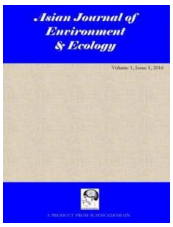

Asian Journal of Environment & Ecology

5(1): 1-12, 2017; Article no.AJEE.35281
ISSN: 2456-690X

Assessing the Use and Determinants of Households' Adoption of Improved Cook Stove in Nigeria: Empirical Evidence from Enugu State

NwaJesus Anthony Onyekuru[1] and Chikamso Christian Apeh[2*]

[1]Department of Agricultural Economics, University of Nigeria, Nsukka, Nigeria.
[2]African Heritage Institution, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author CCA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author NJAO managed the literature searches and the analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2017/35281
Editor(s):
(1) Wen-Cheng Liu, Department of Civil and Disaster Prevention Engineering, National United University, Taiwan, and Deputy Director General, Taiwan Typhoon and Flood Research Institute, National United University, Taipei, Taiwan.
Reviewers:
(1) Aboh Prisca Zidago, China University of Geossciences, China.
(2) Durdana Rais Hashmi, Pakistan Council of Scientific and Industrial Research, Pakistan.
Complete Peer review History: http://www.sciencedomain.org/review-history/22113

Original Research Article

Received 4th July 2017
Accepted 26th July 2017
Published 1st December 2017

ABSTRACT

The study evaluated the use and determinants of households' adoption of biomass improved cook stove in Nigeria. Enugu State was chosen for the study. Structured questionnaires were used to collect the required data. Using a multi stage sampling techniques, a total of 160 households were selected for the study. Findings from the study reveal that majority (23.12%) of the household heads were within the age range of 31-40 years, 68.10% were married and 56.90% were female, while 86% attended school, 61% had other occupations other than farming, 59% had 0-10 years farming experience and 85% had monthly income of between N1000 to N50,000. About 68% of the households use one form of locally fabricated improved cook stove or the other. The different kinds of improved cook stove used are iron bucket stove (33.03%), saw dust stove (39.45%), U shaped mud stove (17.43%), jiko and mirt stove (10.09%). The study found age, gender, educational level, household size and income to be statistically significant as determinants of adoption of ICS. Some of the problems inhibiting the adoption of modern improved cook stove are lack of availability, lack of awareness and high cost. We recommend that stoves should be made available and affordable.

**Corresponding author: E-mail: apehchikamso@yahoo.com, capeh@afriheritage.org;*

Keywords: Improved cook stove; fuelwood; adoption; biomass; household; health.

1. INTRODUCTION

In Nigeria, about 90% of rural households cook with the traditional three-stones stove placed in a triangular formation. This method has faced a lot of challenges due to its inefficiency in conservation of fire, high rate of fuel consumption, high rate of carbon emission and adverse health effects on women and children. Fuelwood gathering were done primarily by women and children who spend several hours in the forests and then carries the wood with their heads back home. These expose them to snake bites and attacks by rapists, kidnapers, Fulani herdsmen, malaria and other diseases. Fuel wood collection has a cumulative effect on the forest as increase in population of fuel-wood users will lead to pressure on the forest resources and eventually leads to destruction of the forest resource base on which this population literally depends on for existence. Finding solutions to the over exploitation of the forest resources has been a very complex issue since the activities which lead to resource exploitation are often essential means of human existence and economic development in rural areas.

According to the World Health Organisation [WHO], use of biomass fuels and coal for cooking and heating accounts for between 10% and 15% of global primary energy use [1]. In many developing countries, biomass account for over 90% of household energy consumption [2]. In Nigeria for instance**,** biomass (fuel-wood, charcoal, agricultural waste and animal dung) account for 85% of the total energy consumption [3]. [4] stated that fuel-wood is the most prolific biomass energy source used in Nigeria. This heavy usage is evidenced by the fact that between the years of 1989 and 2000 fuel wood and charcoal constituted between 32% and 40% of energy consumption in the country [5]. But while it is an attractive source of renewable energy for the rural poor as it is easily acquired and less hazardous to the environment, its wide spread use has led to cases of incessant deforestation. According to [6], approximately 350,000 hectares of natural vegetation and forest are destroyed annually and the deforestation rate is expected to increase alongside the increasing demand for energy. Therefore, while fuel wood is beneficial in solving the energy needs of the poor masses in the rural areas, there is also the need for its sustainable use to control the depletion of vital natural resources.

