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Predictors of Clean Cookstoves Adoption by Households in Lagos State, Nigeria

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Abstract
The adoption of Clean Cookstoves (CCS), which are clean, efficient, renewable and modern forms of cookstoves and fuels, have shown mixed results globally. In Sub-Saharan Africa, the adoption rate of CCS is still at the lowest level despite persistent deteriorating environmental conditions, rapid deforestation, climate change, health hazards and rising mortality rate of women and young children as a result of the use of traditional cookstoves and fuels. Several socio-economic, cultural, behavioural, institutional and environmental factors have been identified as critical factors influencing energy cooking choice of households across the urban and rural regions. Drawing from the value chain framework and relevant literatures, fourteen (14) predictive factors were identified as critical factors for the adoption of CCS and fuels in Lagos State, Nigeria. A survey of 200 households on their perception of CCS adoption in Lagos Mainland LGA of Lagos State was carried out. The outcome of responses was analysed using the Partial Least Square (PLS) Regression Technique. The results revealed that user's preference, household's affordability, CCS suitability, perceived benefits of using CCS, the transition to CCS, level of education and accessibility of CCS are strong predictors of the adoption of CCS by Lagos households; the remaining factors are low predictors. Additionally, the T-test results revealed that all the factors were significant at a 0.05, except for customs and belief which recorded a lower significant value. The study recommended that all the identified fourteen (14) predictors should be considered as the value-added interactions of factors are fundamental to the adoption of a new product or technology, however, the strong predictors identified in the study should be given utmost consideration.

Keywords: *Traditional Cookstoves (TCS), Clean Cookstoves (CCS), Adoption (A), Households, Partial Least Square (PLS) Regression*

1.0 Introduction

Recent studies on cookstoves and fuels show that over 3 billion people in the developing world maintain regular use of solid fuels and primitive indoor cookstoves (Broder, 2010; World Bio-energy Association (WBA), 2016; Gallagher, Beard, Clifford & Craig, 2016). In Sub-Saharan Africa (SSA), more than 700 million people cook with conventional biomass and inefficient cookstoves. This figure is expected to rise above 820 million by 2030

(International Energy Agency (IEA), 2013). The use of the cookstoves and fuels have added to global warming and forest depletion, which is due to constant cutting down of trees for firewood (fuelwood) (Broder, 2010; Bailis, Drigo, Ghilardi & Masera, 2015; Malla & Timilsina, 2014).

Toxic smoke emanating from traditional cookstoves (TCS) and fuels (such as firewood, charcoal, dung and primitive and inefficient indoor cookstoves) has contributed to 4 million deaths (Global Alliance for Clean Cookstoves (GACC), 2011; Lim et al., 2012); of which girls and women are the most affected (The World Bank, 2014). Statistics revealed that a large number of women and children are prone to diseases from TCS and solid fuels, which some researchers referred to as the 'silent killer' (GACC, 2011). Women and girls are also prone to attacks when searching for firewood in forests or isolated places (GACC, 2016).

Africa has recorded about 600,000 deaths due to TCS and fuels (Srilata, Jan Friedrich, Dana, Besnik & Ramana, 2014). In Nigeria, over 136 million individuals are affected by HAP and about 95,000 people (mostly women and children) die annually from poisonous emission from the unclean and unsafe cooking technologies (Nigeria Global Alliance for Clean Cookstoves (NACC), 2015). Nigeria, among other SSA countries, has recorded the highest deaths from the smoke-related crises (Global Alliance for Clean Cookstoves (GACC), 2016).

The clean cooking energy sector is currently bedevilled with challenges that have contributed to the slow adoption of CCS and fuels (GACC, 2011; Simon, Bailis, Baumgartner, Hyman, & Laurent, 2014; GACC, 2016). A huge market potential for CCS market exists in Nigeria, but this is underexploited as the institutional and infrastructural supports to scale-up adoption are absent in many rural and certain urban areas (GACC, 2011; NACC, 2016). For instance, merely 11 % of Africans adopt CCS that utilizes modern fuels such as Liquefied Petroleum Gas (LPG) and electric stoves, while the use of renewable energy solutions such as ethanol, biogas, and solar are unpopular (World Bank Report, 2014; Njenga et al., 2016).

Global Alliance for Clean Cookstoves, (GACC) and government agencies in Nigeria, championing better and healthier clean cooking fuels such as Liquefied Petroleum Gas (LPG) and ethanol (GACC, 2016), are faced with the problem of the slow adoption rate of CCS and fuels in Nigeria, particularly in the rural areas. There are numerous challenges faced by these bodies that make it difficult to achieve the desired successful implementation of CCS and fuels (Simon, Bailis, Baumgartner, Hyman & Laurent, 2014; NACC, 2016).

