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Preferences of future cooking fuel types among urban and peri-urban households in Greater Accra Region of Ghana: Business-as-usual or sustainable pathways?

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ABSTRACT

Women and children in Ghana face risks such as burns, poisoning, and injuries from using solid biomass fuels like charcoal and firewood for cooking. Although LPG is the dominant modern cooking fuel, electricity remains less commonly used. In the Greater Accra Region, 70% of households rely on LPG for cooking, while 23% and 3% use charcoal and firewood, respectively. This study examines the future cooking fuel preferences of households in Ga East, Ga West, and Adenta Municipalities, using data from 1200 urban and peri-urban households collected through a mixed-method approach. Findings reveal that LPG is expected to remain the preferred cooking fuel over the next five years, followed by charcoal, with electricity ranked third. These future preferences reflect current practices, indicating a continuation of existing trends. However, 7.3% of households expressed interest in adopting e-cooking technologies, such as Electric Pressure Cookers (EPC), if these technologies become more accessible and affordable. This suggests a potential shift toward sustainable cooking practices. To promote the adoption of e-cooking technologies, critical policy measures focused on education, affordability, and technology availability are necessary. Such initiatives could support a transition to environmentally sustainable cooking solutions in the Greater Accra Region.

1. Introduction

The need to transition to sustainable cooking fuels for the derivation of environmental sustainability and the general well-being of humanity is paramount among the United Nations Sustainable Development Goals (SDGs). Thus, SDGS 3, 7, 11, and 13 were developed and tailored to the realisation of these intents. In developing countries like Ghana, the reliance on traditional biomass fuels, including charcoal and wood, remains predominant. As of 2021, these two solid fuels nationally, constituted 54.3% of cooking fuel sources in Ghanaian households and 22.7% in the Greater Accra Region (Ghana Statistical Service [GSS], 2021). This biomass dependency contributes to significant environmental challenges such as deforestation and air pollution, as well as health issues related to indoor air quality (Azorliade et al., 2022; Elbayoumi and Albelbeisi, 2023; Kyayesimira and Muheirwe, 2021; Zafar et al., 2021). The World Health Organization (WHO) estimates that traditional solid fuels are among the most dangerous environmental health risk factors in the world and that vulnerable women and children are the most exposed groups to the risks of burns, poisoning, and injuries that result from the gathering, production, and the use of these fuels (World Health Organization, 2016).

In her quest to achieve the greenhouse gas emissions reduction target by 2050, Ghana has aimed for natural gas as a transitional fuel while efforts are made to phase out fossil and biomass fuels for sustainable solutions (Ministry of Energy [MOE], 2022a). Even though the adoption of liquefied petroleum gas (LPG) in Ghana has grown significantly over the years following the government's promotional drives, there remains a huge rural-urban disparity (Mensah and Adu, 2015) where 51.3% of urban households primarily use it compared to 14.8% of rural households that cook with it as their primary cooking fuel (GSS, 2022). LPG is the dominant primary cooking fuel (68.2%) among households in the Greater Accra Region (GSS, 2022). Even though LPG is relatively cleaner than biomass, scientific studies suggest that it has environmental and health concerns that cannot be ignored. Gas stoves contribute to indoor air pollution by emitting nitrogen dioxide (NO_2), carbon monoxide (CO), formaldehyde (HCHO), and particulate matter (PM2.5), which can

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all pose various respiratory challenges to users (Johnston et al., 2020; Nicole, 2014). Paulin et al. (2017) found these compounds to be associated with a higher risk of asthma symptoms in children while Michanowicz et al. (2022) associated significant levels of volatile organic compounds inside homes due to the leakage of unburned natural gas with increased cancer rates in Massachusetts.

Other clean solutions such as cooking with electricity (e-cooking) remain sparingly adopted among the general population. As of 2021, only 0.5% and 0.6% of urban households primarily cook with electricity in Ghana and the Greater Accra Region, respectively (GSS, 2022). Several factors influence household energy choices, including economic constraints, cultural practices, fuel availability, and the effectiveness of government policies (Kemausuor et al., 2014; Brew-Hammond and Kemausuor, 2009). Economic barriers, especially, play a significant role, as many households cannot afford the initial costs of cleaner technologies or the ongoing expenses associated with these fuels (van der Kroon et al., 2013). Additionally, infrastructural challenges, such as inconsistent supply and distribution networks, hinder the widespread adoption of sustainable cooking fuels (Anang et al., 2021).

As Ghana engages in the transition process towards clean energy for all households as captured in the National Energy Transition Framework (Ministry of Energy [MOE], 2022a) and the updated Nationally Determined Contributions (NDCs) under the Paris Agreement (2020–2030) to the United Nations Framework Convention on Climate Change -UNFCCC- (MESTI, 2021), it is unclear what households' future cooking preferences will be and how far such future choices may deviate from present cooking fuel choices. It is, therefore, imperative to understand the intentions of Ghanaian households regarding their future cooking fuel preferences, hence, various empirical studies can inform the development of effective interventions to enhance the green cooking fuels transition. This paper investigates whether households in the Greater Accra Region of Ghana will continue on a 'business-as-usual' path, that is, the predominant use of LPG and biomass fuels, or will transition towards more sustainable alternatives like e-cooking technologies. The key determinants of the households' future choices are also explored. The paper envisages contributing to the broader discourse on energy transitions in developing countries by building insight into the challenges and opportunities associated with shifting towards sustainable energy pathways.

2. Empirical demonstrations and theoretical underpinning of future cooking fuel choices in developed and developing countries

Food is one of the basic needs of the household according to Maslow's Hierarchy of Needs (Maslow, 1943). In this modern era, there is no food without the process or act of cooking, and in most instances, there will be no cooking without energy or fuel. Cooking is, therefore, as important as the energy or fuel required because the continual use of dirty and polluting fuels adversely affects the environment and the climate in ways that will certainly affect the future capacity of households to meet their own needs and the needs of future generations (IPCC et al., 2018). In most developing countries, cooking accounts for a significant share of total energy consumption by the household sector (IEA, 2023). Therefore, the future fuel choices of households can affect the achievement or otherwise of SDGs 3, 7, 11, and 13.

When households perceive sufficient control over some fuel options, they are almost certain to adopt them (Waris et al., 2023; Wolske et al., 2017). For example, when households have technical knowledge about a certain technology, its availability, and the comparative cost to other technologies, they are more likely to show favouritism towards such fuel options. Conversely, when households perceive not to have control over the supply chain, cost, and technical know-how of certain fuel options, they are likely to look toward more favourable alternatives (Wolske et al., 2017). In developed and emerging regions like Europe and some parts of Asia respectively, cooking fuel and technologies have shifted towards cleaner options in the past few decades, motivated by various factors. By 2022, the most common fuel used for cooking in Europe just like in the United States of America (USA) was electricity (45%), followed by gas (39%) and solid fuels (16%) (Leach, 2024). Currently, some 50% of households in the Organization for Economic Co-operation and Development (OECD) countries primarily use electric stoves for their cooking needs. This is partly explained by the full accessibility to electricity contrary to the complexities of gas networks which, for instance, do not reach more than 25% of United States households while only 40% of households are connected in the European Union (Leach, 2024).

Burguillo et al. (2022) observed that households in Europe and the United States of America prefer electric induction stoves as their present and future cooking technologies because of growing awareness of environmental issues surrounding dirty fuels, coupled with their cost savings and advanced technology properties. An earlier comparative study among developed countries on the health impacts of cooking fuels by Choudhuri and Desai (2020), adds more layers to the factors that influence households to utilise fuels that emit fewer pollutants. Accordingly, health and indoor air quality considerations are among the factors that make electrical appliances very appealing to households in developed countries. Technological advancement has also been very instrumental in shaping the cooking fuel landscape in most advanced countries. Damayanti et al. (2023) and Noverita and Mussry (2020), note that the convenience in usage and other advanced features of induction stoves have made them attractive to many households in the developed world. A recent consumer report developed in 2022 by the CR Survey Research Department in the United States found that 70% of the people who participated would consider induction ovens for their next range of cooktops (CR Survey Research Department, 2022). Accordingly, features like auto shut-off, child locks, and cool-to-touch surfaces make cooking technologies like the induction stove an attractive technology for the present and future (CR Survey Research Department, 2022; Damayanti et al., 2023).