A cook stove is heated by burning fuel-wood, charcoal, coal, animal dung or crop residue. The traditional three stone cook stove, requires only three suitable stones of the same height on which a cooking pot can be balanced over a fire. It generally has an unnecessarily large distance between the pot and the fuel bed which leads to heat loss, very low heat transfer to the cooking pot and inefficient. The fuel energy is lost through all the sides of the cooking pot without encountering the cooking pot, further lowering conventional heat transfer. Due to incomplete combustion of biomass fuels in traditional cook stoves, appreciable quantities of irritants, toxins and carcinogens are released into the kitchen environment and these pose a major threat to the respiratory system of the users [7]. In general, the combustion products of wood are carbon dioxide, water vapour and carbon monoxide, particulate and polycyclic organic matters, the last three of which are known to be pollutants hazardous to human health [7].

The use of improved wood-burning cooking stove by rural households is therefore regarded as a win-win option, as it is not just effective in climate change abatement but also cost effective [8]. It plays a significant role in improving household's health conditions, the livelihood of the poor, reduction of the rate of deforestation and mitigation of global climate change [9–11]. Global Alliance for Clean Cookstoves [9] and other promoters of ICS argue that in addition to its contribution to health, economic, gender, environmental imperatives, the adoption of improved cookstoves plays crucial roles in achieving the United Nation Sustainable Development Goals (SDGs), specifically; child mortality, maternal health, gender equality, poverty eradication and environmental sustainability. Below are some of the benefits of improved cook stove:

- ✓ Reduction of deforestation through decrease in fuel-wood consumption.
- ✓ Reduction of emission of toxic carbons leading to fewer respiratory and eye diseases.
- ✓ Reduction of the drudgery task women and children undergo searching for fuel-wood.
- ✓ More opportunity for women and children to embark on other productive activities and educational pursuit.
- ✓ Increase in economic status of families which spend heavily on fuel-wood.

- ✓ Free from dirty and smoky kitchens.
- ✓ Encourages employment in the rural areas as artisans will find its production lucrative.
- ✓ Reduction in Green House Gas (GHG) emission.

For the success of improved cookstoves disseminating initiatives, programs and projects and for the realization of the potential benefits of improved cook-stoves, the stoves must first be adopted and then sustainably used by households [12,13]. To this end, research on understanding factors influencing the sustained use of improved cookstoves is crucial [12–15].

Scholarly literatures in this area points out the influence of socioeconomic factors such as affordability [16], funding source [17], user engagement [18], technology design that responds to consumer preference [19], local scarcity of fuel-wood, and stove manufacture by local artisans [12] on adoption of ICS. [20] study on adoption of ICS shows evidence of a systematically and theoretically consistent relationship between adoption of ICSs and socioeconomic status (including income, education, and social marginalization) and urban location. Also, income is the most widely studied determinant; although it was inconclusive in a few studies, most studies find that households with greater income are more likely to adopt more expensive, healthier and environmentally friendly stoves [20]. So far only few studies on ICS have been carried out in Nigeria; [21] studied the effect of an improved cook-stove on indoor particulate matter, lung function and fuel efficiency of firewood users, [22] equally studied the effects of unsustainable use of biomass energy for cooking and strategies for their reduction in developing countries. Notwithstanding, there is a paucity of research in determinants of use and adoption, constraints and strategies for ICS diffusion in Nigeria. This information is vital going by the fact that over 20 million households in Nigeria are still using traditional cook stoves [23]. This increased use of open fire stove is antithetical to sustainable use of ecosystem resources, particularly tree resources.

Fuel-wood use has been indicated as a major driver of deforestation in Nigeria [24], with deforestation rate standing at 3% per year which is equivalent to the loss of 410,000 hectares of forested land annually [25]. This problem is made more precarious in Enugu State, going by its growing population and urbanization. With a population density of 268 persons per sq. km, which is high when compared with the average national density of about 96 persons per sq. km [26]. There is a lot of pressure on forest resources in the state as many residential areas are being created by government to respond to the increasing need of shelter by its citizens with little or no concern to the environmental implications of these practices and these calls for an urgent policy response to stem this tide and preserve the environment for the next generation.

Furthermore, the rate of fuel-wood use in Nigeria is very unsustainable given the growing contribution of wood burning to global greenhouse gas emission [27] as well as other climate forcers, including black carbon (BC), in the atmosphere [28] and to respiratory diseases [29]. There is therefore a need to ascertain the factors that drive households' adoption of ICS in Nigeria and strategies for the diffusion of more efficient/economic alternative stoves to traditional cook stoves. This is imperative to provide the needed insight into the extent of ICS use, the determinants of ICS adoption, constraints and strategic solutions for policy making on ICS development and adoption in Nigeria. This is a necessary step towards sustainable use of natural resources and healthy environmental/economic development in not just Nigeria, but in other developing economies.

