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Research Article

Adoption of Energy-Efficient Cook Stoves by Charcoal-Dependent Households: Evidence from Kwara State, Nigeria

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Abstract Despite increased advocacy for cleaner cooking technologies, traditional charcoal stoves remain prevalent due to cultural preferences, limited awareness, and financial constraints. This study examines the adoption of energy-efficient cookstoves (EECs) among charcoal-dependent households in Kwara State, Nigeria. A three-stage sampling technique was used to select a sample size of 120 household heads. Primary data were collected using structured questionnaires and analyzed with descriptive statistics and a binary logit regression model. Findings revealed that respondents perceive EECs as convenient, fuel-efficient, and health-promoting, but concerns remain about availability, durability, and cultural preferences. Key determinants of adoption of EECs included income (P<0.01), awareness (P<0.1), and household size (P<0.1). The findings emphasize the complex socio-economic and perceptual factors shaping adoption in this context. Policies aimed at reducing financial barriers, enhancing information dissemination, and developing stove designs appropriate for larger households are crucial to foster wider adoption.

Keywords: Adoption, Charcoal, Energy-efficient cookstoves, Logistic regression, Technology

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Kömürle Çalışan Haneler Tarafından Enerji Verimli Pişirme Ocaklarının Benimsenmesi: Nijerya'nın Kwara Eyaletinden Bulgular

Özet Daha temiz pişirme teknolojilerine yönelik artan savunuculuğa rağmen, kültürel tercihler, sınırlı farkındalık ve mali kısıtlamalar nedeniyle geleneksel kömür sobaları yaygınlığını korumaktadır. Bu çalışma, Nijerya'nın Kwara Eyaleti'nde kömüre bağımlı haneler arasında enerji verimli pişirme sobalarının (EECS) benimsenmesini incelemektedir. 120 hane reisinden oluşan bir örneklem büyüklüğü seçmek için üç aşamalı örnekleme tekniği kullanılmıştır. Birincil veriler yapılandırılmış anketler kullanılarak toplanmış ve tanımlayıcı istatistikler ve ikili lojistik regresyon modeli ile analiz edilmiştir. Bulgular, katılımcıların EEC'leri kullanışlı, yakıt tasarruflu ve sağlığı destekleyici olarak algıladıklarını, ancak bulunabilirlik, dayanıklılık ve kültürel tercihler konusunda endişelerin devam ettiğini ortaya koymuştur. EEC'lerin benimsenmesinde temel belirleyiciler arasında gelir (P<0.01), farkındalık (P<0.1) ve hane büyüklüğü (P<0.1) yer almaktadır. Bulgular, bu bağlamda benimsenmeyi şekillendiren karmaşık sosyo-ekonomik ve algısal faktörlerin önemini vurgulamaktadır. Mali engelleri azaltmayı, bilgi yayılımını artırmayı ve daha büyük haneler için uygun soba tasarımları geliştirmeyi amaçlayan politikalar, daha geniş bir benimsenmeyi teşvik etmek için çok önemlidir.

Keywords: Benimseme, Kömür, Enerji tasarruflu pişirme ocakları, Lojistik regresyon, Teknoloji

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1. INTRODUCTION

Charcoal has served as a primary energy source for human civilizations for millennia, with its production, achieved by carbonizing wood in low-oxygen conditions, dating back as early as 3000 BC (Li et al., 2024). Today, reliance on biomass such as charcoal and firewood remains widespread in developing countries, where it is the dominant source of cooking fuel and a major driver of environmental degradation (Abdela, 2019). In Africa, most households continue to rely on traditional stoves, such as the three-stone firewood setup or simple metal charcoal stoves, which are inefficient, consume large amounts of wood, and contribute significantly to indoor air pollution and associated health risks (Owusu-Amankwah et al., 2023).

Across Sub-Saharan Africa, charcoal and firewood together account for about 30% of total energy consumption (Ekouevi & Tuntivate, 2012). In Nigeria, the charcoal industry expanded during the colonial period alongside urbanization and industrial activity (Ugwukah & Adesegun, 2023). Today, production, which is often through traditional earth kilns, remains central to rural livelihoods, particularly in North-Central states in Nigeria, such as Kwara, where charcoal is deeply embedded in both culture and economy (Boluwaduro & Boluwaduro, 2023). Approximately 20% of the rural population in Kwara State depends on charcoal as a primary livelihood source, engaging in its production, trade, and transport (Tunde et al., 2013). For many households, charcoal persists as the most affordable and accessible fuel compared to alternatives like liquefied petroleum gas (LPG) or electricity. Its use is also culturally reinforced, with many associating charcoal stoves with the distinctive flavor of local dishes (Awuor et al., 2022). However, traditional production methods are inefficient and exacerbate deforestation, biodiversity loss, and climate change (Pereira et al., 2023).

