number of years of residence in the locality (Prob = 0.0008), level of education of the wife of the head of household (Prob = 0.0000), type of dwelling (Prob = 0.0000). Most households alternate their use of cooking energy sources.

According to Table 2, the alternating use of agricultural residues and firewood as a source of cooking energy is adopted by female-headed households (58%), by households that have spent more than 10 years in the locality (41.3%), by households with five (5) or more people (44.6%), by households living in dwellings built of precarious materials (42.9%), and by households that cover less than 50% of their basic needs (38.7%). House owners (67.9%) are relatively more likely to use firewood and charcoal than tenants (52%).

Household heads with at least secondary education use butane gas more than those with no education or primary education. Farmers and stockbreeders make more use of agricultural residues than other occupations. Charcoal and butane gas are used more by craftsmen and civil servants. Similarly, households of fewer than 5 people are relatively more likely to use butane gas and charcoal. The survey revealed that charcoal is used more in urban areas than in rural areas. The use of agricultural residues and firewood is predominant in rural areas.

The multinomial logit model was used to assess the actual effect of each of the factors on the choice of cooking energy source in southwestern Benin. The results of the estimations are presented in Table 1. Table 1 shows the marginal effects.

Table 1. Multinomial logistic regression

Source of cooking energy	Ordre ratio	t-value	p-value	Sig
Firewood				
Arrondissement of residence of the household	0.961	-0.86	0.389	
Sex of the head of household	0.296	-3.70	0	***
Number of years spent in the locality	1.019	0.14	0.886	
Religion of the head of household	0.935	-1.47	0.14	
Level of education of the head of household	0.851	-1.81	0.071	*
Profession of the head of household	0.996	-0.15	0.879	
Size of the household	0.943	-0.35	0.729	
Rate of coverage of the household's basic needs	0.768	-2.46	0.014	**
Level of education of the wife of the head of household	0.986	-0.10	0.919	
Where the household lives	2.266	3.23	0.001	***
Ownership of the house	0.552	-2.62	0.009	***
Type of dwelling	1.149	1.03	0.305	
Constant	7.121	1.77	0.077	*
Charcoal				
Arrondissement of residence of the household	0.933	-0.82	0.412	
Sex of the head of household	1.318	0.52	0.606	
Number of years spent in the locality	1.165	0.71	0.478	
Religion of the head of household	0.832	-2.05	0.04	**
Level of education of the head of household	0.793	-1.22	0.222	
Profession of the head of household	1.093	2.00	0.045	**
Size of the household	.383	-2.58	0.01	***
Rate of coverage of the household's basic needs	1.181	0.85	0.395	
Level of education of the wife of the head of household	1.221	0.84	0.401	
Where the household lives	0.276	-3.18	0.001	***
Ownership of the house	0.329	-2.57	0.01	**
Type of dwelling	0.724	-1.55	0.122	
Constant	12.83	1.41	0.16	
Mean dependent var	1.382	SD dependent var		1.440
Pseudo r-squared	0.139	Number of obs		558
Chi-square	144.600	Prob > chi2		0.000
Akaike crit. (AIC)	975.582	Bayesian crit. (BIC)		1144.232
*** p<.01, ** p<.05, * p<.1				

Source: NutAumed/GRAnAp survey, December 2020

The results show that the gender of the head of household has a negative and significant coefficient on the choice of firewood. Analysis of Table 1 shows that having a female head of household reduces the probability that the household will choose firewood by 70.4% (0.296-1 = -0.704) compared to alternating the use of agricultural residues and wood. The analyses show that the level of education of the head of household has a negative and significant effect on the choice of fuelwood. The survey revealed that:

- (i) a lower level of education of the head of household reduces by 14.9% (0.851-1) the probability that the household will choose fuelwood over a mixture of agricultural residues and fuelwood;
- (ii) covering less than 50% of the household's basic needs reduces by 33.2% (0.768-1) the probability that the household will choose fuelwood over a mixture of agricultural residues and wood;
- (iii) the fact that the household lives in an urban or semi-urban area increases by 126.6% (2,266-1) the probability that the household will choose fuelwood over agricultural residues;
- (iv) the type of property decreases by 44.8% (0.552-1) the probability that the household will choose fuelwood over a mixture of agricultural residues and wood.