Several studies revealed that some critical socio-economic, cultural and behavioural factors may be responsible for the slow adoption rate in middle and low-income countries (Masera, Saatkamp & Kammen, 2000; Slaski, Xander, & Thurber, 2009; Tina & Adler, 2010; Akbar, Barnes, Eil & Gnezditskaia, 2011; Jueland & Pattanayak, 2012; Malla & Timilsina, 2014). The aim of this study is, therefore, to analyse empirically the factors affecting adoption of CCS and fuels independently and collectively, among households in Lagos State, Nigeria.

1.2 Statement of the Problem

The growing concern about environmental pollution and degradation associated with the use of fossil fuels and other existential human activities, such as tree felling, has made the quest for clean, cost-effective and safe energy imperative. Moreover, the hazardous health implication of the utilization of TCS and fuels, which has been linked to increasing mortality rate among women and children due to continuously exposure to high emission of poisonous smoke from open fire, has given rise to the need for more empirical research in the clean cooking energy sector in both the developed and developing countries. Studies revealed that SSA countries have recorded high toxic-smoke related deaths while majority of these deaths occurred within Nigeria. Despite the severe consequences linked to TCS and fuels, and clamour for CCS and fuels, the adoption CCS and fuels is still low in many parts of Nigeria (GACC, 2011, NACC, 2015, GACC, 2016).

Literatures on CCS have shown that there are several causes and barriers for the low adoption rate across countries (World Bank, 2014; Malla & Timilsina, 2014; Jeuland et al., 2015; Haider et al., 2016). There are, however, fewer literatures on CCS and adoption barriers as well as predictive factors that affect CCS adoption among households in Nigeria. Moreover, extant literatures conducted in Nigeria mostly concentrated on the health and environmental impact of TCS and CCS on individuals, communities and the environment; the models and designs of CCS (for example Oluwole et al., 2013; Fajola et al, 2014; Northcross et al., 2016). There is, however, paucity of studies on the predictive factors of CCS adoption in both rural and urban region of Nigeria, which this study seeks to address by collecting and analysing relevant information that established the effects of predictors on the adoption of CCS among households in Lagos State.

1.3 Research Objectives and Questions

The study focused on investigating the predictive factors of adoption of CCS in Lagos State. The study identified 14 predictive factors as critical in the adoption of CCS in Lagos State. The predictive factors were examined individually and collectively, to determine their effects on the adoption of CCS by residents of

Lagos Mainland. The study, therefore, seeks to answer the following specific research questions: (i) what are the individual effects of the identified predictive factors on adoption of CCS by households in Lagos State? (ii) What is the collective effect of the identified predictive factors on the adoption of CCS by households in Lagos State?

1.4 Research Hypotheses

The research hypotheses are stated in null hypothesis as:

H_{01}: The identified predictive factors do not affect the adoption of CCS by Households in Lagos State individually.

H_{02}: The identified predictive factors do not affect the adoption of CCS by households in Lagos State collectively.