Despite its economic and cultural significance, charcoal use generates severe health and environmental costs. The World Health Organization (2016) estimates that over four million premature deaths occur annually due to indoor air pollution from biomass cooking. Women and children are disproportionately affected, as they are primarily responsible for fuel collection and cooking (World Bank, 2011; Grace, 2014). Environmentally, unsustainable charcoal production accelerates deforestation, drives land degradation, and contributes to greenhouse gas emissions (FAO, 2018).
In response, researchers, governments, and development organizations have promoted energy-efficient cook stoves (EECS) as sustainable alternatives. Designed to enhance combustion efficiency, EECS reduces fuel consumption by up to 50% while lowering harmful emissions (Global Alliance for Clean Cookstoves, 2015; Eshetu, 2024). Their promotion in Africa began in earnest in the 1980s, gaining momentum in the 2000s through large-scale initiatives by the African Development Bank and international alliances. In Nigeria, various EECS, including rocket stoves, improved biomass stoves, solar cookers, LPG stoves, and electric stoves, have been introduced (Chikere & Keke, 2025); however, their uptake remains limited. Adoption of EECS involves more than access to technology; it is shaped by income levels, education, cultural norms, and perceived benefits (Lewis & Pattanayak, 2012). Studies have highlighted that affordability, stove performance, social influence, and cultural acceptance strongly influence household decisions on the uptake of EECs (Gebreegziabher et al., 2012; Kizilcec et al., 2022). Traditional preferences for charcoal-cooked food and limited awareness of EECS hinder widespread adoption, while high upfront costs often deter low-income households despite long-term fuel savings (Ngusa, 2025).

This study integrates three complementary theoretical frameworks to explain household adoption of energy-efficient cookstoves (EECs) among resource-constrained populations. Diffusion of Innovations Theory (Rogers, 1962) posits that technology adoption hinges on five key attributes: relative advantage

(fuel savings, health benefits), compatibility (alignment with cultural cooking practices), complexity (ease of ignition and use), trialability (access for testing), and observability (visible benefits to peers). Complementing this, the Utility Maximization Framework (Becker, 1965) conceptualizes households as rational actors who adopt EECs when perceived utility, balancing upfront costs against long-term fuel savings and health improvements, exceeds that of traditional charcoal stoves, subject to binding income and information constraints. The Technology Acceptance Model (TAM; Davis, 1989) further elucidates this process by emphasizing perceived usefulness (efficiency, time savings) and perceived ease of use as primary drivers of behavioral intention, with external factors like awareness shaping these perceptions.

These frameworks form a cohesive model where diffusion attributes influence perceptions, utility maximization governs economic trade-offs under budget and information constraints, and TAM explains the translation of positive perceptions into adoption decisions. Diffusion theory highlights the role of social learning and product attributes, utility maximization underscores financial barriers facing low-resource households, and TAM captures the psychological mechanisms linking awareness to action. This integrated approach is particularly suitable for analyzing clean cooking transitions in developing contexts, where cultural preferences, economic limitations, and information asymmetries interact to determine technology uptake (Lewis & Pattanayak, 2012). These perspectives provide a robust theoretical foundation for examining EEC adoption among charcoal-dependent households.

Previous studies have identified socio-economic factors, cultural beliefs, and awareness levels as significant barriers to the adoption of EECs. For instance, a study by Fingleton-Smith (2022) highlighted that many households perceive traditional charcoal stoves as integral to their cooking practices, believing they impart a unique flavor to meals. Olaoye et al. (2022) reported that the primary factors influencing rural households' choice of cooking stoves and fuels were the ease of purchasing the fuel and its ability to cook food quickly. Studies by Lewis & Pattanayak (2012) and Pope et al. (2019) have shown that cultural factors, such as taste preferences and cooking habits, are critical determinants of the uptake of new cooking technologies. Moreover, findings from other studies, such as those by Ashagrie et al. (2024) in Ethiopia, indicate that economic constraints significantly influence households' decisions regarding the adoption of cleaner cooking technologies. Research by Hanna et al. (2016) indicates that while EECs provide long-term savings in fuel costs, the initial cost of purchasing the stoves is often prohibitive for poor households. A study by Bensch & Peters (2013) suggests that a lack of awareness and inadequate information about the benefits of EECs restricts their adoption in rural communities.