2. THEORITICAL FRAMEWORK

2.1 Externality and Public Goods Theory

Externalities are goods that have influence on the welfare (positive or negative) of another entity without being considered by any agent producing them. [30] stated that an externality exists when agent A's utility or production function depends directly on real variables chosen by another agent *B* without attention given to the effect on A's well-being. Many externalities in environmental economics have a structure that is like that of public goods. Public goods are goods that are at least partially non-rival and non-exclusive. Non-rival means multiple people can simultaneously enjoy the services of the good; non-exclusive means that none of these people can be prevented from enjoying the services of the good. The smoke from the combustion of biomass fuel is an externality which is being produced during household use of traditional cook stoves in their cooking

(households are made better off by getting cooked food on their table) without particular attention to its adverse effects to the well-being of the people (mainly women and children close to the kitchen are made worse off by getting respiratory diseases which at times end up in premature deaths) or environment (emission of greenhouse gasses GHGs).

Many environmental problems and their solutions share characteristics of public goods (or bad). For example, air pollution occurs frequently in Enugu metropolis due to unfortunate combinations of industrial activities, deforestations, use of traditional cook stoves and vehicle traffic and broadly affects people with respiratory problems and the environment in general. Efforts to reduce air pollution in the city would benefit these same people, regardless of their contribution to the control effort. In this sense air pollution is a public bad, and a reduction in air pollution is a public good. Therefore, the use of open fire cooking is a public bad and changing to improved cook-stove (ICS) is a public good as it helps to check deforestation for the good of all.

Consider a simple modern economy with two individuals, a dirty good (open fire cooking), a clean good (ICS), and labour as the only factor of production. Define the utility function for each person by $U_i(x_i,z_i,E)$ for i=1,2 where x_i and z_i are consumption levels of the two goods (open fire cooking and ICS) and E is an exogenous (to the consumer) level of pollution emissions. Production of x causes the emissions. Define the production function for x by $X = f(l_x,E)$, where both labour input l_x and emissions E have a positive marginal product. This setup treats emissions as an input, implying that a reduction in pollution reduces the output of x by decreasing a productive factor. While it is also possible to develop the model by treating *x* and E as joint products, this approach reduces notational clutter. The clean good z is produced using only labour according to the production technology $Z = g(l_z)$. Labour employed in the economy is constrained by the work time endowment l such that $l_x+l_z=l$.

The model pollution assumed that emissions are a pure private bad, and that people have no ability to protect themselves from the adverse consequences of exposure. Individuals can often take private action to mitigate the effective level of pollution by using ICS.

3. METHODOLOGY

The study was conducted in Enugu State, Nigeria, which is in the South East geo-political zone of Nigeria. It has an estimated total land area of about 8,022.96 sq. Km [31]. It lays entirely within the tropical zone at latitudes 5^0 56^0N to 7^0 05^0E of the Equator and longitude 6^0 53^0N to 7^0 55^0E of the Greenwich Meridian (Enugu State Agricultural Development Project [32]. Boundaries are formed by Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west. Enugu state has a population of 3,267,837 [26]. The state is made up of seventeen local government areas, which are divided into three (3) senatorial zones, namely: Enugu North, Enugu East and Enugu West. It has good soil-land and climatic conditions all year round, sitting at about 223 metres (732 ft.) above sea level, and the soil is well drained during its rainy seasons. The mean temperature in Enugu State in the hottest month of February is about 87.16 ℉ (30.64 ℃), while the lowest temperatures occur in the month of November, reaching 60.54 ℉ (24.86 ℃). The lowest rainfall of about 0.16 cubic centimetres (0.0098 cu in) is normal in February, while the highest is about 35.7 cubic centimetres (2.18 cu in) in July.

A multi-stage sampling technique was employed in the selection of the respondents for the study. Purposive sampling was used to select two towns (Nsukka and Enugu) for urban areas and ten rural communities were randomly selected from the list of rural communities in the state, 40 households were randomly selected from each of the two towns and eight households were randomly selected from each of the ten rural communities. This makes the total of 160 respondents studied.

Data were collected using pre-tested questionnaire with the help of research assistants. The questionnaires were administered to the literate households while the researcher interviewed the illiterate households and their responses were recorded accordingly to ensure accuracy of collected data. The data collection instrument was organized in sections to reflect specific objectives of the study.

The data collected were presented using descriptive statistics and analysed using inferential statistics. To ascertain the socioeconomic determinants of households'

adoption of improved cook stove in the study area, the study adopted the logit model. A similar approach and parameters was adopted by [33] in determining the socioeconomic determinants of cultivation of non-wood forest products in southern Nigeria and [34] in assessing the determinants for adoption of ICT-based market information services by smallholder farmers and traders in Mayuge District, Uganda. To measure the role of explanatory variables on the use of ICS by households in this study, the logit model was specified as follows:

$$Y = \propto + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_9 X_9 + \varepsilon \quad (1)$$

Where:

Yi = dependent variable, ICS adoption (1 if household adopts ICS, 0 otherwise)
α = Intercept,
$\beta_1 \ldots B_9$ = parameters to be estimated,
e= error term,
$X_1 \ldots X_9$ = vector of explanatory variables.