In developing countries, there is generally a low preference for non-traditional fuel technologies among households. A large section of the rural population in these countries continually depends on fuelwood, dung cake, and crop residues for cooking (Rahut et al., 2019). Rasel et al. (2024) found that more than 70% of rural dwellers in Bangladesh rely on solid fuel even though several health issues like cough, chest pressure while breathing, eye discomfort, diabetes, asthma, and allergies have been significantly found present among the rural population. Many of the participants, according to the study, are unable to afford modern cooking fuels/technologies because of economic challenges. Unless there is a drastic improvement in the living standards of rural Bangladeshis, they will continue to depend on traditional fuels in the future. Among agricultural households in Nigeria, Aminu et al. (2024) found that even though traditional cooking fuels consisting of wood, crop residue, and animal dung continue to dominate their cooking-fuel landscape, continuous receipt of remittances by the households, increased wealth status, higher educational level, and access to electricity can facilitate the transition towards modern and clean cooking fuels in the future. Among urban Pakistanis, Rahut et al. (2020) found that households with higher education and wealth status are more likely to stick with cleaner fuels like gas and electricity in the future while poorer households and those with less education will continue to depend on dirty solid fuels like cake dung and crop residues for cooking. Besides education, wealth, and income, age has also been found to significantly influence the choice of cooking fuel in Uganda, Tanzania, and other parts of the developing world. According to Katutsi et al. (2020) and Nkolo et al. (2019), as people get older in developing countries like Uganda and Tanzania, they tend to stick to traditional fuels which are cheap and readily available because these people already have depleted savings and inadequate investments.

Karimu (2015) investigated the key factors influencing the choice of cooking fuels in Ghana. The researcher showed that while education, income, urban location, and access to infrastructure highly influence the choice of households' main cooking fuel, an increase in households' income is the most likely factor that increases the probability of choosing modern fuels like LPG or electricity. Alem et al. (2016) found similar results in Ethiopia where households are accustomed to using multiple fuels often determined by their economic status, price of alternative energy sources, and education. Poblete-Cazenave and Pachauri (2018) structurally modeled cooking fuel choices in Ghana, Guatemala, India, Nigeria, and Uganda using the Method of Simulated Moments. Their results were in sync with those of Karimu (2015) and Alem et al. (2016). They found a strong response of demand for LPG to income and a strong responsiveness of self-collected free biomass to increased fuel prices and decreased income. The results suggest that low-income and upward price changes adversely affect future preferences for clean cooking solutions and will require policies that help to reorient people about the harmful impacts of cooking with solid fuels.

Bawakyillenuo et al. (2021), reviewed existing literature on the landscape of energy for cooking in Ghana. The review revealed that households in Ghana generally adopt different cooking fuels, cooking methods, and conversion technologies based on fuel availability and affordability, staple food, and household sizes. Accordingly, the costs and benefits identified with types of cooking fuels determine the choice of the fuel. The review cited the example that while biomass fuels are the most adopted fuel because of affordability, accessibility, and availability, electric cooking was not on the radar for many households because of the perceived high cost and supply issues. The study argued for the promotion of clean fuel stacking with LPG and electricity as the viable pathway. Bofah et al. (2022) assessed the factors that determine the transition to cleaner cooking energy in Ghana using the GLSS 7 household data in a multinomial logistic regression model. The study found education, modern housing, paid employment, and higher income of household heads to drive the adoption of cleaner cooking fuels. Oyeniran and Isola (2023) analysed the 2015/16 and 2018/19 waves of Nigeria's National Household Survey data, which clearly showed slow adoption of clean cooking fuels, with the trend likely to continue in the future until policymakers address the issues of low income, fuel accessibility challenges, and low education on the benefits of sustainable fuels. According to Mishra et al. (2024), India houses more than a quarter of the world's solid fuel users, and a transition to cleaner fuels will enhance global environmental and socio-economic impacts. However, LPG and piped natural gas are the fuels that many Indians are being encouraged to adopt for the present and the medium-term future.

Three theories provide an anchorage to this paper in terms of explaining households' future cooking fuel decisions and choices: the Energy Stacking Theory (EST), the Theory of Planned Behaviour (TPB), and the Diffusion of Innovation (DOI) Theory. Masera et al. (2000) critiqued the linear progression model of the energy ladder hypothesis where income or economic growth alone is considered the main and only driver for households to change their energy-user behaviour. Other factors could affect the fuel-switching behaviour of households such as preferences, taste, reliability of supply, and cooking habits which the energy ladder hypothesis has not accounted for. These criticisms have led to the proposal of the EST to explain the fuel-switching behaviour of households (Masera et al., 2000). The proponents of the EST posit that households do not switch exclusively from traditional to modern fuels but use a combination of different energy sources, depending on availability, cost, convenience, and specific cooking needs. The EST acknowledges the complexity and flexibility of household energy use and, hence, allows households to adapt to changing circumstances and resource availability. The choice of fuels can vary due to the economic status of the households, access to different fuels, and other contextual factors. In effect, energy stacking ensures continuous energy access by hedging against supply disruptions, price fluctuations, and other uncertainties (Masera et al., 2000). Because it is believed to be practised by everyone (Dumga and Goswami, 2023; Shankar et al., 2020), some studies (Dumga and Goswami, 2023; Perros et al., 2024) argue that fuel stacking encourages the usage of polluting fuels and limits the potentials of clean cooking solutions.

The TPB, developed by Ajzen (1991) proposes that individual behaviour is driven by his/her behavioral intentions, which are normally influenced by attitude toward the behaviour, subjective norms, and perceived behavioral control (Fig. 1). These three factors collectively shape an individual's behavioral intentions, which in turn predict the likelihood of the behaviour being performed.

Accordingly, subjective norms reflect the influence of family, friends, and colleagues, and societal norms on the individual's decision-making process. The individual's attitude toward the behaviour refers to the positive or negative evaluation of performing the behaviour such that behaviours that promise favourable outcomes are more likely to be performed. Perceived behavioral control encompasses the ease or difficulty of performing the behaviours and is influenced by past experiences and anticipated obstacles (Ajzen, 1991).

Rogers' (1995) DOI Theory explains how new ideas, products, or practices spread within a population. The process is influenced by four key factors (Fig. 2). First, the innovation itself plays a central role, with five attributes affecting its adoption: relative advantage (the perceived benefit over existing solutions), compatibility (alignment with users' values and needs), complexity (ease of understanding and use), observability (visibility of its benefits), and trialability (opportunity to test before committing). Second, communication channels are critical, as information about the innovation must flow effectively through interpersonal interactions, media, and networks. Third, time is vital, encompassing the rate of adoption and the categorization of adopters into innovators, early adopters, early majority, late majority, and laggards. Finally, the nature of the social system—its norms, values, and structure—determines the level of acceptance and dissemination of the innovation, as well as the influence of opinion leaders and social networks.

In the context of households' future cooking fuel choices, the TPB and DOI theories provide insights into the factors that drive or hinder the adoption of some fuel options in the present and future periods. When households perceive certain benefits of a particular fuel such as health benefits, cost savings, easy access, availability, compatibility, and convenience, they exhibit positive attitudes towards such fuel, leading to its adoption. Future adoption of certain fuels may be hindered if they are perceived as not having a clear relative advantage over others and if the benefits are not observable. The EST suggests an alternative behaviour of using multiple fuels at the same time to reflect the complex and interactive web of factors that may influence households' future cooking fuel choices.

3. Methodology

3.1. Research design

The study utilised a sequential mixed methods approach in the

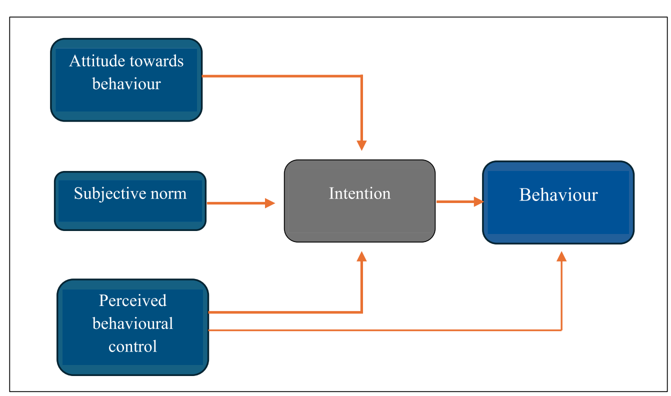

Fig. 1. Pictorial representation of the Theory of Planned Behaviour.