Although these studies explored the barriers to the adoption of improved stoves, the driving factors influencing the adoption of EECS in Kwara State, Nigeria, remain underexplored. Existing research often generalizes findings from broader contexts, neglecting local drivers. This study addresses these gaps by investigating the adoption of EECs among charcoal-dependent households in Kwara State, Nigeria. Specifically, it assesses household awareness of EECS, examines adopters' perceptions, and identifies key determinants of EECS adoption. Understanding these dynamics is essential for designing locally relevant interventions that can accelerate adoption, reduce environmental impacts, and improve household health outcomes in the state. This research contributes to the growing literature on sustainable household energy use, offering practical guidance for stakeholders working toward an energy transition in a similar socio-cultural context.

2. MATERIAL and METHOD

Study area

The study was conducted in Kwara State, located in the North-Central region of Nigeria. The state lies between latitudes 8°–10°N and longitudes 4°–6°E, positioning it as a strategic link between northern and southern Nigeria. It shares boundaries with Niger State to the north, Kogi State to the east, Ekiti, Osun, and Oyo States to the south, while its western boundary forms part of Nigeria's international border with the Republic of Benin. Administratively, Kwara State is divided into 16 Local Government Areas (LGAs), including Ilorin West, Ilorin East, Ilorin South, Baruten, Patigi, Asa, Offa, Oyun, and Edu. These LGAs play crucial roles in governance and service delivery at the grassroots level. Covering about 36,825 square kilometers, Kwara is among the larger Nigerian states by land area (Figure 1).

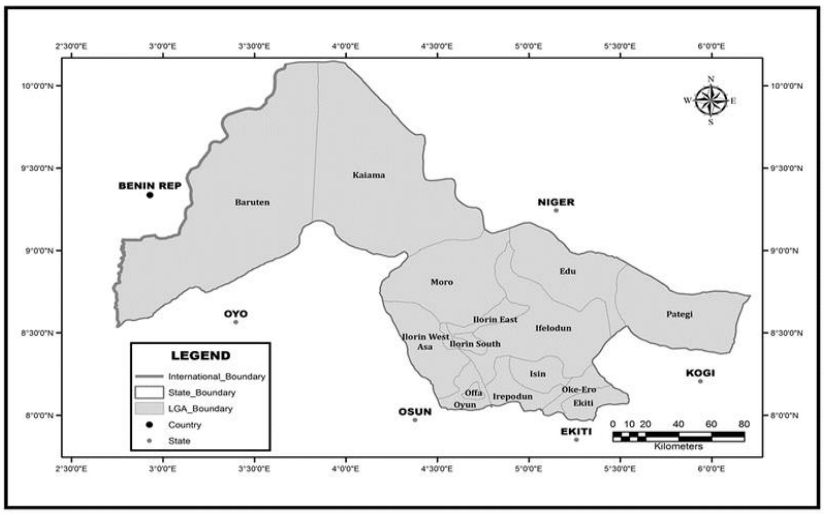

Figure 1: Map of Kwara State, Nigeria, showing the local government areas (Bamidele & Idowu, 2023).

Sampling Procedure and Sampling Size

A three-stage sampling procedure was adopted for this study. In the first stage, three Local Government Areas (LGAs), namely Asa, Ifelodun, and Ilorin South, were randomly selected. The second stage involved randomly selecting two communities from each chosen LGA. At the third stage, 20 household heads were randomly drawn from each community, giving a total sample size of 120 respondents. To ensure equal representation, simple random sampling was applied by assigning numbers to households and using a random number generator to identify participants.

Data Collection

Primary data was gathered through the use of a semi-structured questionnaire administered to respondents. The first section of the questionnaire captures the demographic characteristics and institutional factors. A Likert Scale was used to capture items relating to the perception of adopters of energy-efficient stoves. A Likert scale is a rating scale that assesses opinions, attitudes, or behaviors quantitatively. A 5-point Likert Scale was designed to measure respondents' perceptions based on their level of agreement with various attributes of Energy Efficient Stoves, such as performance, benefits, affordability, durability, and convenience. Responses were structured on a 5-point scale as follows: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The reliability of the 11-item perception scale was assessed using Cronbach's α, yielding $\alpha = 0.81$, indicating good internal consistency.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical analyses.