Where:

X_1= age (years), X_2= gender (dummy, 1 = male, 0 = female),
X_3= level of education (years),
X_4= Marital status (dummy, 1 = married, 0 if otherwise),
X_5 = Farming Experience (years),
X_6= Household size (number of persons),
X_7= Occupation (dummy, 1 = farming, 0 if otherwise),
X_8= Household income level in a month (Naira) and
X_9 = Location (Dummy, 1 = Urban, 0 = Rural) respectively.

A 4-point Likert type scale rating was used to analyze the constraints faced by households' in the use of ICS and this was used to enable respondents to specify their levels of agreement or disagreement on a symmetric agree – disagree scale for series of item statements. This were regarded as strongly agree (SA) agree (A) disagree (DA) strongly disagree (SD), with corresponding values of 4, 3, 2, and 1 respectively. The mean score of the respondents based on the 4 – point rating scale were computed as: $\frac{4+3+2+1}{4}$ = 2.50 cut off point. Based on this, any score below 2.50 (MS<2.50) were taken as a weak factor and not considered while those with mean score greater than 2.50 (MS>2.50) were taken as strong factors and considered.

4. RESULTS AND DISCUSSION

This section presents the results of the analysis and interpretation of the responses, reactions and discussions gathered through the structured questionnaire on the specific objectives of the study.

4.1 Socioeconomic Characteristics of Household

Table 1 shows the relevant socio-economic characteristics of households. Age, gender, marital status, educational level, occupation, household size, farming experience, location and household income level in a month were discussed in this section.

The results show that majority (23.12%) of the age of the household heads are within the range of 31-40 years of age, closely followed by 41-50 (22.50%) age range and 20-31 (21.25%), indicating that most of the household head in the study area were young and still in their productive age. Younger household head are known to be good adopters of innovation as older people are usually more conservative towards adopting innovations and instead they prefer to continue using their traditional methods [20]. They found statistically significant relationship between age and ICS stove adoption decision.

Majority of the household heads interviewed were female (56.90%). Females are more responsible for use of stoves in the households for the preparation of food and other uses. They therefore are the victims of the adverse effects of preparing food and collecting fuel-wood as compared to their male counterparts, therefore they are the primary beneficiaries of fuel efficient improved cooking technologies as compared to male household members. It is consistent with the studies of [35,36] which found that women (female headed households) are more likely in adopting improved cooking technologies.

Most of the household heads were married (68.10%). It is expected that married women are more likely to adopt more efficient cooking technologies as they can easily source for finance from their husbands for the procurement of these technologies. Most of the household heads in the study area had other occupations (60.60%) other than farming (39.40%) and has lesser farming experience with 0-10 years (74.38%) being most of the experiences garnered in farming from the area.

Table 1. Socioeconomic characteristics of the households'

Variables	Percent	Mean	Std. Dev
Age			
20-30	21.25		
31-40	23.12		
41-50	22.5		
51-60	18.13		
61 and above	15		
TOTAL	100	46.58	14.957
Gender			
Female	56.9		
Male	43.1		
TOTAL	100	0.43	0.497
Marital status			
Married	68.1		
Otherwise	31.9		
TOTAL	100	0.68	0.467
Educational level (Yrs)			
No Edu	14.4		
Pri Edu	14.4		
Sec Edu	28.8		
Tert Edu	25.6		
MSc	14.4		
PhD	2.4		
TOTAL	100	11.33	5.879
Occupation			
Farming	39.4		
Otherwise	60.6		
TOTAL	100	0.39	0.490
Farming experience (Yrs)			
0-10	74.38		
11 20	16.25		
21-30	6.25		
31 and above	3.12		
TOTAL	100	9.49	8.700
Household size			
1-5	59.38		
6-10	31.25		
11-15	8.12		
16-20	1.25		
TOTAL	100	5.31	3.843
Location			
Rural	50		
Urban	50		
TOTAL	100	0.50	0.502
Monthly Income level			
1000-50000	85		
50001-100000	10		
100001-150000	3.12		
150001-200000	1.88		
TOTAL	100	2.96E4	36107.187

Source: Field Survey, 2016

Majority of the household heads attained secondary (28.80%) and tertiary (25.60%) education. Thus, it is expected that literate women are more likely to adopt, compared to the illiterate women as they are more aware of the benefits of ICS as compared to uneducated ones.

It was found also that majority of the household size in the area were within 1-5 (59.38%). It is most likely that because most of the household heads are educated and know the importance of family planning and child education. Finally, majority of the household's income level in a month was within the range of ₦1000 to ₦50000 (85%), indicating that they are of low income class.