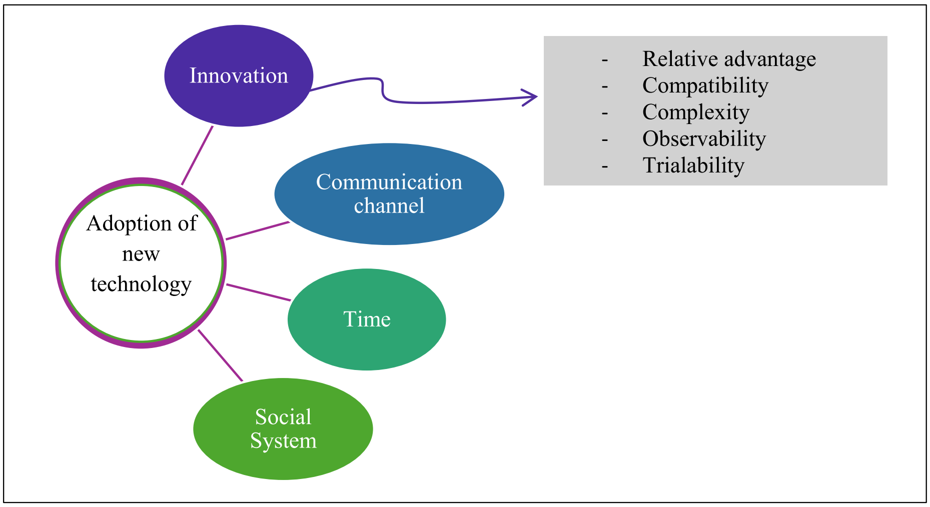

Fig. 2. Combined factors facilitating the spread of new ideas among a population.
Source: Authors' construct based on Rogers (1995)

household data collection phase of the MECS[1] Phase II project, from which this paper is written. The researchers first collected and analysed the quantitative data, followed by the collection of the qualitative data informed by preliminary findings from the quantitative data analysis. The two approaches were integrated at the data analysis stage to ensure complementarity.

3.2. Study locations

Three urbanized districts with slightly differentiated features were selected as the locations for the study. These are Ga East, Ga West, and Adenta Municipalities. Ga East Municipality is an urbanized city with over 80% of the residents living in urban and peri-urban areas while the rest live in rural areas. It is densely populated with a household population of 90,835 and a total population of 283,379, and predominantly youthful (GSS, 2021). Commerce and Services are the main economic activities that residents are engaged in. Agricultural and industrial activities are also common, particularly in the construction sub-sector, which has seen an upsurge in estate and housing development projects in the city. Ga West Municipality also has a mix of urban and peri-urban residents who constitute about 80% of the population. In recent years, the municipality has become known for its housing development and dormitory characteristics with sprawling middle-class families living there and commuting to Accra for their business activities. The household population of the municipality is 88,433 and the total population is 314,299 with broad-base characteristics (GSS, 2021). Lastly, Adenta Municipality is a highly urbanized and rapidly growing municipality of about 73,281 households and a broad-based population of 237,546 (GSS, 2021). Over 80% of its residents live in urban and peri-urban communities as of 2021.

The study targeted urban and peri-urban settlements in the three (3) municipalities for the research activities. Through the help of high-level municipal officers from the three (3) municipalities, ten (10) urban and peri-urban settlements/communities (Fig. 3) were identified from their Medium-Term Development Plan documents. Additionally, the settlements in the three (3) municipalities have been demarcated as first-, second-, and third-class settlements based on the availability of social amenities like good roads, water, electricity, etc., for the purposes of revenue collection by the local authorities.

3.3. Data requirements and sampling frame

The study used data collected for the MECS Phase II project in 2023. The quantitative data is cross-sectional and was collected from urban and peri-urban households in selected communities in the three (3) municipalities after ethical approval was obtained from the Ethics Committee for Humanities at the University of Ghana.[2] Smith's (2013) sample size determination method was adopted to compute the sample size based on the household population of the three districts according to the 2021 Population and Housing Census (PHC). The sample size was determined using the formula:

$$ss = \frac{(Z - score)^2 * StdDev(1 - StdDev)}{(CI)^2}$$

where Z-score is the z value corresponding to the 95% confidence level *(Z-score = 1.960)*; StdDev is the standard deviation *(StdDev = 0.5)*; and CI is the confidence interval *(CI = 5)*.

When the population size is known, the actual sample size (*new ss*) is computed using:

$new\ ss = \frac{ss}{1+\frac{ss-1}{pop}}$; where *pop* is the population

Four hundred (400) households each were sampled in Ga East and Ga West while 403 were selected from Adenta Municipality. Due to missing data on key variables for one respondent household, the total sample used for the analysis is 1202. Broken down further, 882 households were from urban areas while 320 were sampled from peri-urban areas. Out of the urban households, 201 first-class and 240 s-class treatment households were sampled against 201 and 240 first and second-class control households. The determined sample is representative of the three (3) selected municipalities, which are cosmopolitan, reflecting characteristics typical of municipalities in Ghana and Africa. Therefore, the findings are broadly applicable to similar settings.

The household quantitative survey was undertaken by twenty (20) trained field workers who used the computer assisted personal interviewing (CAPI) system to administer the structured/semi-structured questionnaires to respondents. The study employed a random sample approach that targeted respondents in the selected communities, with

[1] Institute of Statistical, Social and Economic Research (ISSER) Modern Energy Cooking Services (MECS) Phase II 'Consumer Needs, Behaviour, and Expectations Survey on MECS in Urban and Peri-urban Ghana' 2023. This study, with Contract Number 7206640, was awarded to the lead author of this paper, a researcher at ISSER, by The World Bank Group, and the research was carried out by him and the rest of the co-authors.

[2] Ethical Clearance No.: ECH 068/23–24).

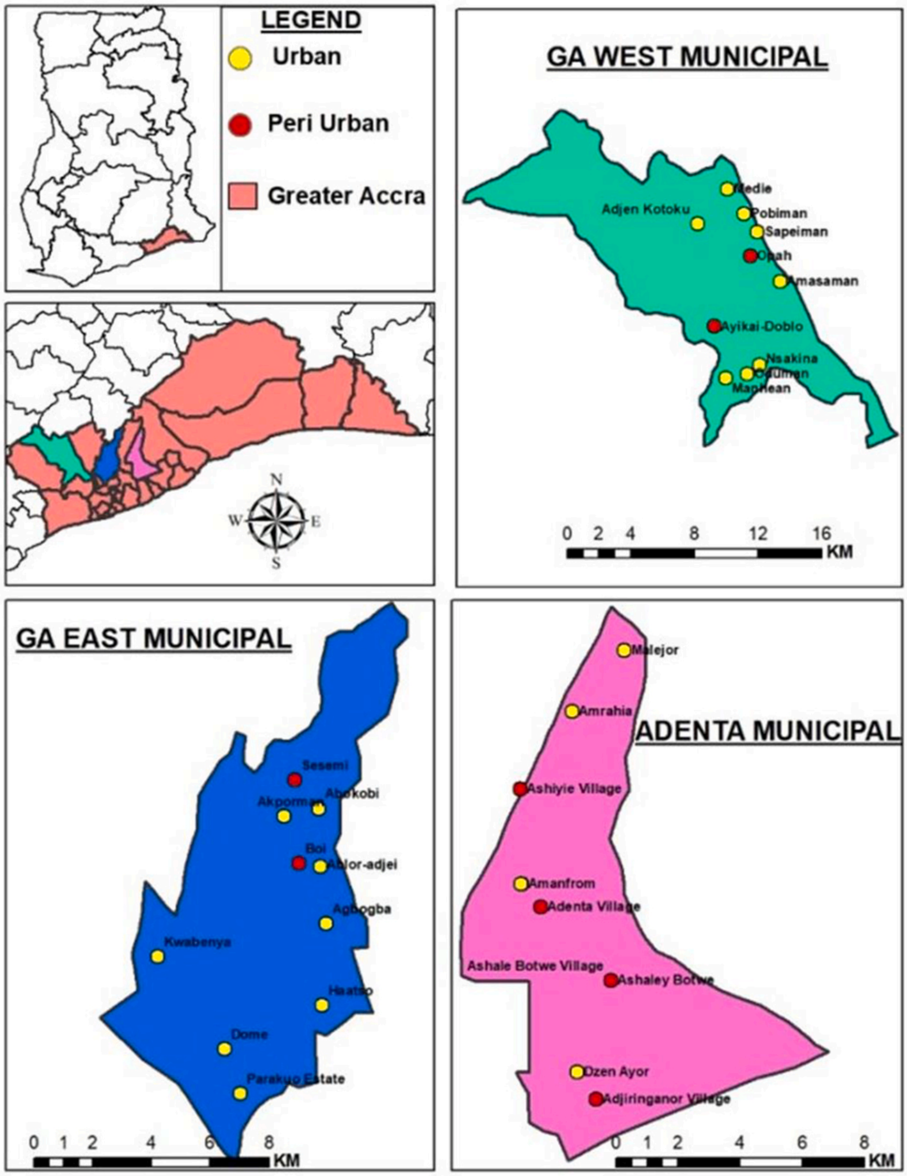

Fig. 3. Study areas (municipalities) showing urban and peri-urban communities.
Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

each respondent's willingness to participate being the key eligibility criterion. The qualitative component targeted households in the three municipalities who could share their experiences and future cooking fuel preferences. The qualitative study employed a Focus Group Discussion (FGD) instrument to collect the necessary data. Eight (8) participants from Ga East and ten (10) each from Adenta and Ga West Municipalities participated in the FGDs. The identification and selection of participants of the FGDs were coordinated by experienced field supervisors recruited for the surveys. The FGD participants in the Ga East municipality consisted of households from both urban and peri-urban, while only urban households participated in Adenta municipality, and only peri-urban households participated in the Ga West municipality. The final datasets were securely stored without identifiers to ensure data confidentiality.