Descriptive statistics: Descriptive statistics, such as frequencies and percentages, were used to describe the level of awareness of energy-efficient cookstoves. Respondents' perceptions, based on the Likert Scale (the level of agreement with various attributes of energy-efficient stoves), were also described using frequency, mean, and percent.

Binary Logit Regression Model: Binary logit regression is used to predict the probability of a binary outcome (0 or 1) based on independent variables. This was used to analyze the factors influencing the adoption of EECSs among sampled households.

The Logit model can be expressed as follows:

$$\ln[P(Yi = 1) / (1 - P(Yi = 1))] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + ei \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eqn. 1)}$$

Where:
Yi = Adoption of Energy-Efficient Cookstoves (Binary: Yes = 1, No = 0)
P(Yi = 1): Probability that household i adopts an EEC
ln[P/(1-P)]: The log-odds (logit) of adoption
$\beta 0$ = Intercept
$\beta 1, \beta 2, \ldots, \beta 8$ = Coefficients of independent variables
Independent Variables (Explanatory Variables):
X_1 = Age of Household Head (in years)
X_2 = Gender of Household Head (Female = 1, Male = 0)
X_3 = Marital Status (Married = 1, Unmarried = 0)
X_4 = Education (Educated = 1, Uneducated = 0)
X_5 = Income (Below ₦ 100,000 = 1, Otherwise = 0)
Monthly household income was recoded into a binary variable, where '1' denotes households earning less than ₦100,000 per month and '0' otherwise, reflecting commonly used low-income thresholds in Nigeria and the fact that a majority of sampled households fell into this vulnerable income group.
X_6 = Occupation (Trading = 1, Otherwise = 0)
X_7 = Awareness of EECs (Yes = 1, No = 0).
X_8 = Household Size
ϵ = Error term

3. RESULTS and DISCUSSION

Socio-economic characteristics of the respondents

Table 1 presents the socioeconomic distribution of households. The findings show that the largest share of respondents (45.00%) were aged 41–50 years, suggesting that cooking decisions and the potential adoption of energy-efficient cookstoves (EECs) are mainly influenced by individuals in their productive age group. Females accounted for 75.83% of respondents, reflecting their central role in cooking activities and highlighting them as a critical target group for awareness campaigns and adoption initiatives (Storz et al., 2022). These findings underline the larger involvement of women in cooking activities and emphasize their importance as a target group for public health nutrition initiatives. A majority (68.33%) were married, indicating family-based households where cooking technology decisions may be made jointly between spouses. Adewale et al. (2025) also reported that the majority of adopters of agricultural technologies were married.

With respect to income, 46.67% of households earned between ₦51,000 and ₦100,000 per month, placing most within the low- to lower-middle-income bracket and suggesting limited financial flexibility. In terms of education, 46.67% of respondents had attained secondary education, which

implies a moderate literacy level that could facilitate awareness and acceptance of EECs, as noted by Zhao et al. (2022), who found that digital awareness improves the awareness and application of cooking technology. Household size data revealed that 66.67% of respondents lived in households of 4–6 members, typical of Nigerian urban and peri-urban families. Larger households may be more cost-sensitive, thereby increasing interest in fuel-saving technologies. Munezero et al. (2023) in their study reported a household size of 6-7 on average. Occupationally, 40.83% of respondents were traders, reflecting the prominence of informal-sector livelihoods in the study area.

Table 1. Socioeconomic characteristics of households (N=120)

Variables	Frequency	Percent
Age		
20-30	15	12.50
31-40	45	37.50
41- 50	54	45.00
Above 50	6	5.00
Gender		
Male	29	24.17
Female	91	75.83
Marital Status		
Single	17	14.17
Married	82	68.33
Divorced	16	13.33
Widowed	5	4.17
Educational status		
No formal education	11	9.17
Primary education	26	21.67
Secondary education	56	46.67
Tertiary education	27	22.50
Household size		
1-3	30	25.00
4-6	80	66.67
6-9	10	8.33
Monthly household income (₦)		
Below 50,000	14	11.67
50,000 – 100,000	56	46.67
101,000-150,000	40	33.33
Above 150,000	10	8.33
Primary occupation		
Farming	23	19.17
Trading	49	40.83
Civil service	22	18.33
Artisan	10	8.33
Others	16	13.33

Source: Field Survey (2025). Note: 1 USD = ₦1,522.45 (average 2025 exchange rate).