4.2 Extent of Improved Cook Stove Use

Tables 2 and 3, shows that majority (68%) of the households in the study area uses one form of ICS or the other which shows that the adoption rate of ICS is very high. It equally showed that majority (41.35%) of the households use saw dust stove, while 29.81% uses iron bucket stove, 18.27% use U-shaped mud stove and 10.57% use Jiko/Mirt stove.

Table 2. Extent of locally fabricated improve cook stove use

Variables	Percentage
Uses ICS	68.10
Do not use ICS	31.90
TOTAL	100

Source: Field survey, 2016

Table 3. Different kinds of locally fabricated ICS used

Categories of ICS usage	Freq.	Percent
Iron bucket stove	36	33.03
Saw dust stove	43	39.45
U shaped mud stove	19	17.43
Jiko&Mirt stove	11	10.09
Total	109	100.00

Source: Field survey, 2016

To prefer a stove type or category does not necessarily guarantee one's interest in using it as many factors come into play. This is because one could prefer a stove type but, because of lack of finance, resorts to using a cheaper one. However, the results of the survey imply that majority of the households in the state are using more of the locally fabricated ICSs of various categories than modern ICSs due to lack of availability, lack of awareness and high cost (Tables 5 and 6).

4.3 Determinants of Improved Cook Stove Adoption

The result of the logit analysis in Table 4 indicates that different factors influence households' use of ICS in the study area. The Chi-square is significant at ($P< 0.01$) suggesting the goodness of fit of the model. Due to the significance of the model, we reject null hypothesis which states that socioeconomic factors do not influence households' adoption of biomass improved cook stove and accept the alternative hypothesis which states that socioeconomic factors have influence on households' adoption of biomass improved cook stove. The model seems to have behaved well in consistency with *a priori* expectations, based on literature on the relationship between the dependent and the explanatory variables.

It further found that age of household head was negatively significant at $p<0.1$. The marginal analysis shows that a year increase in age of household head has 2.8% likelihood of decreasing ICS adoption in the study area. This means that younger household heads tend to adopt more technologies than older household heads. This is supported by [37] in their study on Socioeconomic Factors Affecting the Adoption of Improved Agricultural Technologies among Women in Marakwet County Kenya found that the older the women, the lesser the likelihood of adopting the technology. And gender of household head also was negatively significant at $P<0.05$. The marginal analysis shows that one percent increase in the number of male household head has an 88.7% likelihood of decreasing ICS use in the study area. This could be because females are more responsible for use of stoves in the households for the preparation of food and other uses, therefore more willing to accept an improvement in stoves efficiency. This is because in Nigeria culturally, they are the more responsible for cooking therefore more prone to the adverse health, social and economic effects of inefficient stoves like open fire stoves than the male heads. Recent empirical studies in Ethiopia [38], Ghana [39], Nigeria [40] and Benin [41] all document gender based disparities in adoption of improved technologies including improved seed, inorganic fertilizer, chemical insecticide etc. They agreed that some technologies appear to be more easily adopted by women than men. The result of this study is consistent with the findings of [36] in clean fuel-saving technology adoption in urban Ethiopia and [35] in the role of social capital in the adoption of firewood efficient stoves in the Northern Peruvian Andes. They found that female headed households are more likely to adopt ICS than male headed households.

Table 4. Logit results of the determinants of households' adoption of ICS

Variables	Coefficient	P> | Z|	Marginal analysis	P > |Z|
Constant	-2.068373	0.099		
Household head age	-0.0281824	0.097	-0.0053141	0.101
Household head gender	-0.886851	0.037	-0.1712942	0.041
Marital status	0.5929511	0.171	0.1173352	0.189
Educational level	0.1974002	0.001	0.0372222	0.002
Occupation	0.4671514	0.497	0.0858253	0.484
Farming experience	0.0260985	0.370	0.0049212	0.372
Household size	0.1283522	0.060	0.0242024	00.64
Location	0.6700866	0.275	0.1260374	0.273
Income level in a month	0.0000257	0.043	4.85e-06	0.025
Number of observation	160			
Pseudo R^2	0.2344			
Chi^2	246.94			
Prob>chi^2	0.0000			

Source: Field survey, 2016
(dy/dx) is for discrete change of dummy variable from 0 to 1

The results of the logit analysis also found that the household head educational level was positively significant at P<0.01. The marginal analysis shows that there was 19.74% likelihood of educated household heads using ICS than the less educated and illiterate household heads. This agrees with [42] who found in their study that education has a positive significant influence on early adoption of Improve cooking stove. This shows also that literate women are more adopters of ICS as compared to the illiterate women, as they are more aware of its benefits compared with uneducated ones. This is because they try to improve on their standards of living. These more educated household heads tend to work more as civil servants, thus have more money to purchase ICS and as well like a more convenient cookstove than the open fire stove. Use of ICS is also more prestigious than open fire stove. Furthermore, they are more aware of the impacts on their health and global warming through smoke inhalation and greenhouse gas emission, respectively.