3.4. Analytical methods

The quantitative component of the study relied on descriptive, chi-square, and inferential analytical techniques to assess the associations between key variables of interest. The qualitative data, largely textual, representing the voices of the FGD participants, was interlaced with the quantitative findings. Key quotations from developed themes were used to complement the quantitative findings.

For the inferential analysis, the study used the multinomial logistic regression technique, which best predicts the probability of category membership on a dependent variable based on multiple independent variables. Multinomial logistic regression allows for more than two categories of the dependent or outcome variable, which in this paper is the future cooking fuel choices. This dependent variable has been categorised into biomass (charcoal and firewood), LPG, and green fuel (electricity and biogas). The variable was derived from the respondents' answers to the question: *"In 5 years' time, which fuel will be your household's primary cooking fuel?"* The 5-year period (2023–2028) aligns closely with the Greater Accra Regional Co-ordinating Council's Medium Term Development Plan (2022–2025), making the findings relevant for future planning. While many studies like Mensah and Adu (2015), Rahut et al. (2019) and Bofah et al. (2022) have predicted the adoption of household cooking fuels using models like the multinomial logistic regressions, they did not employ the future preferences mode of inquiry as used in this study. Thus, the utilisation of this distinctive approach in this paper aligns with established behavioral science theories like the Theory of Planned Behaviour, which posits that intentions are the strongest predictors of future behaviour, as they reflect an individual's attitudes, subjective norms, and perceived behavioral control. The authors acknowledge that the reported preferences are likely based on households' current circumstances and anticipated future conditions and, hence, may be subject to change in the future. However, they provide valuable insights into the future cooking fuel choices of households; and will be indispensable to the development of Ghana's Clean Cooking Strategy as part of the National Energy Transition Framework.

The future cooking fuel variable is then modeled using the multinomial logistic regression which uses maximum likelihood estimation to evaluate the probability of categorical membership. The general form of the multinomial logit (mlogit) model is specified as

$$\Pr(y_i = j) = \frac{\exp(X_i\beta_i)}{1 + \sum_{j=1}^{j} \exp(X_i\beta_i)} \tag{1}$$

and can be simplified as;

$$\Pr(y_i = 3) = \frac{1}{1 + \sum_{j=1}^{j} \exp(X_i\beta_i)} \tag{2}$$

where "i" and "j" represent the individual and observed outcome of the choice of future cooking fuel and β_i are the unknown parameters to be estimated. The categorical future cooking fuel choice variable is defined as:

$$FUTURE\_FUEL(y_i) = \begin{Bmatrix} y_1 = Biomass \\ y_2 = LPG \\ y_3 = Greenfuel \end{Bmatrix} \tag{3}$$

The multinomial logistic model often selects one of the categories as a reference category with which all other outcomes are compared. In this paper, the third category (Green fuel) is selected as the reference or base category. The general mlogit models in Equations (1) and (2) are, therefore, transformed to specifically suit the current study as:

$$P_{ij} = \frac{\exp(X_i\beta_i)}{1 + \sum_{j=1}^{2} \exp(X_i\beta_i) for\ j = 1, 2} \tag{4}$$

P_{ij} is the probability of choosing biomass and LPG.

$$P_{i\,3} = \frac{1}{1 + \sum_{j=1}^{2} \exp(X_i\beta_i)\ for\ j = 3} \tag{5}$$

$P_{i\,3}$ is the probability of being in the reference group, that is, choosing green fuel (i.e. electricity or biogas). In practice, when estimating the model, the coefficients of the reference group are normalized to zero (Maddala, 1983; Greene 1994; Kimhi, 1994) because the probabilities for all the choices must sum up to unity (Greene 1994). In this paper, however, marginal effects were estimated for all three categories to show the effect change for each category for any unit change in the explanatory variables. The empirical model that was estimated is specified as:

$$\begin{aligned} FUTURE\_FUEL_i = {} & \beta_0 + \beta_1 SEX_i + \beta_2 LOC_i + \beta_3 EDU_i + \beta_4 AGE_i + \beta_5 SPACE_i + \beta_6 CC\_MEASURES_i \\ & + \beta_7 CUR\_FUEL_i + \beta_8 HHINCOME_i + \beta_9 PRICE\_BIOMASS_i \\ & + \beta_{10} PRICE\_LPG_i + \beta_{11} PRICE\_ELECTRICITY_i + \varepsilon_i \end{aligned} \tag{6}$$

where *FUTURE_FUEL* is the dependent future cooking fuel choice variable, *SEX* is the sex of the household head measured in male-female binary form, *LOC* is the urban or peri-urban locality of the household, *EDU* is the educational status of the household head measured in three categories (no formal education, primary and secondary plus), *AGE* is the age category of the household head measured in three categories (18–35 years, 36–60 years, and above 60 years), *SPACE* represents the availability of space for cooking measured as a yes or no binary variable, *CC_MEASURES* is a binary variable that assesses whether the household head has knowledge of climate change adaptation and mitigation measures or not, *CUR_FUEL* is the current fuel preference of the household measured in three categories (biomass, LPG, and electricity), *HHINCOME* is the income bracket of the household measured in four categories (0–500, 501–2000, 2001–5000, and 5001 plus, all in Ghana Cedis), *PRICE_BIOMASS* is households' perception of the price of charcoal in their locality measured in three categories (expensive, neither expensive nor cheap, and cheap), *PRICE_LPG* is households' perception of the price of LPG in their locality also measured in the same three categories, and *PRICE_ELECTRICITY* is households' perception of the price of electricity in their locality measured in the same three categories. Per the principles of the Theory of Planned Behaviour, while variables like income, education, and age shape positive or negative evaluations of adopting certain fuel types in the future, others like current fuel choices and the perceptions of their prices affect the perceived ease or difficulty of making future fuel choices.

4. Presentation and discussion of results

4.1. Key characteristics of the sampled households

The households selected for this study consisted of more male-headed households, around 62%, than female-headed households (Table 1). This sex composition was observed across the three municipalities and the urban and peri-urban locations. About 42% of the sample attained a Middle/Junior High School level of education while some 24% and 11% also attained Secondary School and Tertiary levels of education. Only 10% did not have any formal education (Table 2). Similar patterns are observed in both urban and peri-urban areas. About 68% of the respondent households are self-employed, 16% are in paid employment, both public and private, while some 11% are inactive, either retired, ill or out of the labour force (Table 3).

Regarding who makes the decisions on what to cook in the house, the head of the household often dominates (Table 4). While 24% also pointed to the spouse as the decision maker, about 17% equally noted that the household head and the spouse jointly make decisions regarding cooking in the house (Table 4).

Some viewpoints from the qualitative participants corroborate the results of the quantitative study. Two such viewpoints from the FGDs are

Table 1
Sex of household heads (percent of households) vis-à-vis their locations.

Sex	Municipality			Locality		Total
	Adenta	Ga East	Ga West	Peri-urban	Urban	
Male	59.3	66.2	60.0	63.4	61.2	61.8
Female	40.7	33.8	40.0	36.6	38.8	38.2
Sample (n)	403	399	400	320	882	1202
Weighted sample (N)	73281	90608	88433	64948	187374	252322

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

Table 2
Educational status of household heads (percent of households) vis-à-vis their locations.

Education level	Municipality			Locality		Total
	Adenta	Ga East	Ga West	Peri-urban	Urban	
No formal education	10.2	3.5	17.5	11.9	9.9	10.4
Primary	7.0	14.0	15.0	9.1	13.0	12.0
Middle/JSS/JHS	39.0	44.4	43.3	43.4	42.7	42.2
Secondary	29.0	25.3	19.3	24.7	24.5	24.5
Tertiary	14.9	12.8	5.0	10.9	10.9	10.9
Sample (n)	403	399	400	320	882	1202
Weighted sample (N)	73281	90608	88433	64948	187374	252322

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

below.

"I do the cooking, but the man I live with decides on what to cook" (A 29-year-old female FGD participant in Adenta municipality, Oct. 2023)

"The man takes the decision; you need to ask him what he wants to eat and then you cook the exact meal for him. I can't cook yam when he prefers rice; so, it's the man who takes the major cooking decisions". (A 37-year-old female FGD participant in Ga East municipality, Oct. 2023).