Level of awareness of energy-efficient cookstoves

Table 2 reveals that 93.33% of respondents were aware of energy-efficient cookstoves (EECs). The media, particularly radio, television, and the internet, emerged as the primary sources of this awareness, accounting for 42.50% of responses. This underscores the effectiveness of media platforms in disseminating information and suggests that expanding media campaigns and fostering community-based discussions could further enhance awareness and adoption. These findings are consistent with those of Adhikari et al. (2025), who identified mass media as a critical driver for promoting clean cooking technologies nationwide.

Respondents were asked if they were aware of the benefits of EECs, to which they answered yes or no. A large proportion of respondents (91.67%) also reported being aware of the benefits of EECs, reflecting a generally high level of knowledge. However, when asked to specify benefits, the responses were uneven: 29.17% mentioned improved health, 28.33% cited fuel cost savings, 26.67% highlighted reduced smoke emissions, 15.00% recognized environmental benefits, and 4.17% reported no knowledge of specific benefits. This indicates that while general awareness is strong, a comprehensive understanding of the diverse benefits remains limited. Such gaps mirror the observations of Wolf et al. (2017), who noted that many users are aware of clean cooking solutions but often underappreciate their broader health and environmental advantages, sometimes resulting in partial or temporary adoption.

Regarding adoption, 70.00% of respondents reported using EECs. The leading motivation was affordability, with 48.33% indicating that lower prices encouraged their adoption. Other factors included increased awareness (27.50%), government subsidies (18.33%), and public campaigns (5.83%). Kwara State exhibits 70% EEC adoption, far exceeding Nigeria's 10-25% national average (Roche et al., 2024), due to its peri-urban location near Ilorin markets, recent government interventions (NAICCI subsidies), and high media awareness. Traders and secondary education levels further facilitate uptake compared to rural/northern regions. This reflects successful local diffusion rather than sampling bias. Similar conclusions were reported by Gill-Wiehl et al. (2021), who emphasized affordability as a key determinant of uptake of cooking technology.

Table 2. Awareness of Energy-Efficient Stoves

	Freq	**Percent**
Awareness of EEC		
Yes	112	93.33
No	8	6.67
Means of awareness		
Community	23	19.17
Media (Radio/TV/Internet)	51	42.50
Friends and relatives	40	33.33
Others	6	5.00
Awareness of EEC benefits		
Yes	110	91.67
No	10	8.33
Benefits associated with EEC		
Reduced smoke emission	32	26.67
Cost savings on fuel	34	28.33
Improved health	35	29.17
Reduced environmental impact	18	15.00
I do not know	5	4.17
EEC Adoption by household		
Yes	84	70.00
No	36	30.00

Reason for EEC Adoption		
Lower price	58	48.33
More awareness	33	27.50
Campaigns	7	5.83
Government subsidy	22	18.33

Source: Field Survey (2025)

Perception of adopters of energy-efficient cook stoves

Table 3 shows that convenience was the most highly rated attribute of energy-efficient cookstoves (EECs), with a mean score of 4.145, indicating that respondents strongly perceived EECs as easier and more practical than traditional charcoal stoves. This was closely followed by time-saving benefits (mean = 4.073), supporting the findings of Kshirsagar (2009), who found that improved cookstove design allowed for better combustion control, making cooking easier and more practical for daily use compared to the traditional stoves, which require more fuel and produce more smoke. Reduced smoke emissions (mean = 3.984) were also highly valued, reflecting appreciation for the health advantages of EECs. This aligns with Cuesta-Mosquera et al. (2025), who observed that improved cookstoves reduce respiratory and eye-related health problems associated with smoke exposure. Attributes such as ease of ignition (mean = 3.895) and ease of use (mean = 3.887) were also positively rated, while environmental friendliness (mean = 3.863) highlighted recognition of the ecological benefits of EECs. These perceptions are consistent with reports by Fekadu et al. (2024), which emphasized that improved cookstoves contribute to reduced deforestation and lower greenhouse gas emissions compared to traditional methods. On the other hand, factors such as pride in using EECs, durability, and affordability received comparatively lower ratings, suggesting moderate satisfaction with these aspects. This indicates lingering concerns regarding long-term performance and purchase costs, particularly among low-income households, in line with Berkouwer & Dean (2019). The lowest-rated attributes were availability within communities and perceived improvement in food taste, suggesting that limited market access and cultural food preferences remain barriers to broader adoption.