Table 4 equally found household size to be positively significant at p<0.1. The marginal analysis indicates that one percent increase in household size has a 12.8% likelihood of increasing adoption of ICS. This means that as the member of the household increases, their food demands will equally increase and the need for more efficient method of cooking becomes inevitable. This was in accordance with [42] who equally found that higher family size has a positive significant influence on early adoption of Improve cooking stove.

Table 4 on the same not found income level to be also positively significant at P<0.05. The marginal analysis implies that one percent increase in income level of a household has a 0.0026% likelihood of increasing use of ICS in the study area. This infers that money has a direct relationship with adoption of an innovation (ICS), as the adopter must be financially buoyant enough to offset the cost of such innovation. This also supports [20] finding that households with greater income are more likely to use more expensive, healthier and environmentally friendly stoves such as ICS.

4.4 Constraints Faced by Households in their Use of ICS

From the result on Table 5, variables such as not easily affordable (M-2.56), lack of awareness (M-2.61), it does not last (M-2.81) and not suitable for heavy pots (M-2.71) are constraints faced by households in the study area as they attained the decision mean score of 2.5, while other variables (lack of information on proper use, lack of input materials, takes more time in cooking and Culture forbids it) are not constraints to the use of ICS in the study area.

This implies that affordability, awareness, quality/durability and size of ICS in the study area must be seriously accessed to enable easy diffusion of ICS in the area.

4.5 Possible Solutions to the above Constraints

This section discusses the possible solutions to ICS constraints stated by the households in the study area.

Table 5. Mean score for the constraints faced by households in the use of ICS in Enugu State

Variables	Mean ($\bar{x}$)	Decision
Not easily affordable	2.56	Accept
Lack of awareness	2.61	Accept
Lack of information on proper use	2.06	Reject
Lack of input materials	2.00	Reject
It does not last	2.81	Accept
It takes more time in cooking	1.96	Reject
Not suitable for heavy pots	2.71	Accept
Culture forbids it	1.50	Reject

Source: Field survey, 2016

Table 6. Distribution of the possible solutions to ICS use constraints in Enugu state

Variable	Mean ($\bar{x}$)	Decision
Availability	3.06	Accept
It should be made cheaper	3.09	Accept
More awareness should be created	2.57	Accept
It should be made more durable	3.83	Accept
Should be subsidised by Government	3.11	Accept

Source: Field survey, 2016

From Table 6, the mean score Likert type rating were used which showed that the possible solutions to ICS use in the state are availability of ICS in local markets which will help more people in the rural communities who are willing to adopt ICS have access to it, reduction of the prices of ICS to enable the low-income earners in the rural communities afford it. According to [43] farmers in Africa continue to adopt high yielding varieties, efficient technologies and improved management systems at low rates. Awareness creation, production of standard quality of ICS and Government role in making policies that will favour more production and adoption were accepted to be the possible solutions to ICS constraints in the study area having attained the decision mean of 2.5.

5. CONCLUSION

This study examined the use and determinants of households' adoption of biomass improved cook stove in Enugu state, Nigeria. The study analysed the socioeconomic factors affecting households' adoption of improve cook stove, the extent of improve cook stove adoption and the constraints with possible policy influencing solutions.

The socioeconomic factors of households in the area showed that majority (56.90%) were females aged between 31 – 40 years (23.12%) and are married (68.10%). Majority of the household heads attained secondary (28.80%) and tertiary (25.60%) education with a household size within 1 – 5 members (59%) and income level ranging from N1000 – N50000 (85%) per month indicating low income class of the households.

The findings show the extent of improved cook stove use in the area which revealed that majority of the households in the study area (68%) use one form of biomass improved cook stove or another.

The study revealed the socioeconomic determinants of improved cook stove adoption in the study area as thus; age, gender, educational level, household size and household income level. These determinants were found to be significantly affecting improved cook stove adoption in the study area. Age and gender were found to be negatively significant while educational level, household size and income were found to be positively influencing adoption of improved cook stove in the area. Male household head has an 88.7% likelihood of decreasing ICS use, an increase in education has a 19.74% likelihood of increased adoption of ICS and an increase in income level of households has 0.0026% likelihood of increasing ICS adoption. Therefore, it shows that socioeconomic characteristics of the household have significant influence on ICS adoption.

It also revealed that constraints faced by households over the adoption of ICS are: affordability, lack of awareness, poor quality and unsuitable for heavy pots but on a similar note solutions were proffered which are availability of

ICS in local markets which will help more people in the rural communities who are willing to adopt ICS have access to it, reduction of the prices of ICS to enable the low income earners in the rural communities afford it and government interventions in making adequate policies necessary for easy diffusion of improved cook stove due to its tripartite economic, health and environmental benefits.