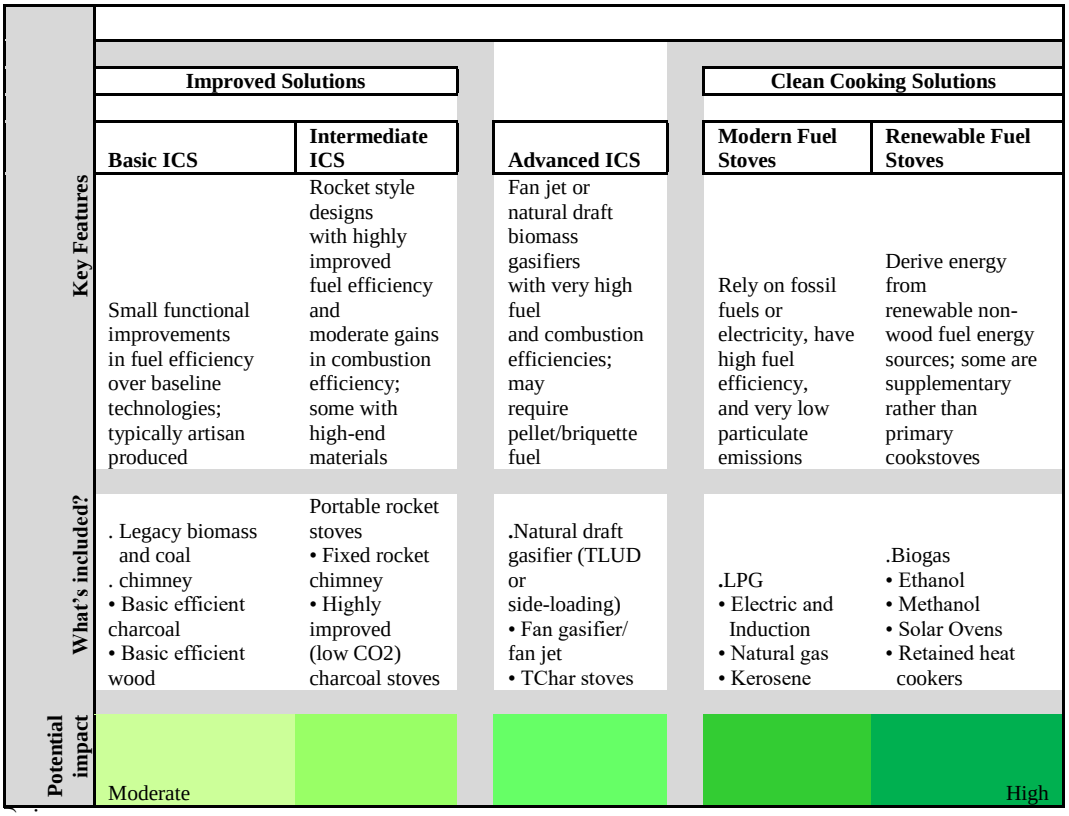
2.0 Literature Review

Clean Cookstoves- CCS Defined

The CCS concept is a generic term that refers to any cooking technology, using modern and renewable fuels that produce an improved combustion of energy, better indoor air quality and heat transfer, and low emission of particulate and carbon monoxide levels. Examples include high-performance biomass cookstoves (ACS), LPG, natural gas, electric stoves, solar stoves, retained- heat cooking devices, biogas stoves, and the ethanol stoves (Africa Clean Cooking Energy Solutions, (ACCES), 2014).

Cookstoves designs and models determine their performance. The categorization of kerosene as CCS depends on the stoves quality. While well-designed kerosene stoves emit minimal smoke, poorly designed kerosene stoves emit a high level of smoke. The basic and intermediate ICS, on the other hand, are classified as improved solutions with low and moderate combustion efficiencies while the advanced improve cookstoves have high fuel and combustion efficiencies. The modern fuel stoves and renewable fuel stoves are grouped under the clean cooking technologies (ACCES, 2014). This is shown in Figure 2.

Figure (2) Overview of Improved and Clean Cooking Technologies



Source: Adapted from World Bank, Global Alliance for Clean Cookstoves, Team analysis (ACCES, 2014).

Clean and efficient cookstove appliance costs are high compared to the purchasing power of the population in Africa. Most highly improved and clean cooking solutions in Africa cost between US$20-100 and US$500-1,500 for most households' technologies. The penetration of better and clean cookstoves is expected to rise from 24% (48 million households) in 2010 to 36% (80 million households) in 2020. However, the market situation still leaves an immense majority of Africans without access to better and efficient clean cooking solutions, due to a major hindrance to accelerating the uptake of CCS and ICS solutions in Africa (ACCES, 2014).

Challenges of Adoption of CCS in Sub-Saharan Africa

It has been proven that an estimated 80.9 million clean and efficient stoves have reached several households globally since 2010 (GACC, 2015; World Bank, 2014). Bangladesh and India have recorded a significant progress in terms of

adoption of clean cookstoves and fuels (GACC, report 2016). This is not the same in SSA, given that less than 1 million households (less than 0.5 per cent of the region population) still use alternative biomass fuels, such as pellets, carbonized and un-carbonized briquettes, ethanol and ethanol gel (World Bank Report 2014; Piedrahita et al., 2016).

The literature on CCS and improve cookstoves are extensive on the causes and barriers for the low adoption rate across countries, particularly in SSA countries (Jeuland et al., 2015; Haider, Rahman & Islam, 2016; World Bank 2014). These barriers include among others, consumer preferences, household profiles, purchasing power or household income, socio-cultural background and institutional constraints (Ruiz-Mercado, Masera, Zamora, & Smith, 2011). Similarly, Rehfuess, Puzzolo, Stanistreet and Bruce (2014) maintain that several cookstoves designs and programs have low success rate and have not been able to achieve the desired outcomes due to indifference to the users' needs.

The challenge of affordability, quality of CCS, funding, and users' education seems to plague the clean cooking energy sector in Nigeria (NACC, 2016; GACC, 2016). For instance, estimation from the United Nations reveals that a figure of over 66.4 per cent of people living in Nigeria lives below $1 a day (WHO, 2010). Thus, the choice of cooking energy, which is affected by the low-income level, poses a threat to the successful implementation of the CCS. Moreover, the free collection of firewood had resulted in its over-dependence despite the problems attributed to solid fuels (Isihak & Akpan, 2012).