Table 3. Perception of Adopters of Energy-Efficient Stoves

Items	**SA**	**A**	**N**	**D**	**SD**	**Mean score**	**Rank**
	Freq (%)	Freq(%)	Freq (%)	Freq (%)	Freq (%)		
Energy-efficient stoves are more convenient to use than charcoal stoves.	47 (39.16)	42 (35.00)	31 (25.83)	0 (0)	0(0)	4.145	1
Cooking with energy-efficient stoves saves time.	42 (35.00)	48(40.00)	25 (20.83)	5 (4.17)	0(0)	4.073	2
Energy-efficient stoves produce less smoke compared to charcoal stoves.	39 (32.50)	41 (34.17)	37 (30.83)	3 (2.50)	0(0)	3.984	3
Energy-efficient stoves are easy to ignite.	32 (26.67)	47 (39.17)	35 (29.17)	6 (5.00)	0(0)	3.895	4

Energy-efficient cookstoves are very easy to use.	27 (22.5)	55 (45.83)	33 (27.50)	5 (4.17)	0(0)	3.887	5
Energy-efficient cookstoves are environmentally friendly.	25 (20.83)	57 (47.50)	32 (26.67)	6 (5.00)	0(0)	3.863	6
I feel proud to use an energy-efficient stove in my household.	31 (25.83)	38 (31.67)	43 (35.83)	8 (6.67)	0(0)	3.790	7
Energy-efficient cookstoves are more durable than traditional cookstoves	24 (20.00)	51 (42.50)	36 (30.00)	9 (7.50)	0(0)	3.774	8
Energy-efficient stoves are cheap and affordable.	24 (20.00)	51 (42.50)	30 (25.00)	15 (12.50)	0(0)	3.726	9
Energy-efficient cookstoves are readily available in my community	14 (11.67)	64 (53.33)	33 (27.50)	9 (7.50)	0(0)	3.718	10
Using energy-efficient stoves improves the taste of meals more than charcoal stoves.	18 (15.00)	37 (30.83)	46 (38.33)	19 (15.83)	0(0)	3.484	11

Source: Field Survey (2025). N: B. SA (Strongly agree), A (Agree), N (Neutral), D (Disagree), SD (Strongly disagree)

Factors influencing the adoption of energy-efficient cookstoves by households

Binary logistic regression shows the factors influencing the adoption of energy-efficient cookstoves by households (Table 4). Income, awareness of energy-efficient cook stoves, and household size are the significant predictors of energy-efficient cook stoves. The result indicates that the income level below ₦100,000 is significant ($p < 0.01$) and negatively associated with EECs adoption, indicating that lower-income households are much less likely to adopt energy-efficient cookstoves. This reflects well-documented economic barriers, where upfront costs of EECs deter poorer households despite potential long-term fuel savings. Low-income families often struggle to allocate scarce resources for initial purchases, even when technology adoption yields substantial financial benefits over time, such as lower fuel expenditures and improved health outcomes. This finding aligns with those of Lewis & Pattanayak (2012), showing credit constraints and affordability as key barriers to clean cookstove adoption in low-income settings. The positive and significant effect ($p < 0.1$) of awareness highlights the importance of knowledge and information dissemination in promoting adoption. Awareness increases households' understanding of benefits, reduces uncertainty, and can motivate behavioral change. Programs focused on raising awareness, demonstrations, and education are vital to enhancing adoption rates. This is supported by the study of Adane et al. (2022), which found that the lack of awareness is a critical barrier and that education campaigns and information dissemination significantly enhance adoption rates by increasing users' understanding of the benefits and proper use of clean cookstoves. Increased education and awareness about the health, environmental, and economic benefits of clean cooking fuels significantly increase the likelihood of households adopting these technologies (Gould et al., 2020).