The voices suggest that men do not necessarily take part in the actual cooking of the meal for the household, but they sometimes decide what must be prepared which agrees with some findings of scholars from the African Region. Ochieng et al. (2021), for example, argued that gender roles for so long in Kenya have dictated for women to be more involved in cooking which ultimately meant that most cooking technology innovations often targeted women. In agreement, Wooten acknowledged in his paper that "women always make the meals" in contemporary rural Mali (Wooten, 2022). In other cultures, even the decision of what to cook is left entirely for the women to make. Allen et al. (2015), for instance, examined how African American men perceived the roles their wives played in their eating habits. Accordingly, the men indicated that their wives influenced what they ate at home more than their preferences, unlike the freedom they enjoyed when eating out.

Table 3
Employment status of household heads (percent of households) vis-à-vis their locations.

Employment status	Municipality			Locality		Total
	Adenta	Ga East	Ga West	Peri-urban	Urban	
Unemployed	3.7	5.8	4.0	5.0	4.3	4.5
Employee (private)	17.4	14.0	4.8	14.4	11.2	12.1
Employee (public)	6.7	3.8	3.0	5.0	4.3	4.5
Self-employed	62.3	65.7	76.3	63.4	69.7	68.1
Inactive (retired, ill, out of labour force)	9.9	10.8	12.0	12.2	10.4	10.9
Sample (n)	403	399	400	320	882	1202
Weighted sample (N)	73281	90608	88433	64948	187374	252322

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

Table 4
Household member(s) who make major cooking decisions (percent of households).

Major cooking decisions maker	Municipality			Locality		Total
	Adenta	Ga East	Ga West	Peri-urban	Urban	
Household head	52.4	46.6	59.8	46.6	55.1	52.9
Spouse	21.1	26.1	24.8	26.6	23.3	24.0
Both the household head and spouse	20.4	18.8	12.5	18.0	16.7	17.2
Other household member	6.2	8.5	3	8.9	4.9	5.9
Sample (n)	403	399	400	320	882	1202
Weighted sample (N)	73281	90608	88433	64948	187374	252322

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

Table 5
Current fuel stacking by households per their locations.

Cooking fuels used by households	Locality		Total
	Peri-urban	Urban	
LPG	72.5	72.6	75.6
Charcoal	94.1	88.6	90.0
Firewood	17.2	13.3	14.3
Wood pellets/chips	0.3	0.5	0.4
Electricity	22.5	24.7	24.1
Kerosene	0.3	0.1	0.2
Valid cases	320	882	1202

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

4.2. Current versus future cooking fuel choices

Going by the stipulations of the EST it emerges that households, in recent years, have embraced the idea of using different fuels for different reasons rather than completely shifting to more clean fuel sources when their incomes increase. The results of the study reveal that households in the Greater Accra Region use multiple fuel sources, predominantly LPG, charcoal, electricity, and firewood (Table 5) which is consistent with the findings of Dumga and Goswami (2023) in Southern Ethiopia and Perros et al. (2024) in Kenya. Of the fuels that are often stacked, the households revealed their first, second, and third preferences as presented in Figs. 3–5. Generally, nearly equal numbers of households prefer LPG and charcoal as their first-choice cooking fuels. About 49% of the sampled households reported that LPG is their first-choice cooking fuel currently, while 45% preferred charcoal as their first-choice cooking fuel (Fig. 4).

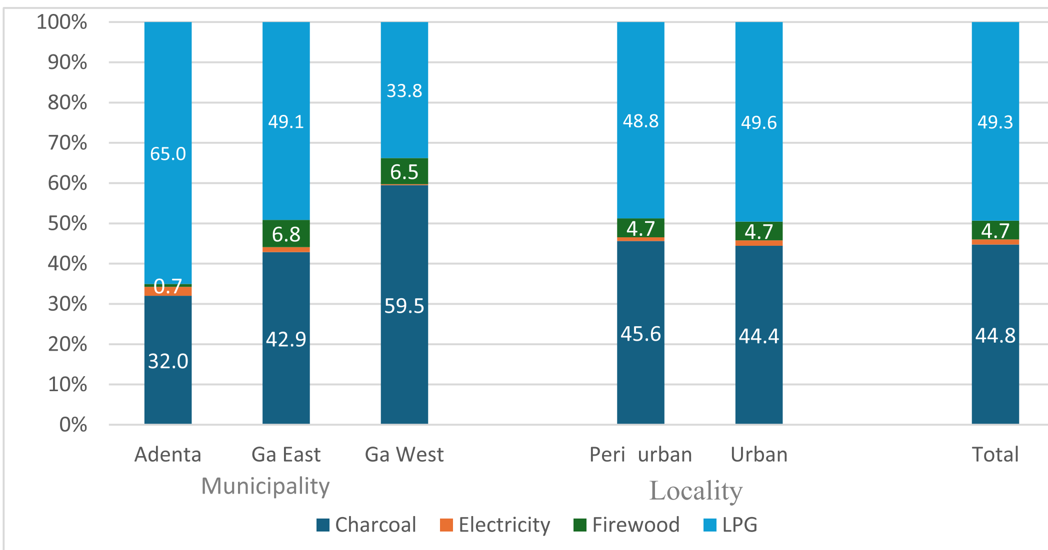

Fig. 4. Households' first choice cooking fuels according to various locations
Percentage of households who selected electricity (orange-coloured data series) as their first-choice cooking fuel: Adenta - 2.2%, Ga East - 1.3%, Ga West - 0.3%, Peri-urban - 0.9%, Urban - 1.4%, Total - 1.3%. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

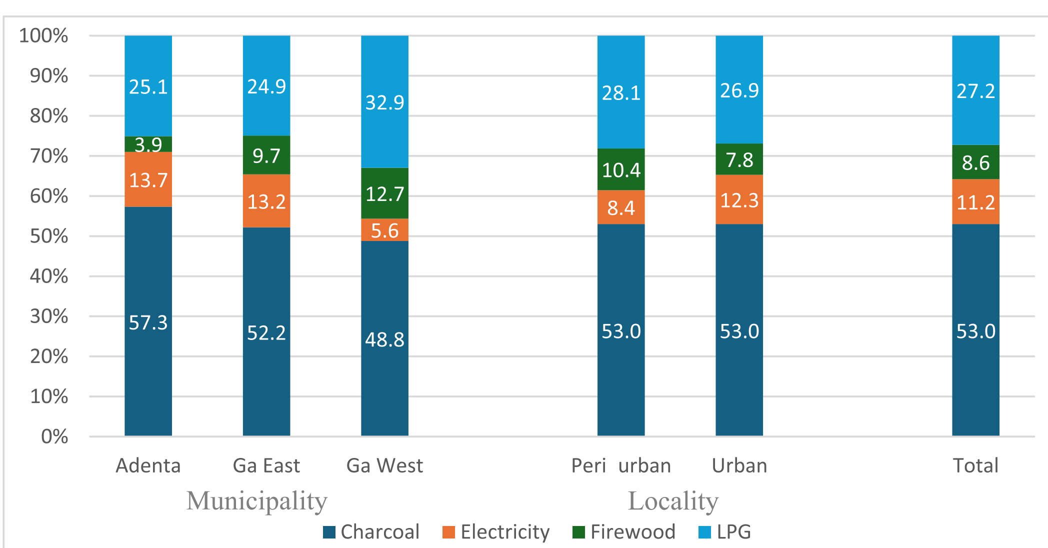

Fig. 5. Households' second choice cooking fuels according to various locations.
Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

These preferences are very much the same among urban and peri-urban localities, although along the different municipalities' context, charcoal is most preferred as a first-choice fuel in Ga West while LPG is most preferred in Adenta Municipality. The Ga East preference mirrors the general average.

In analysing the fuel that is mostly preferred as a second-choice cooking fuel currently, charcoal emerges tall among them across the urban-peri urban localities, as well as the different municipalities (Fig. 5). This result corroborates the findings of earlier studies like Karimu (2015), Alem et al. (2016), and Bawakyillenuo et al. (2021) that households in developing countries, particularly those in urban areas have shifted to the usage of LPG but still maintain biomass for different purposes. Some of the reasons for the present fuel preferences as articulated by the participants of the FGDs include the quantity (size) of meals being cooked, convenience of fuel usage, and pollution caused by the fuels. The viewpoints of three FGD participants illustrate the phenomenon vividly:

> *"If I want to cook in bulk, I will do the cooking outside because I will use charcoal; but will use LPG inside the kitchen when I am cooking small quantity of food"* (A 30-year-old female FGD participant in Adenta municipality, Oct. 2023)

> *"I use LPG. I like it very much. During our time, we used the traditional firewood stove, and it cooked like LPG. When I don't have money to fill my cylinder, I fall on the charcoal, and I will fan it till my frontage becomes dirty. That's why we prefer LPG because it also cooks fast"*. (A 73-year-old female FGD participant in Adenta Municipality, Oct. 2023).