With regard to the sole use of charcoal, the results indicate that:

- (i) the religion of the head of household reduces by 16.8% (0.832-1) the probability that the household will choose charcoal over a mixture of agricultural residues and wood;
- (ii) the occupation of the head of household increases by 9.3% (1,093-1) the probability that the household will choose charcoal over agricultural residues;
- (iii) larger household size decreases by 61.7% (0.383-1) the probability that the household will choose charcoal over a mixture of agricultural residues and wood;
- (iv) the type of property reduces by 67.1% (0.329-1) the probability that the household will choose firewood over a mixture of agricultural residues and wood.

With regard to butane gas, only two (2) households, i.e. 0.36% (0.36% < 5%) of the households surveyed reported using butane gas as a source of cooking energy in their household. Therefore, no regression model could be applied to the two observations. In addition, agricultural residues are combined with other cooking sources. All these results give rise to discussions that enable us to compare them with the work of other researchers.

4. Discussions

Dependence on the surrounding biomass is very high among the rural population, and the majority of the population in developing countries lives in rural areas (Imran and Ozcatalbas, 2020). This study classify the factors determining the choice of cooking energy source by households in the southwestern region of Benin into three (3) categories: economic factors (the occupation of the head of household, the type of ownership of the house, the rate of coverage of the household's basic needs), socio-demographic factors (the gender, level of education and religion of the head of household and the level of education of his wife, the size of the household, the number of years spent in the locality), and sociogeographic factors (the type of dwelling, the district in which the household is located, the area of residence).

According to our findings, the type of ownership of the house, the occupation of the head of household and the level of coverage of household needs have a significant influence on the choice of cooking energy source among households in southwestern Benin. This finding has been confirmed by many researchers. The fuel choice is linked to the economic characteristics of the household. Imran and Ozcatalbas (2020) found that household income, influenced mainly by the occupation of the head of household, had a significant positive impact on mixed fuel use. This indicates that an increase in income leads to a transition from biomass to mixed fuels for cooking. Behera et al. (2016) and Onyekuru et al. (2020) also demonstrated that when household heads' income improves, they switch to transitional energy sources. Adeyemi and Adereleye (2016) found that the occupation of the household head and the type of ownership of the dwelling are statistically significant economic factors influencing the choice of cooking energy demand. These authors show that heads of household who own the dwelling where they live would prefer to use firewood, given that the household often shares the dwelling with members of a large family and is responsible for managing the space in its dwelling. The extent to which households cover their basic needs influences their choice of cooking energy source. This result further confirms the importance of income in the choice of energy source.

In addition to economic factors, our results show that socio-demographic characteristics significantly influence the choice of cooking energy source among the heads of households surveyed. These results corroborate existing literature. Indeed, the work of Imran and Ozcatalbas (2020) indicates that the probability of choosing gas rather than biomass is 81% for a household composed of a single adult compared with a household composed of a larger number of adult males. Suliman (2010) also found that a 1% increase in household size tends to increase the average probability of choosing fuelwood, straw, and bush/crop residues by 0.009%, 0.02% and 0.007% respectively. With regard to the influence of the gender of the head of household on the choice of cooking energy source, our results support those obtained by Suliman (2010). This author showed that the presence of a female head of household, or a relatively high ratio of adult women in the household, is closely associated with asset poverty, and both tend to increase the probability of choosing the smokier fuels of straw and agricultural residues. Suliman (2010). More specifically, the effect of female-headed households compared to male-headed households significantly increases the probability of adopting straw and crop residues by 0.01% for each fuel. Our results show the influence of the level of education of the head of household and his wife on the choice of cooking energy source. Education improves income, access to better-paid jobs and the opportunity cost of time. Households whose heads have a high level of education tend to choose cleaner energy sources because of the convenience of use, the health benefits and the opportunity cost of their work. Our results corroborate with the findings of Behera et al. (2016), Imran and Ozcatalbas (2020), and Pangaribowo and Iskandar (2022). For Imran and Ozcatalbas (2020), an increase in the level of education of the head of household increases the likelihood that the household will use liquefied gas for cooking. Rahut et al. (2020); Sambodo and Novandra (2019) and Pangaribowo and Iskandar (2022) indicate that better education leads to the use of cleaner energy choices through increased human capital, higher incomes, improved purchasing power and awareness of the health impact of indoor air pollution due to the use of traditional fuels. The results of this study also highlight the essential role of religion in the choice of energy source for cooking in less developed regions. The results also show that the number of years spent in the area influences households' choice of energy source, which could be justified by the fact that the number of years spent in the area allows the household to adapt and have easy access to an energy source. Similar results were found by Nnaji et al. (2012) and Song et al. (2012).