The World Bank Report (2009) on the availability, affordability and awareness of fuels types shows that firewood and charcoal are in surplus and easily accessed from a wide network of retailers. Moreover, these fuels are easily adjustable to the income profile of households in developing countries. LPG and other renewable fuels, on the other hand, are not readily accessible and this undermines their attractiveness for regular use by households.

However, in Nigeria, the use of LPG shows mix results. A study on the household choice of cooking types in Ikeja, by Emagbetere, Odia and Oreko (2016) demonstrates that there is a high use of gas and kerosene in some parts of Lagos State while in Oshogbo; there is low usage of LPG as the majority of the households depend on charcoal and firewood for cooking. This explains the views of Leiwen and O'Neill (2003) that the choice of cooking energy varies from place to place.

The Socio-Economic, Cultural and Behavioural Feasibility of CCS Adoption

Malla and Timilsina (2014) categorize some factors affecting clean and efficient cookstoves and fuels into three main divisions: socio-economic factors (such as, prices, income, education and knowledge, distribution cost, accessibility and availability), cultural and external factors (government programmes, indoor air pollution), and behavioural factors (such as, lifestyle, social class, food and tastes). Masera, Saatkamp and Kammen (2000) also describe four main factors- the economics of fuel and stove types, cultural preference, indoor air pollution, environmental and health implications, the technicality of cookstoves types, and accessibility as significant in the choice of fuels and cookstoves among rural households.

Several literature confirm that households income, age, educational background, gender and leadership status, including cultural beliefs, social norms and institutional factors determine the choice of energy cooking technology (Makame, 2006; Bikram, 2008; Beyene & Koch, 2013; Okuthe & Akotsi, 2014). Studies carried out by Lewis and Pattanayak (2012) identify factors such as socioeconomic status- income, education and socially marginalised status while Foell, Pachauri, Spreng and Zerriffi (2011) identify some intervention measures such as societal awareness, public-private partnerships, government involvement, and socio-economic indicators (such as healthcare, education and economic development) as important to CCS and fuels adoption.

Consumer (user) awareness and education on the environment, health, gender roles and potential benefits of CCS are critical to enhancing the adoption of CCSs (GACC, 2011; WHO, 2014; Malla & Timilsina, 2014). Affordability and level of engagement are significant to households' choice of cookstoves and fuels (Slaski & Thurber, 2009). Households' characteristics and per capita income, institutional hurdles, consumers' preference, the financial constraint of households, and socio-cultural environment are crucial to CCS and efficient fuels adoption (Bansal, Saini & Khatod, 2013; Bielecki & Wingenbach, 2014). Female educational background and poor stakeholders' relationships were also found to be significant in the choice of cooking energy (Heltberg, 2004; Pundo & Fraser, 2006; Suliman, 2010; Ekouevi & Tuntivate, 2012).

Riley (2014) maintains that financial cost of efficient cookstoves creates affordability issues in many developing countries while Fatihiya and Kenneth (2015) consider low awareness level among clean and efficient cookstoves as a major obstacle; individuals having a low level of literacy and social relationships

or networks tend to have limited information on the health and socio-economic benefits of clean and improved cookstoves (Rogers, 2003).

The behavioural and cultural implication of clean energy adoption is that it reveals households preference, food tastes, cultural beliefs, and cooking pattern (Mesara et al., 2000; Heltberg, 2004; Narasimha Rao & Reddy, 2007). The failure to consider the social, functional and the cultural background of users/households will limit CCS preference by consumers (Bielecki & Wingenbach, 2014). Religious beliefs and customs make people less likely to adopt some certain forms of cooking technologies (Narasimha Rao & Reddy, 2007).

The Value Chain Framework

Value chain activities of firms cut across linkages or corporate interactions with many other organisations or stakeholders. One vital point, however, is that a firm's value chain activities cannot be devoid of its environment. The local environment plays a major role in the value chain framework and business linkages such that their configurations are much dependent on the peculiarities of the broad socio-economic, cultural, and social settings (Altenburg, 2007). The value chain is also the vehicle through which new forms of networks, organisational processes, logistics and technologies are introduced. However, how to enter these value chain networks and how to improve on it, to compete in a new market, had become a major challenge for many developing countries (Trienekens, 2011).

Ability to access a market relies on the availability of infrastructures, technological abilities of manufacturers, market orientation and information as well as the bargaining position of stakeholders (Grunert, Fruensgaard, Risom, Jespersen & Sonne, 2005). Characteristically, the value chain describes ways value can be added, its government types and network structures (Ruben, van Boekel, van Tilburg & Trienekens, 2007).