> *"When I use the LPG to cook all my meals and I need to eat some at any given time, I will not use the LPG to heat the food, but I will use the microwave to heat it. They are all helpful because sometimes if there's any power outage, I use the LPG and when I run out of it I also depend on the electricity"*. (A 44-year-old male FGD participant in Ga East municipality, Oct. 2023).

The fuel mostly preferred as the third-choice cooking fuel is electricity as depicted in Fig. 6. About 55% of the households who made known their use of electricity to cook indicated they use it as a third-choice fuel. This third-choice e-cooking status was evident across both urban and peri-urban localities, as well as across different municipalities (Fig. 6). This contrasts the cooking fuel choices in developed countries, where electricity is utilised as the most preferred cooking fuel, according to the works of Burguillo et al. (2022), and Leach (2024).

In the future, LPG will have a stronger role in the cooking fuel mix among households in urban and peri-urban communities in the Greater Accra Region, with the differences being very small and statistically insignificant (Table 6). About 71% of the sampled households indicated that they would use LPG as their primary cooking fuel in five years

Table 6
Households primary future cooking fuel choices by locations.

Households preferred PRIMARY cooking fuel in the next five (5) years	Locality		Total
	Peri_urban	Urban	
LPG	69.4	71.7	71.1
Charcoal	20.6	19.1	19.5
Firewood	1.3	1.5	1.4
Wood pellets/chips	0.3	0.0	0.1
Electricity	8.1	7.0	7.3
Biogas	0.3	0.8	0.7
Sample (n)	320	882	1202
Pearson Chi2 (Prob)	4.5131 (0.478)		

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

Table 7
Households primary future cooking fuel choices by sex and age of household head.

Households preferred PRIMARY cooking fuel in the next five (5) years	*Sex of household head*		*Age group of household head*			*Total*
	Male	Female	18–35	36–60	Above 60	
LPG	*72.1*	*69.3*	*76.4*	*71.0*	*59.3*	*71.1*
Charcoal	*16.8*	*23.8*	*9.6*	*21.7*	*30.7*	*19.5*
Firewood	*1.6*	*1.1*	*1.2*	*1.1*	*3.3*	*1.4*
Wood pellets/chips	*0.1*	*0.00*	*0.0*	*0.1*	*0.0*	*0.1*
Electricity	*8.2*	*5.9*	*12.0*	*5.4*	*6.0*	*7.3*
Biogas	*1.1*	*0.0*	*0.9*	*0.6*	*0.7*	*0.7*
Sample (n)	*743*	*459*	*334*	*718*	*150*	*1202*
Pearson Chi2 (Prob)	*15.53 (0.0083)*		*51.82 (0.0000)*			

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

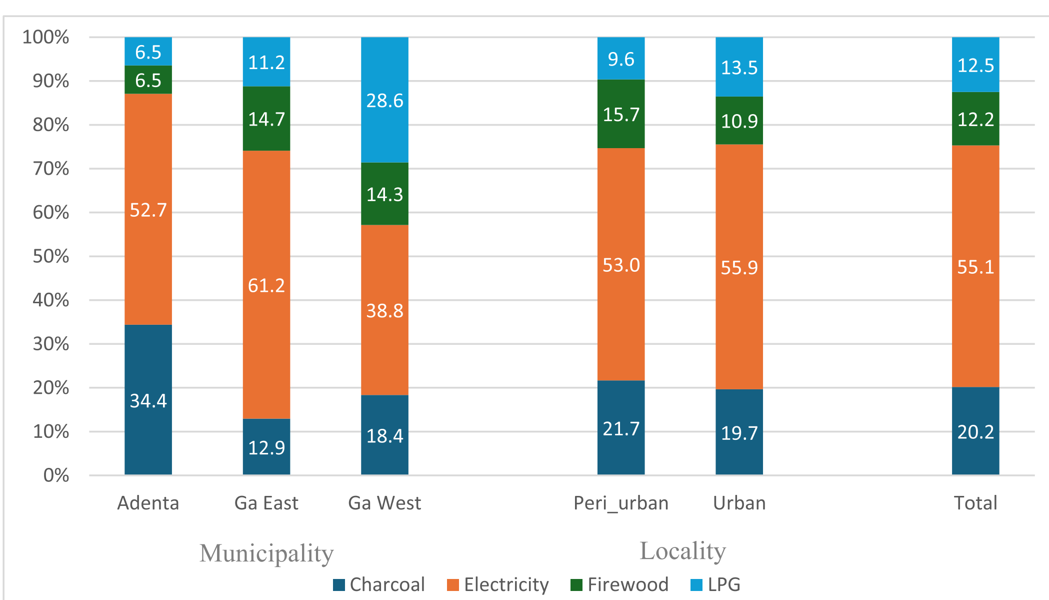

Fig. 6. Households' third choice cooking fuels according to various locations.
Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

(Table 6). This is followed by charcoal (20%) and electricity (7%). More male-headed households would use LPG in the future and slightly more female-headed households would use charcoal in the future (Table 7). This may be down to resource availability which many studies have revealed to be higher for male-headed households (Lewis and Pattanayak, 2012; Pachauri and Rao, 2013) contrary to other studies like Mensah and Adu (2015) and Rahut et al. (2019), who found female-headed households to favor cleaner cooking solutions since they mostly do the cooking. Additionally, while higher proportions of households headed by adults (36–60 years) and the aged (above 60 years) are more likely to use charcoal in the future compared to households headed by youths (18–35 years), the reverse is true for future e-cooking prospects where a higher proportion of households headed by youths are more likely to cook with electricity in the future than households headed by adults and the aged (Table 7). The observed differences are significant at 1% from Pearson's Chi-square statistics (Table 7).

Aside from age seemingly influencing future cooking fuel choices, particularly e-cooking (Table 7), education also plays a role in the prospects of cooking with electricity in the future. The proportion of households that would cook with electricity as their primary fuel increases with higher levels of education attained by the household head. The results reveal that the majority of households will opt for LPG as their primary cooking fuel in the future. It is evident from Table 8 that the usage of biomass fuel (charcoal and firewood) would decline in the future upon the attainment of a higher education by the household head. About 32% of households whose heads have no formal education will use charcoal in the future. This percentage has reduced to 11% and 12% for household heads who have completed secondary and tertiary levels of education respectively. Conversely, the proportions of households who revealed that they would use electricity as their primary cooking fuel in the future have increased with higher levels of education. For households headed by people with secondary level education, the percentage of those who will rely on electricity as their primary cooking fuel is almost equal to those who would cook with charcoal, and for households whose heads have completed tertiary level education, the percentage of those who will practice e-cooking in the future (15%) is more than the percentage that would use biomass in the future (13%). These results of future preferences for cleaner cooking fuels; LPG and electricity by households headed by people with higher levels of education are consistent with the findings of studies like Aminu et al. (2024), Bofah et al. (2022) and Rahut et al. (2020) who found education to be a key driver of the adoption of such modern cooking fuels among urban and rural households.

4.3. *Determinants of future cooking fuels among urban and peri-urban households*

In support of the associations discussed in the preceding section regarding future cooking fuel choices vis-a-vis education, location, age category, and sex of the household heads, the paper explores herein, the inferential relationship between future cooking fuels and various determining factors using multinomial logistics regression analysis. The estimation outputs of the 'mlogit' model presented in Table 9 reveal significant LR chi-square statistics which suggest that the included

Table 9
Mlogit regression output (marginal effects) for future cooking fuel choices.