As verified through this study, economic viability is a very important topic that needs to be emphasised in as far as purchase and produce of goods are concerned. The issue of affordability plays a key role in the lives of many mainly the poor rural dwellers. The motives behind the preference of stoves used differed from one community to the other. In the urban area, many preferred a stove type because of efficiency, affordability and maybe less smoke production while in the rural area, affordability is the main driving force behind stove use.

Measures should be taken by environmental experts and policy makers to promote the use of ICS by making it available, affordable and promote more awareness on the use of improved cook stove. Such measures will help in reduction of the consumption rate of fuelwood, implying a reduction in the pressure of wood resources; reduce health risk and contributing towards mitigation of global climate change through controlled deforestation.

Government should use economic incentives measure in the development of environmental policies to convince the people in change their behaviour in tandem with the aim of the policy, instead of the use of command and control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. WHO. Fuel for life - household energy and health. Geneva, Switzerland: World Health Organization (WHO); 2006.
2. OECD/IEA. World Energy Outlook. Organisation for Economic Co-operation and Development (OECD)/International Energy Agency (IEA); 2006.
3. simonyan KJ, Fasina O. Biomass resources and bioenergy potentials in Nigeria. Afr J Agric Res. 2013;8(40):4975–89.
4. Onyekuru NA. Effects of cooking energy price changes on their substitution and resource allocation': A comparative analysis of rural and urban households in Enugu State, Nigeria [Masters Degree]. [Nsukka]: University of Nigeria, Nsukka (UNN); 2008.
5. Kevelaitis K. Solar energy implementation in Nigeria [Bachelor Degree]. Business Studies. Roskilde University, Denmark; 2008.
6. Sambo AS. Renewable energy for rural development: The Nigerian perspective. J ISESCO Sci Technol. 2005;1:12–22.
7. Sarkar MQ, Akter N, Rahman M. Assessment of existing improved cookstove in Bangladesh. [Dhaka]: Dhaka: BRAC; 2006.
8. Onyekuru NA, Marchant R. Climate change impact and adaptation pathways for forest dependent livelihoods in Nigeria. Afr J Agric Res. 2014;9(24):1819–32.
9. GACCS. Igniting change: A strategy for universal adoption of clean cookstoves and fuels. Global Alliance for Clean Cookstoves; 2011.
10. GIZ. Clean and efficient cooking energy for 100 million homes: Results from the bonn international cooking energy forum. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. 2013;26–8.
11. WHO. Guidelines for indoor air quality: Dampness and mould. WHO Regional Office for Europe, Copenhagen, Denmark: World Health Organization (WHO); 2009.
12. Barnes DF, Openshaw K, Smith KR, Van der Plas R. What makes people cook with improved biomass stoves? A Comparative International Review of Stove Programs. World Bank Tech Pap Wash DC; 1994.
13. GACCS. Results report: Sharing progress on the path to adoption of clean cooking solutions. Global Alliance for Clean Cookstoves; 2012.
14. Mobaraka A, Dwivedib P, Bailisb R, Hildemannc L, Millerd G. Low demand for non-traditional cookstove technologies. PNAS. 2012;109(27):10815–20.
15. Puzzolo E, Stanistreet D, Pope D, Bruce N, Rehfuess E. Factors influencing the large-scale uptake by households of cleaner and more efficient household

energy technologies: Systematic review; 2013.