Sociogeographic factors such as dwelling type, the borough in which the household resides, and the area of residence have been shown to have significant effects on the choice of energy source in the work of Suliman (2010). Living in an urban area may encourage a shift from wood to clean fuels due to better access to modern fuel markets (Suliman, 2010). In addition, the type of housing determines the choice of energy source, confirming the results of work by Jaime et al. (2020), Geremew et al. (2020) and Aziz and Chowdhury (2022).

Overall, socio-economic factors (occupation and level of education, type of home ownership, type of dwelling, income), demographic factors (gender, household size) and place of residence significantly influence cooking fuel choice in southwestern Benin. These seem to be the same factors that influence cooking fuel choice in Africa in general and West Africa in particular. The work of Dongzagla and Adams (2022) on Ghana, Nlom and Karimov (2015) on Northern Cameroon, Sana et al. (2020) on Burkina Faso, Ifegbesan et al. (2016) on Nigeria illustrate the factors that influence the cooking fuel choice behavior of West African households. Dongzagla and Adams (2022) have shown that the gender of the head of household, the age of the head of household, the marital status of the head of household, the size of the household, the level of education of the head of household and household income are the main factors influencing the choice of cooking fuel by urban Ghanaian households. For these authors, the Ghanaian households most likely to use clean fuels are male-headed households, small households, households whose head is under 30, households whose head has received formal education and wealthy (high-income) households, which corroborates perfectly the results of this study the case of Benin. Similarly, the results of Nlom and Karimov's (2015) studies on Northern Cameroon demonstrate the sensitivity of fuel choices to clean and alternative fuel prices, household income and exogenous variables related to household socio-demographic attributes. In addition, the work of Sana et al. (2020) on Burkina-Faso, and Nwaka et al. (2020) on Nigeria all agree that cooking fuel choice is strongly influenced by socio-economic status, family size, as well as women's level of education and age.

5. Conclusions and recommendations

The aim of this study is to examine the factors determining the choice of cooking energy source among households in the commune of Bopa in southwestern Benin. The material used to achieve this objective comes from the database of a survey carried out in December 2020, involving 558 households, representative of the commune of Bopa. The data collection method used is based on a two-stage survey.

A bivariate analysis and a multivariate logistic regression model were used for the analyses. The Chi-square tests indicate a dependent relationship between the household's choice of cooking energy and various factors. These include the head of household's gender, religion, profession, and education level, as well as their spouse's education, the household's district, home ownership, residential area, basic needs coverage, size, tenure in the locality, and dwelling type. The results of the multinomial logit analysis confirm that the sex of the head of household, the level of education of the head of household, the household's rate of coverage of basic needs, the area of residence and the type of property significantly influence the choice of fuelwood over a mixture of agricultural residues and wood. Similarly, household size, house ownership, religion of the head of household and occupation significantly influenced the choice of charcoal over a mixture of agricultural residues and wood.