Variable	*Biomass*	*LPG*	*Green Fuels*
Sex (Ref.: Male)			
Female	*0.012 (0.019)*	*0.028 (0.044)*	*−0.039 (0.048)*
Location (Ref.: Peri-urban)			
Urban	*−0.008 (0.02)*	*0.03 (0.044)*	*−0.022 (0.048)*
Educational status (Ref.: No formal edu.)			
Basic	*−0.038 (0.036)*	*−0.022 (0.081)*	*0.06 (0.09)*
Secondary and beyond	*−0.079* (0.044)*	*−0.138 (0.092)*	*0.217** (0.097)*
Age category (Ref.: Above 60 years)			
18–35 years	*−0.094** (0.045)*	*0.036** (0.074)*	*0.058 (0.077)*
36–60 years	*−0.029 (0.032)*	*0.069 (0.062)*	*−0.04 (0.069)*
Cooking space available (Ref.: Yes)			
No	*−0.064** (0.03)*	*−0.062 (0.064)*	*0.125* (0.066)*
Knowledge of CC_Measures (Ref.: Yes)			
No	*0.041 (0.033)*	*−0.133** (0.057)*	*0.091 (0.0263)*
Current fuel preference (Ref.: Biomass)			
LPG	*−0.329*** (0.054)*	*0.234*** (0.059)*	*0.095** (0.040)*
Electricity	*−0.293*** (0.087)*	*−0.024 (0.162)*	*0.317* (0.166)*
Household income bracket (Ref.: 0–500)			
501-2000	*−0.28 (0.031)*	*−0.31 (0.062)*	*0.059 (0.066)*
2001-5000	*−0.047 (0.033)*	*−0.013 (0.07)*	*0.06 (0.073)*
5000+	*−0.007 (0.044)*	*−0.097 (0.088)*	*0.104 (0.097)*
Perception of price of biomass (Ref.: Expensive)			
Neither expensive nor cheap	*−0.022 (0.025)*	*−0.07 (0.056)*	*0.092 (0.059)*
Cheap	*−0.01 (0.03)*	*−0.10* (0.06)*	*−0.11* (0.064)*
Perception of price of LPG (Ref.: Expensive)			
Neither expensive nor cheap	*−0.029 (0.025)*	*−0.071 (0.05)*	*0.10* (0.052)*
Cheap	*−0.06 (0.041)*	*−0.002 (0.073)*	*0.062 (0.073)*
Perception of price of electricity (Ref.: Expensive)			
Neither expensive nor cheap	*0.014 (0.026)*	*−0.035 (0.046)*	*0.021 (0.046)*
Cheap	*−0.028 (0.036)*	*−0.235*** (0.083)*	*0.263*** (0.09)*

Obs.	*1202*	***LR chi-square (38)***	*347.05*
Pseudo R-squared	*0.1869*	***Prob > chi-square***	*0.000*

NB: Std. errors. in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

Table 8
Households primary future cooking fuel choices by educational status of household heads.

Households preferred PRIMARY cooking fuel in the next five (5) years	Education level completed by the household head					Total
	No formal education	*Primary*	*Middle/JSS/JHS*	*Secondary*	*Tertiary*	
LPG	*61.6*	*68.1*	*71.6*	*76.3*	*69.5*	*71.1*
Charcoal	*32.0*	*27.8*	*20.3*	*11.9*	*12.2*	*19.5*
Firewood	*4.0*	*2.1*	*1.4*	*0.3*	*0.8*	*1.4*
Wood pellets/chips	*0.0*	*0.0*	*0.2*	*0.0*	*0.0*	*0.1*
Electricity	*2.4*	*2.1*	*6.1*	*10.9*	*14.5*	*7.3*
Biogas	*0.0*	*0.0*	*0.4*	*0.7*	*3.1*	*0.7*
Sample (n)	*125*	*114*	*507*	*295*	*131*	*1202*
Pearson Chi2 = 79.53 Prob = 0.0000						

Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

independent variables jointly explain variations in the dependent variable (future cooking fuel choices). According to the marginal effects estimates, household income, sex of the household head, and location appear less influential, suggesting other socio-cultural or contextual factors may play a larger role in fuel choice decisions. The education level completed and the age category of the household head, the current fuel preferences, and how their prices are perceived have emerged as strong predictors of future fuel choices, with higher education levels, current use of modern fuels (LPG or electricity), and affordability pushing households toward modern cooking fuels and away from biomass.

Compared to no formal education, having a secondary education or above significantly decreases the likelihood of choosing biomass in the future by 7.9% and increases the likelihood of choosing electricity or biogas by 21.7%. Educated households tend to have a greater understanding of the health risks and pollution associated with traditional fuel sources, as well as the relative advantages of using cleaner sources as postulated in the DOI and TPB theories. The finding resonates with those of Alem et al. (2016), Aminu et al. (2024a), Karimu (2015), and Poblete-Cazenave and Pachauri (2018) who highlighted education as one of the most likely factors that increase the probability of choosing modern fuels like LPG or electricity.

Households headed by younger individuals (18–35 years) are less likely to choose biomass in the future by a margin of 9.4% relative to households headed by the aged (60 years plus). The youth-headed households, however, are more likely to choose LPG in the future compared to their aged counterparts by 3.6%. This result reflects the increasing availability and awareness of LPG among this demographic and their transition towards modern fuel which is also shown in their desire to choose green fuels in the future even though that result is statistically insignificant. The results agree with findings in energy transition literature such as Katutsi et al. (2020) and Nkolo et al. (2019) who found that younger people are more open to using modern fuels than older generations in the future.

Households currently using LPG are significantly less likely to return to the usage of biomass by a proportion of 32.9, more likely to stick with LPG by a percentage of 23.4, or transition to a green fuel by a percentage of 9.5 compared to households currently using biomass. Similarly, households currently using electricity are more likely (31.7%) to shift toward green fuels, indicating a potential preference for cleaner alternatives compared to households currently using biomass. Current fuel preferences are a strong habit-forming factor, consistent with Ajzen's (1991) TPB and Rogers' (1995) DOI. Once households perceive the benefits such as the convenience, cleanliness, and safety of the future fuels through their current observations and trials, they are less inclined to revert to traditional options.

Considering cost-related factors, the effects of households' perceptions of the current prices of biomass, charcoal, and electricity in their localities on future fuel choices are explored. The perception that charcoal is cheap currently decreases the likelihood of choosing LPG and green fuels in the future compared to those who perceive charcoal to be expensive. The perception that LPG is neither expensive nor cheap significantly increases the likelihood of choosing a green fuel like e-cooking in the future. Households perceiving electricity as currently cheap are less likely to choose LPG in the future (−0.235, significant at 1%) and more likely to choose green fuels (+0.263, significant at 1%) compared to those who perceive electricity to be expensive in the current period. These results suggest that perceptions of relative affordability drive the transition towards modern cooking fuels and highlight the role of perceived ease or difficulty in adopting such modern fuels as postulated in the TPB and DOI theories.

Households without a designated cooking space are less likely (−0.064) to use biomass and more likely (0.125) to adopt green fuels in the future. This suggests space limitations push households toward cleaner or modern fuels. The literature on housing characteristics and fuel choice points to the fact that households who live in modern housing units like flat apartments, and semi-detached houses, and those who are in rented houses are less likely to use dirty fuels because of the inconveniencies associated with such fuels (Bofah et al., 2022). Little is known about how the availability of cooking space (kitchen) might affect cooking fuel choices. It is important to state, however, that newly developed modern housing units have designated cooking spaces, and it is instructive to understand how such infrastructural developments affect fuel choices.

Table 10
Diagnostics tests for the MLOGIT model.

Measures of Fit for the mlogit model		Hausman tests of IIA assumption			
Log-Lik Full Model:	−754.71	Ho: Odds (Outcome-J vs Outcome-K) are independent of other alternatives			
LR (38):	347.05				
Prob > LR:	0.00				
McFadden's Adj R2:	0.09	**Omitted**	**Chi2**	**df**	**P > chi2**
Cragg & Uhler's R2:	0.32				
Adj Count R2:	0.07	Biomass	1.03	9	0.99
AIC*n:	1695.43	LPG	−33.81	9	1.00
BIC:	−77.57	Green fuel	2.35	9	0.99

Source: Authors' estimations

Table 10 presents some diagnostic test results for the multinomial logistic regression model to confirm the appropriateness of the model and reliability of the results. Various measures of Fit are presented in the left-sided columns while Hausman tests of independence of irrelevant alternatives (IIA) assumption are presented in the right-sided. The measures of fit statistics demonstrate a well-fitted model while the null hypothesis (Ho) of the Hausman tests is not rejected implying that the relative preferences between the future fuel options remain consistent, regardless of other choices available.

In addition to the socio-demographic, cost-related, and other household characteristics explored inferentially as the determinants of future cooking fuel choices, the study investigated the reasons behind the preferences of the households regarding their future cooking fuels. These factors have been depicted in Fig. 7. Most households who prefer LPG as their primary cooking fuel in the future are influenced by the perceived convenience of using LPG. This was declared by 64% of households who would mainly use LPG in the future. About 33% also based their decision on the fact that LPG is easily accessible, 21% felt that it is available, 20% found it to be suitable and 19% considered it to be affordable to be used in the future. For households who would mainly depend on charcoal in the future as their cooking fuels, their decisions are ultimately based on the perceived low cost (according to 40% of future charcoal users) and convenience (as reported by 38% of future charcoal users) of the fuel. For households that would cook with electricity in the future as their primary cooking fuel, the majority are moved by the convenience of e-cooking (75%). Some 47% also based their decision on the fact that electricity is easily accessible while 31% said they would use electricity in the future because it best suits them. The overwhelming preference for LPG as the future cooking fuel per the results of the quantitative data was supported by the FGD participants. One FGD participant voiced as follows:

> *"I believe in 5 years to come I will use LPG because now firewood is difficult to access. Now too, the logs they will use to process charcoal are becoming scarce, hence, charcoal is expensive. So, if you buy the LPG it will be better"*. (A 26-year-old female FGD participant in Ga West, Oct. 2023).