16. Slaski X, Thurber M. Research note: Cookstoves and obstacles to technology adoption by the poor. Stanford, CA; 2009. Report No.: 89.
17. Bailis R, Cowan A, Berrueta V, Masera O. Arresting the killer in the kitchen: The promises and pitfalls of commercializing improved cookstoves. World Dev. 2009; 37(10):1694–705.
Available:http://linkinghub.elsevier.com/retrieve/pii/S0305750X09000862
[Cited 2017 Jul 31]
18. Pohekar SD, Ramachandran M. Dissemination of cooking energy alternatives in India - A Review; 2005.
Available:https://www.researchgate.net/publication/222513562_Dissemination_of_cooking_energy_alternatives_in_India_-_A_review
[Cited 2016 Oct 10]
19. Sinton JE, Smith KR, Peabody JW, Yaping L, Xiliang Z, Edwards R, et al. An assessment of programs to promote improved household stoves in China. Energy Sustain Dev. 2004;8(3):33–52.
Available:http://linkinghub.elsevier.com/retrieve/pii/S0973082608604652
[Cited 2017 Jul 31]
20. Lewis JJ, Pattanayak SK. Who adopts improved fuels and cookstoves? A systematic review. Environ Health Perspect. 2012;120(5):637–45.
21. Fajola A, Fakunle B, Aguwa EN, Ogbonna C, Amechi AO. Effect of an improved cookstove on indoor particulate matter, lung function and fuel efficiency of firewood users. Am J Res Commun. 2014;2(8):189–207.
Available: www.usa-journals.com
22. Bolaji BO. Effects of Unsustainable use of biomass energy for cooking and strategies for their reduction in developing countries. Dev Ctry Stud. 2012;2(3).
23. ICEED. Nigeria sets standards for wood cooking stoves. International Centre for Energy, Environment & Development; 2013.
Available:http://www.bailiffafrica.org/nigeria-sets-standards-for-wood-cooking-stoves/
[Cited 2017 Jun 13]
24. Nasiru IM. Desertification in the dry lands of Nigeria and its consequences; 2007.
Available:http://fab.utm.my/wpcontent/uploads/2011/10/cStudents_student3Seminar200708.pdf
[Cited 2016 Mar 16]
25. FAO. Global Forest Resources Assessment 2005. Food and Agriculture Organisation of the United Nations; 2005. Report No.: 147.
Available:http://ftp://ftp.fao.org/docrep/fao/008/A0400E/A0400E00.pdf
[Cited 2016 Mar 16]
26. NPC. Population by State and Sex. National Population Commission; 2006.
Available:http://web.archive.org/web/20110519235026/http://www.population.gov.ng/files/nationafinal.pdf
27. Venkataraman C, Sagar AD, Habib G, Smith K. The national initiative for advanced biomass cookstoves: The benefits of clean combustion. Energy Sustain Dev. 2010;14(2):63–72.
28. Ramanathan V, Carmichael G. Global and regional climate changes due to black carbon. Nat Geosci. 2008;1:221–7.
29. Smith KR, Mehta S. The burden of disease from indoor air pollution in developing countries: Comparison of estimates. Int J Hyg Env Health. 2003;206:279–89.
30. Baumol W, Oates W. The Theory of environmental policy. 2nd ed. Cambridge: Cambridge University Press; 1988.
31. Ezike JO. Delineation of old and new Enugu State bulletin. Ministry of Works, Land and Survey, Enugu State; 1998;
32. ENADEP. Annual Report. Enugn State Agricultural Development Project; 2009.
33. Chukwuone NA. Socioeconomic determinants of cultivation of non-wood forest products in southern Nigeria. Biodivers Conserv. 2009;18(2):339–53.
Available:http://link.springer.com/10.1007/s10531-008-9489-y
[Cited 2017 Jul 31]
34. Sekabira H, Bonabana J, Asingwire N. Determinants for adoption of ICT - based Market information services by smallholder farmers and traders in Mayuge District, Uganda [Master of Science degree]. [Kampala]: Makerere University; 2012.
Available:http://www.aes.ac.uk/upload_area/papers/Haruna_Ahmad_Sekabira_SEKABIRA-Rural-ICT-USE.pdf

35. Adrianzén M. The role of social capital in the adoption of firewood efficient stoves in the Northern Peruvian Andes; 2009.
36. Damte A, Koch S. Clean fuel-saving technology adoption in urban Ethiopia. Work Pap 229; 2011.
37. Sulo T, Koech P, Chumo C, Chepng'eno W. Socioeconomic Factors affecting the adoption of improved agricultural technologies among women in Marakwet County Kenya. J Emerg Trends Econ Manag Sci JETEMS. 2012;3(4):312–7.
38. Tiruneh A, Tesfaye T, Mwangi W, Verkuijl H. Gender Differentials in agricultural production and decision-making among smallholders in Ada, Lume and Gimbichu Woredas of the central highlands of Ethiopia. Mexico: CIMMYT, EARO and EU: Mexico; 2001.
39. Doss CR, Morris ML. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Agric Econ. 2001;25:27–39.
40. Sanginga PC, Adesina AA, Manyong VM, Otite O, Dashiell KE. Social impact of soybean in Nigeria's southern Guinea savanna. IITA Ib Niger; 2007.
Available:http://pdf.dec.org/pdf_docs/Pnacq302.pdf
[Cited 2016 Oct 27];
41. Kinkingninhoun-Mêdagbé FM, Diagne A, Simtowe F, Agboh-Noameshie AR, Adegbola PY. Gender discrimination and its impact on income, productivity and technical efficiency: Evidence from Benin. Agric Hum Values; 2008;
42. Gebreyohanes TG, Bahiigwa G, Tefera W. Impacts of fuel efficient improved cooking stove on biomass collection and consumption in rural Ethiopia. Int Food Policy Res Inst IFPRI Ethiop. 2015;16–8.
43. Doss C. Designing agricultural technology for African women farmers: Lessons from 25 years of experience. World Dev. 2001;29(12):2075–92.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/22113