Household size with a negative coefficient and significant relationship ($p < 0.1$) suggests that larger households are less likely to adopt EECs. This may relate to the higher cooking fuel and volume

demands in larger families, which could make single-unit efficient stoves less practical or economically attractive. Additionally, larger households may experience difficulties coordinating stove use or perceive that the fuel savings do not justify the costs for higher consumption levels. This supports the findings of Agbokey et al. (2019) that households with larger family sizes often combine the use of clean cookstoves with traditional stoves because clean cookstoves may not accommodate the large cooking pots or the quantity of food needed for bigger families. Wolf et al. (2017) reported that larger households tend to retain traditional stoves for certain cooking needs despite having clean cookstoves, indicating a negative relationship between household size and exclusive adoption of efficient cookstoves. Larger households require scaled-up stove designs and targeted subsidies to overcome bulk cooking barriers. Family-sized EECs and community cooking hubs can unlock adoption among Nigeria's dominant household structure. Although women constitute 75.83% of our sample, the gender dummy is not statistically significant. This suggests that being female does not necessarily confer greater decision-making power over stove adoption, as purchase decisions for durable goods are often made jointly with, or dominated by, male household heads. In this context, adoption appears more strongly constrained by income and awareness, both significant predictors in our model, than by gender alone, consistent with evidence that intra-household bargaining and affordability can mute gender effects in clean cooking adoption. Other variables, including age, marital status, education, and occupation, were not statistically significant. This may be due to a variety of reasons, including limited variation within the sample, the overpowering influence of income and awareness factors, or the fact that these socio-demographic factors do not substantially impact adoption decisions in this specific context.

Table 4. Logit regression showing the factors influencing the adoption of Energy-Efficient Cookstoves

Variables	**dy/dx (SE)**	**Coeff (SE)**	**P > |Z|**	**Odds Ratio**
Age	0.032 (0.086)	0.110 (0.297)	0.712	1.116
Gender (Female)	0.052 (0.090)	0.178 (0.311)	0.565	1.195
Married	-0.040 (0.092)	-0.137 (0.317)	0.665	0.872
Education	0.068 (0.083)	0.234 (0.289)	0.417	1.264
Income (Below ₦ 100,000)	-0.294 (0.080)***	-1.014 (0.309)	0.001	0.363
Trader Occupation	-0.057 (0.081)	-0.196 (0.281)	0.484	0.822
Awareness of EEC	0.221 (0.116)*	0.763 (0.416)	0.067	2.145
Household size	-0.051 (0.029)*	-0.176 (0.102)	0.086	0.839
Constant		1.123 (0.712)	0.115	
Pseudo r-squared	0.164			
Chi-square	25.112			
Number of obs	120			
Prob > chi2	0.001			

Source: Field Survey (2025) *** *p<.01, ** p<.05, * p<.1*

4. CONCLUSION

This study examined the adoption of energy-efficient cookstoves (EECs) among charcoal-dependent households in Kwara State, Nigeria, highlighting key drivers and barriers. The study revealed that most respondents perceive EECs as convenient, fuel-efficient, and producing less smoke, with many appreciating their time-saving and health benefits. However, concerns remain around affordability, stove durability, availability, and cultural food preferences, which limit widespread adoption and sustained use. The results show that income, awareness, and household size significantly influence adoption. Specifically, lower-income households are less likely to adopt EECs due to financial constraints, despite recognizing the benefits. Awareness plays a positive role; households with greater exposure to information about EECs demonstrate higher adoption rates, underscoring the importance of knowledge dissemination. Conversely, larger households are less likely to adopt EECs exclusively, likely due to the inability of some stove designs to meet their cooking volume and fuel demand. Overall, this research enriches the understanding of the socio-economic and perceptual factors shaping household energy transitions in charcoal-dependent communities. It identifies that both economic capability and information access are crucial for fostering greater uptake of clean cooking technologies.

Based on the findings of this research, the following recommendations are proposed to promote the adoption of energy-efficient cookstoves in Kwara State:

i. Government and NGOs implement targeted subsidies, financing schemes, or microcredit programs to reduce upfront costs for low-income households. Making cookstoves affordable will help overcome financial barriers and increase adoption among the poorest segments.

ii. Educational campaigns and community outreach should be promoted to increase awareness of the benefits and availability of energy-efficient cookstoves. Engaging local leaders and health workers and using demonstration programs can enhance knowledge and motivate adoption.

iii. Efforts should be geared towards developing and promoting cookstove models suited for larger households or communal cooking to better meet their fuel and cooking volume needs.

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Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

Conflict of Interest

The authors of the articles declare that they have no conflict of interest.

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