Value Chain Analysis Framework for CCS adoption

Value chain framework for CCS adoption illustrates interactive processes in which stakeholders (Government agencies, family units/ties, health care providers, users, religious and community leaders, PPP, NGOs and developmental organisations) exploit the opportunities of value added (benefits) of CCS in a manner that would maximize stakeholders interests. Figure 1 illustrates opportunities for value-adding interactions taking into consideration the order of analysis of the value chain.

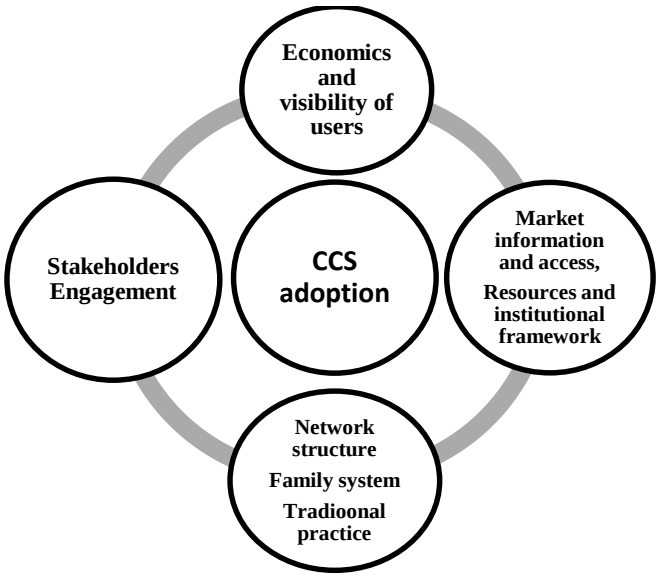


Figure 1: Value Chain Analysis Framework for CCS Adoption
Source: Designed by the Researcher (2016).

Figure 1 depicts the continuum of the value chain process for scale-up adoption of CCS. Value chain value-adding strategies are linked to costs, delivery times, quality, delivery flexibility and innovativeness, institutional environment and traditional practices. Customers' willingness to pay will determine the size of the value-added strategies (captured under the economic and feasibility of users adoption). Furthermore, market information on the process and product needs (public awareness) is fundamental to the adoption of a new product or technology (Trienekens, 2011).

Conceptual Framework for CCS Value Chain Networks

Figure 3 describes the conceptual framework of the study. The diagram illustrates the relationship between several factors and CCS adoption by households. Factors such as product suitability, price, market access, customs and belief, public awareness, education impact the ease of adoption of CCS by households.

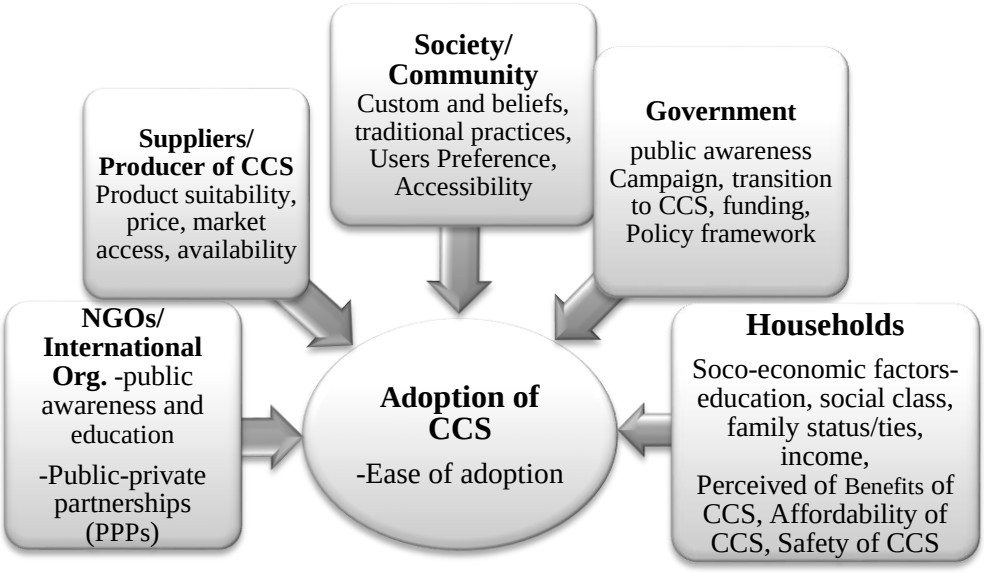


Figure 3: Factors Affecting the Ease of Adoption of CCS
Source: Researcher's own conceptualization (2016).

3.0 Methodology

The researcher employed the quantitative method in carrying out this study. A questionnaire survey was utilized to collect data from respondents. The population of the study comprises all residents of Lagos State. The researchers employed a purposive sampling method to select Lagos Mainland LGA as the study site where a sample of 200 respondents was drawn. The choice of sampling site was due to the diverse nature of people with diverse ethnicity, educational background and income level (low and high-income earners) in this area. Data collection was accomplished with the aid of a questionnaire survey of households. A cross-sectional random sampling of Lagos Mainland LGA households includes market women, self-employed, civil servants and business owners. From the initial sampling of 200 Lagos residents, 120 responses (60% response rate) were received.