However, this study has some limitations. The fact that the survey took place in December (a festive or end-of-year period) is a limitation for the results relating to the food consumption score. Similarly, the survey covers a single commune in Benin, so the results cannot be extrapolated to the whole department or the whole country.

Actions to reduce the environmental and health impact of solid fuel use must take socio-economic factors into account. This means subsidizing the price of clean fuels and related equipment, particularly for the poor, encouraging small families, and substantially increasing household incomes to significantly reduce the use of firewood for cooking, improving access to modern fuel markets, and raising awareness among household heads of the harmful effects of solid fuels through religious leaders. In addition, investment in education in rural schools and adult education on the benefits of cleaner fuels will be an effective method of encouraging fuel switching.

Conflict of interest statement

The author states that there is no conflict of interest. All statements or arguments made in this paper are the sole responsibility of the authors.

Ethical approval

The analyses carried out by the authors preserve the confidentiality of the individual data of the people surveyed. Indeed, a commitment has been made by applied anthropology research group to Benin's national ethics committee to guarantee the confidentiality of the individuals involved in the survey.

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The data used in this paper is fully available and can be accessed upon request.

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Annex

Table 2. Chi 2 results

	Sources of cooking energy by gender of head of household				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Male	240	35	2	186	463
Female	31	9	0	55	95
Total	271	44	2	241	558
Pearson Chi2 = 12.49 Prob = 0.0059					
	Cooking energy sources by borough				
Arrondissement	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
LOBOGO	61	25	0	75	161
YEGODOE	57	1	0	28	86
BADAZOUIN	74	4	0	30	108
AGBODJI	18	1	0	29	48
POSSOTOME	18	2	0	32	52
GBAKPODJI	8	1	0	8	17
BOPA	35	10	2	39	86
Pearson Chi2 = 73.68 Prob = 0.0000					
	Cooking energy sources by house ownership				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Homeowner	92	14	0	50	156
Tenant	179	30	2	191	402
Pearson Chi2 = 12.15 Prob = 0.0069					
	Sources of cooking energy by religion of head of household				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Catholic	32	10	2	30	74
Evangelical	90	18	0	76	184
Protestant	2	0	0	2	4
Celestial Christianity	3	6	0	14	23
Muslim	0	1	0	2	3
Endogenous (Vodoun, animism)	133	7	0	99	239
Others	11	2	0	18	31
Pearson Chi2 = 28.39 Prob = 0.0008					

	Sources of cooking energy by level of education of head of household				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
None	135	12	0	101	248
Primary	56	13	0	48	117
Secondary	77	16	1	82	176
Higher	3	2	1	10	16
Certificate of completion of alph training	0	1	0	0	1
Pearson Chi2 = 43.89 Prob = 0.0001					
	Cooking energy sources by number of years spent in the locality				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Less than one year	8	1	0	5	
1 to 5 years	25	6	1	28	
5 to 10 years	6	6	1	23	
More than 10 years	232	31	0	185	
Pearson Chi2 = 28.39 Prob = 0.0008					
	Sources of cooking energy by occupation of head of household				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Farmer	127	5	0	89	221
Fisherman	1	0	0	1	2
Hunter	1	0	0	0	1
Breeder	0	0	0	1	1
Retailer	10	3	0	23	36
Craftsman	71	15	2	64	152
Driver	14	5	0	17	36
Teacher	2	0	0	4	6
Nurse / Care assistant	0	1	0	3	4
Professional/Official	3	2	0	2	7
Police/Military	0	0	0	1	1
Retired	1	0	0	0	1
Other	15	10	0	22	47
None	26	3	0	14	43
Pearson Chi2 = 59.35 Prob = 0.0194					
	Sources of cooking energy by place of residence				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Urbin	39	28	0	70	137
Rural	232	16	2	171	421
	Pearson Chi2 = 54.67 Prob = 0.0000				
	Sources of cooking energy according to the level of coverage of basic household needs				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Less than 25	84	11	0	85	180
25 to 50%	118	15	0	59	192
50 to 75%	54	10	2	69	135
75 to 100%	15	8	0	28	51
Pearson Chi2 = 34.72 Prob = 0.0001					
	Cooking energy sources by number of economically active people in the household				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
Less than 5 people	100	24	2	87	213
5 to 9 people	137	19	0	138	294
10 people or more	34	1	0	16	51
	Pearson Chi2 = 16.02 Prob = 0.0136				