5. Conclusion and policy implications

The transition to clean cooking fuels is a critical component of Ghana's broader energy and environmental objectives. Nationally, 54.3% of Ghanaian households cook with biomass fuel sources (Ghana Statistical Service [GSS], 2021), contributing to deforestation,

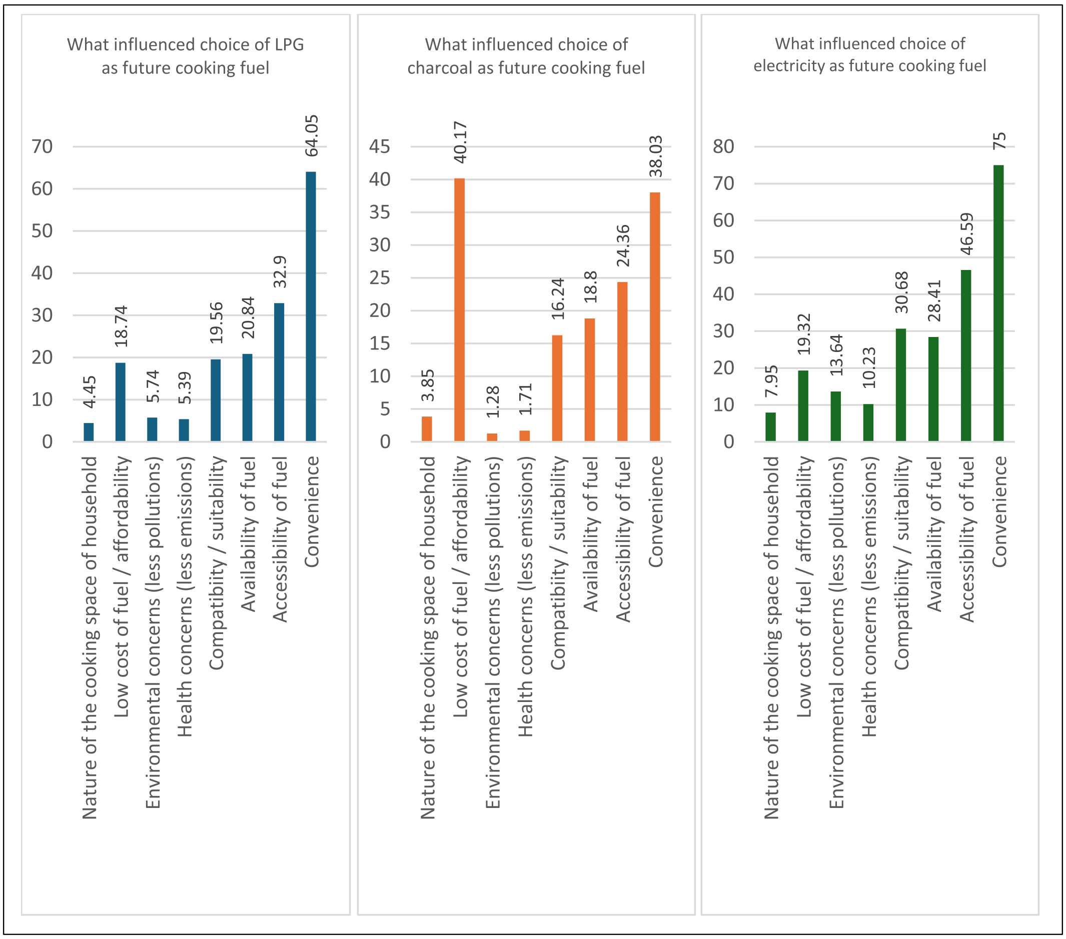

Fig. 7. Factors that influenced households' future cooking fuel choices.
Source: ISSER MECS Phase II Behavioral Change Household Study, 2023

greenhouse gas emissions, and adverse health outcomes due to indoor air pollution. These challenges are compounded by urbanisation and population growth. The study results revealed that households in the three municipalities practise fuel stacking, utilising a combination of LPG, charcoal, firewood, and electricity for their cooking needs for various reasons. For instance, some biomass users prefer to use charcoal or firewood when they must cook in larger quantities while some LPG users prefer it because it pollutes less compared to other traditional fuels. In Adenta and Ga East municipalities, households prefer LPG as their primary cooking fuel. In contrast, households in Ga West Municipality favor charcoal as their first-choice fuel, followed by LPG, with the choice of electricity for cooking placed third.

The future cooking fuel landscape choices of households reflect a business-as-usual scenario, with LPG being the most preferred fuel, followed by charcoal, and lastly, electricity. Even though LPG is a modern fuel preferred to traditional biomass fuels, it is not completely green as it is found to contribute somewhat to indoor air pollution through the emission of nitrogen dioxide (NO2), carbon monoxide (CO), formaldehyde (HCHO), and particulate matter (PM2.5), all of which can pose various respiratory challenges to users. Nonetheless, it is an important fuel source for Ghana to engender the push towards achieving universal access to modern cooking fuel. An overwhelming shift towards this fuel in the future aligns with SDG 3, SDG 7, and SDG 13. At the national level, the adoption of LPG and e-cooking contributes to Ghana's Nationally Determined Contributions (NDCs) under the Paris Agreement, which emphasises reducing emissions from biomass use. Furthermore, the National Energy Transition Framework identifies modern energy solutions as key to achieving a sustainable and resilient energy system by 2050; thus, a need to promote electricity-based cooking technologies. The evidence of the interest in e-cooking among the youth and educated people suggests that this cleaner cooking fuel could have great prospects regarding adoption in Ghanaian households in the future, particularly in urban areas, if the right policy interventions are implemented.

Some countries with similar socioeconomic contexts have made notable progress in promoting clean cooking solutions, and they offer valuable policy lessons for Ghana. For instance, The Ministry of Energy (2022b) study on Kenya's approach to promoting clean energy cooking identified seven key strategies: ideation, branding, and rallying call; execution of an awareness and behaviour change strategy; focus on elements of behaviour change; media advocacy to enhance public awareness and understanding of clean cooking; partnerships and coalitions; special events to promote clean cooking; and involving the private sector/industry players in the process. The document further outlined two essential tactics for the success of these strategies: above-the-line (ATL) tactics—including media advertising, broadcast SMSs, social media adverts, and promotional materials such as t-shirts, lessons, and umbrellas—and below-the-line (BTL) tactics, which leveraged existing networks of Community Health Volunteers (CHVs), Community Forest Associations (CFAs), Agricultural Extension Officers (AEOs), Water Users Associations (WUAs), and women's groups. Also, Aggarwal et al. (2018) examined India's approach to clean energy cooking and found that the government significantly reduced biomass fuel use among low-income households and increased LPG consumption through subsidies under the Pradhan Mantri Ujjwala Yojana (PMUY) programme, complemented by educational campaigns. Similarly, Energy 4 Impact (2021) highlighted that for Rwanda to transition from traditional cooking methods to modern energy solutions, key prerequisites include policy and regulatory framework changes, supply chain improvements, financing, and human capital development.

The foundation strategies and policy frameworks informing the existing clean cooking landscapes in countries similar to Ghana are very instructive as Ghana strives to develop its clean cooking sector. First and foremost, like other countries, the government must develop an all-encompassing programme, including an education campaign that facilitates access to efficient e-cooking technologies, particularly those with features and functions that will appeal to the younger generation. This education campaign will be effective if it is co-led by other stakeholders such as CSOs and youth groups. Secondly, incentivization approaches such as subsidies should be introduced for electric cooking technologies and LPG to make them affordable. In addition, the government should develop vibrant public-private partnerships in the sector, to improve the supply chain for LPG and electric cooking technologies to ensure reliability and availability across urban and rural areas.

Advancing policies to promote clean cooking fuels can serve as a foundation for Ghana's larger energy transition. The widespread adoption of LPG and electricity for cooking could stimulate investments in renewable energy technologies such as solar and wind, supporting the decarbonization of the electricity grid. Moreover, successful transitions in the cooking sector could build public trust and momentum for the broader adoption of modern energy solutions in other sectors, such as transportation and industry.

CRediT authorship contribution statement

Simon Bawakyillenuo: Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Innocent S.K. Agbelie:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Aba O. Crentsil:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Stephanie K. Danquah:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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