Data Analysis Techniques

The study adopted descriptive and inferential analytical methods. The researcher uses descriptive methods such as pie charts, bar charts and frequency distribution to present the perception of respondents on the various questions posed in the questionnaire instruments. The following predictor variables were identified as critical for the adoption of CCS: family network, social class, age group, education, public awareness, affordability, accessibility, stakeholders'

engagement, health and safety, ease of adoption, user's preference, customs and beliefs, product suitability and others. The method of the Partial Least Square (PLS) and T-test techniques were employed as the analytical tool to test the research hypotheses. The PLS analysis was carried out with the aid of the XSTAL statistical software 2016 and IBM analytical software version 23.

4.0 Empirical Analysis

This section presents the results of the survey of respondents. The results of the descriptive statistics and the PLS analyses are presented here. From the initial 200 households sample size, 120 responses (60%) are received from the following household categories; self-employed 28%; market seller 15%; civil servants 49% and others are about 8%. Civil servants are predominant in Lagos Mainland LGA and this account for its high representation in the survey.

Table (1) Demographic Information of Respondents

Age Group	10-29 years	20	16.7	16.7	16.7
	30-49 yrs	60	50	50	66.7
	50-69 yrs	35	29.2	29.2	95.8
	70 & above	5	4.2	4.2	100
	Total	120	100	100	
Family Size	1-4		42.5	42.5	42.5
	5-9	62	51.7	51.8	94.2
	10-14	7	5.8	5.8	100
	Total	120	100	100	
Gender	Male	27	22.5	22.5	22.5
	Female	93	77.5	77.5	100
	Total	120	100	100	
Level of Education	Tertiary Education	86	71.7	71.7	71.7
	Secondary Education	18	15	15	86.7
	Primary Education	8	6.7	6.7	93.3
	Informal Education	8	6.7	6.7	100
	Total	120	100	100	
Ethnicity	Yoruba	86	71.7	71.7	71.7
	Igbo	21	17.5	17.5	89.2
	Hausa	3	2.5	2.5	91.7
	Others	10	8.3	8.3	100
	Total	120	100	100	
Occupation	Self-employed	33	27.5	27.5	27.5
	Market Sellers	18	15	15	42.5
	Civil Servants	59	49.2	49.2	91.7
	Others	10	8.3	8.3	100
	Total	120	100	100	

Source: Author's Survey (2016)

Majority of the participants have tertiary education at approximately 86 per cent which reveals a high level of literacy. This may not be unconnected to the availability of tertiary institutions in the area. Furthermore, an approximate 93 per cent of the participants are female, which shows that gender plays a significant role in this study.

Sources of Cooking Energy by Households

Figure 4 depicts the frequency distribution of responses on the sources of cooking energy by the selected participants. LPG; Kerosene, Electric Stoves and Firewood are the most common sources of energy for cooking based on the respondents. Coal, solar and others are insignificant sources. The high usage of LPG and kerosene among respondents shows that the adoption rate of CCS and an ICS fuels are high in this area. However, the usage of firewood and tree branches shows that the respondents still depend on solid fuels as an alternative source of cooking solutions. Furthermore, Figure 4 indicates that none of the respondents use Ethanol fuel and Biogas, which is categorized as part of the highest form of CCS and fuels, as their source of cooking energy.