	Cooking energy sources by level of education of wife of head of household				
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
None	178	22	2	146	346
Primary	60	10	0	49	119
Secondary	33	10	2	45	90
Higher	0	1	0	1	2
Certificate of completion of alph training	0	1	0	0	1
Pearson Chi2 = 47.46 Prob = 0.0000					
cooking energy sources type of accommodation					
	Firewood	Charcoal	Gaz	Firewood + Agricultural residues + Charcoal	Total
House made from sustainable materials	25	21	0	65	111
House made of recycled materials	76	3	0	32	111
House in precarious materials	170	20	2	144	336
	271	44	2	241	558
Pearson Chi2 = 60.05 Prob = 0.0000					

Source: NutAumed/GRAnAp survey, December 2020

Table 3. Multinomial logistic regression

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
	Source of cooking energy : Firewood						
Arrondissement of residence of the household	-.04	.046	-0.86	.389	-.13	.051	
Sex of the head of household	-1.218	0.329	-3.70	0	-1.863	-0.573	***
Number of years spent in the locality	0.019	0.132	0.14	0.886	-0.241	0.279	
Religion of the head of household	-0.068	0.046	-1.47	0.14	-0.157	0.022	
Level of education of the head of household	-0.161	0.089	-1.81	0.071	-0.336	0.014	*
Profession of the head of household	-0.004	0.024	-0.15	0.879	-0.052	0.044	
Size of the household	-0.059	0.17	-0.35	0.729	-0.392	0.274	
Rate of coverage of the household's basic needs	-0.264	0.107	-2.46	0.014	-0.474	-0.054	**
Level of education of the wife of the head of household	-0.014	0.142	-0.10	0.919	-0.293	0.264	
Where the household lives	0.818	0.254	3.23	0.001	0.321	1.315	***
Ownership of the house	-0.593	0.226	-2.62	0.009	-1.037	-015	***
Type of dwelling	0.139	0.136	1.03	0.305	-0.127	0.405	
Constant	1.963	1.109	1.77	0.077	-0.211	4.137	*
	Source of cooking energy : Charcoal						
Arrondissement of residence of the household	-0.07	0.085	-0.82	0.412	-.237	0.097	
Sex of the head of household	0.276	0.535	0.52	0.606	-0.773	1.325	
Number of years spent in the locality	0.153	0.215	0.71	0.478	-0.269	0.574	

Religion of the head of household	-0.184	0.09	-2.05	0.04	-0.36	-0.008	**
Level of education of the head of household	-0.232	0.19	-1.22	0.222	-0.603	0.14	
Profession of the head of household	0.089	0.044	2.00	0.045	0.002	0.176	**
Size of the household	-0.959	0.371	-2.58	0.01	-1.686	-0.231	***
Rate of coverage of the household's basic needs	0.166	0.195	0.85	0.395	-0.217	0.548	
Level of education of the wife of the head of household	0.2	0.238	0.84	0.401	-0.266	0.666	
Where the household lives	-1.288	0.405	-3.18	0.001	-2.081	-0.494	***
Ownership of the house	-1.111	0.433	-2.57	0.01	-1.959	-0.263	**
Type of dwelling	-0.323	0.209	-1.55	0.122	-0.732	0.086	
Constant	2.552	1.815	1.41	0.16	-1.005	6.109	

Mean dependent var	1.382	SD dependent var	1.440
Pseudo r-squared	0.139	Number of obs	558
Chi-square	144.600	Prob > chi2	0.000
Akaike crit. (AIC)	975.582	Bayesian crit. (BIC)	1144.232
*** p<.01, ** p<.05, * p<.1			

Source: NutAumed/GRAnAp survey, December 2020