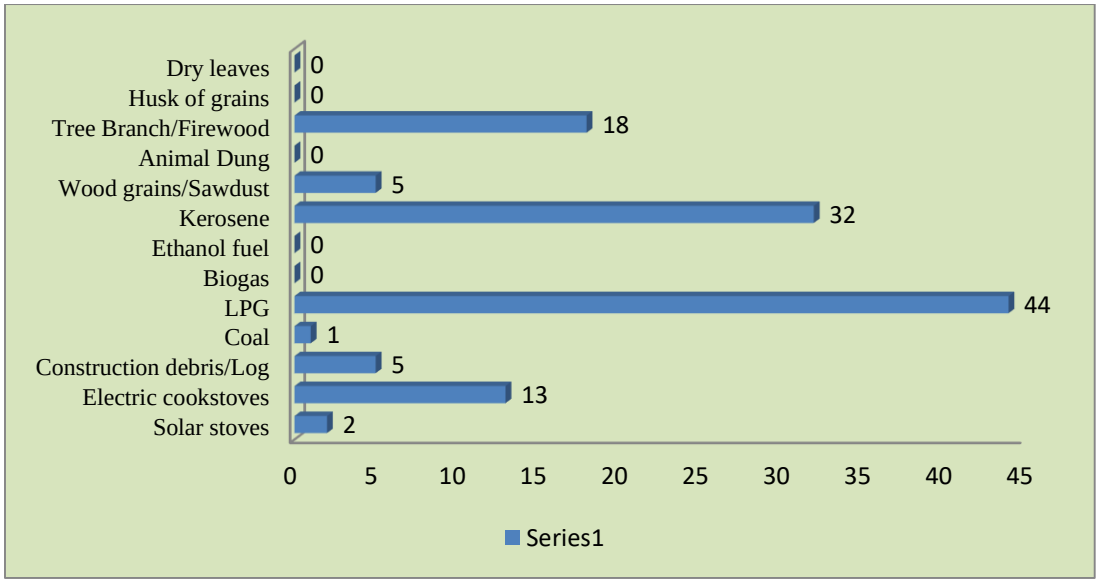


Figure (4): Sources of Cooking Energy by Respondents
Sources: Authors' Survey, (2016).

Traditional Cooking versus Improved Cookstoves/Clean Cookstoves

Figure (5) illustrates the percentage distribution of responses of the selected participants on Traditional cooking, Improved/Clean cookstoves and complete CCS. This shows that though the level of adoption of ICS/CCS (LPG and kerosene) is high among respondents at 63 per cent; the adoption rate of the complete CCS (solar stoves, ethanol fuel and biogas) is at 13 per cent, which is critically at a low level while TCS is 24 per cent (see Figure 2 and 4).

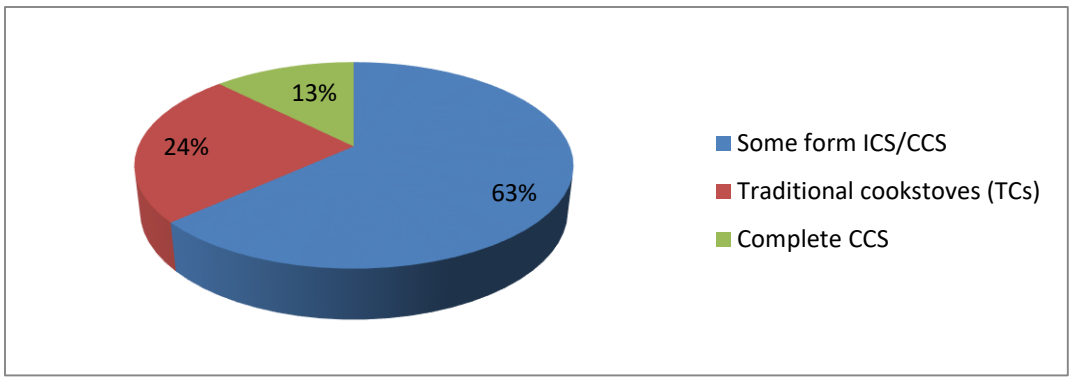


Figure (5) Traditional Cooking Vs Improved Cookstoves/Clean Cookstoves
Sources: Authors' Survey, (2016).

Hypotheses Testing and Results

The hypotheses testing were carried out using the regression analytical models. The PLS regression technique and the student T-test were employed on the various estimates of the regression model to test for the stated hypotheses.

Test of Hypothesis One

H_{01}: The identified factors do not affect the adoption of CCS by Households in Lagos State individually.

The PLS regression model is specified in depicting the 14 predictors variables alongside the dependent variable shown in Table 2. The adoption of CCS (q1) is the dependent variable while the 14 explanatory variables were given as q2, q3, q4, q5, q6, q7, q8, q9, q10, q11, q12, q13, q14, q15 (see Table 3). Table 3 presents the correlation results of the variables. There is a high and moderate positive correlation among the various factors; this thus shows positive relationships exist among the various explanatory variables, which may lead to spurious regression results.

To avoid this pitfall, the PLS regression method was adopted to estimate the regression model. Thus, Households adoption of CCS (q1) was regressed on the 14 factors in a system of equation model. Thereafter, the tests of the stated hypotheses were carried out. In addition, the researcher carried out a model quality check to estimate the quality of the number of components; if it sufficiently fit for the application of the PLS. The results below in Figure 7 show that the number of components is satisfactory.

Table (2) Descriptive Summary Statistics

Variables	Variable Code	Observations	Minimum	Maximum	Mean	Std. deviation
Adoption of CCS	q1	120	1.000	5.000	2.150	1.527
Social Class	q2	120	1.000	4.000	2.375	0.926
Users Preference	q3	120	1.000	4.000	2.000	0.635
Accessibility	q4	120	1.000	3.000	1.392	0.626
Public Awareness	q5	120	1.000	3.000	1.908	0.518
Level of Education	q6	120	1.000	3.000	2.008	0.399
Custom and Belief	q7	120	1.000	4.000	1.817	1.021
Clean stove Suitability	q8	120	1.000	5.000	4.150	1.326
Transition to Clean stoves	q9	120	1.000	4.000	1.900	1.032
Ease of Adoption	q10	120	1.000	4.000	3.300	1.127
Perceived Benefits of Using Clean stoves	q11	120	1.000	4.000	1.275	0.648
Household Affordability of Clean Stoves	q12	120	1.000	5.000	2.950	1.263
Safety of Using Clean Stoves	q13	120	1.000	3.000	1.717	0.871
Stakeholder Engagement	q14	120	1.000	5.000	1.842	0.840
Family/Clan Network	q15	120	1.000	5.000	2.000	0.810

Source: XLSTAT output (2016).

Table (3) Correlation Factor Matrix

Variables	q2	q3	q4	q5	q6	q7	q8	q9	q10	q11	q12	q13	q14	q15	q1
q2		0.2	0.7	0.6	0.3	0.2	0.2	0.2	0.4	-0.1	0.7	0.4	0.0	0.5	0.2
q3	0.2		0.1	0.0	0.7	0.7	0.7	0.0	0.1	0.8	0.8	0.5	0.0	0.2	0.7
q4	0.7	0.1		0.9	0.3	0.1	0.2	0.7	0.4	0.0	0.6	0.1	0.5	0.4	0.3
q5	0.6	0.0	0.9		0.2	0.1	0.1	0.7	0.3	-0.1	0.5	0.0	0.4	0.4	0.0
q6	0.3	0.7	0.3	0.2		0.9	1.0	0.4	0.4	0.4	0.6	0.0	-0.3	0.2	0.5
q7	0.2	0.7	0.1	0.1	0.9		0.9	0.1	0.1	0.2	0.5	0.0	-0.4	0.2	0.2
q8	0.2	0.7	0.2	0.1	1.0	0.9		0.4	0.3	0.4	0.5	0.0	-0.2	0.1	0.6
q9	0.2	0.0	0.7	0.7	0.4	0.1	0.4		0.7	0.1	0.3	-0.2	0.4	0.0	0.4
q10	0.4	0.1	0.4	0.3	0.4	0.1	0.3	0.7		0.2	0.3	0.2	0.0	0.2	0.5
q11	-0.1	0.8	0.0	-0.1	0.4	0.2	0.4	0.1	0.2		0.6	0.5	0.5	0.3	0.8
q12	0.7	0.8	0.6	0.5	0.6	0.5	0.5	0.3	0.3	0.6		0.6	0.3	0.2	0.5
q13	0.4	0.5	0.1	0.0	0.0	0.0	0.0	-0.2	0.2	0.5	0.6		0.1	0.2	0.2
q14	0.0	0.0	0.5	0.4	-0.3	-0.4	-0.2	0.4	0.0	0.5	0.3	0.1		0.0	0.4
q15	0.5	-0.1	0.4	0.4	0.2	0.2	0.1	0.0	0.2	0.3	0.2	0.2	0.0		-0.1
q1	0.2	0.7	0.3	0.0	0.5	0.2	0.6	0.4	0.5	0.8	0.5	0.2	0.4	-0.1	

Source: XLSTAT output (2016).

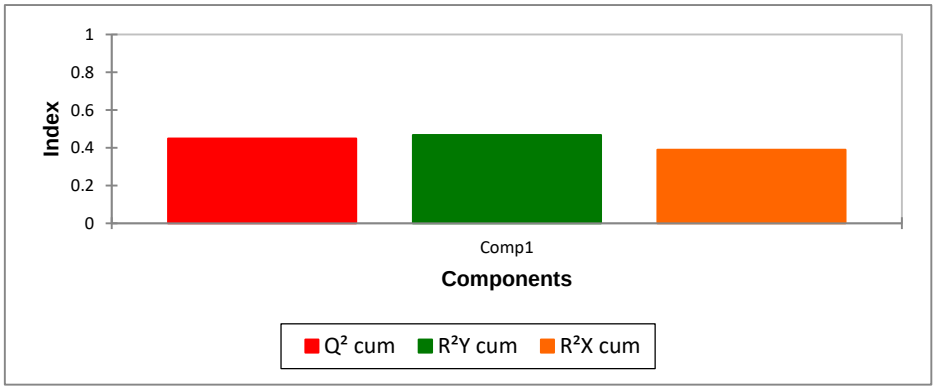


Figure (6) Model Quality by Number of Components
Source: XLSTAT output of Authors' Survey, (2016).

Figure 6 explains the principal component; R^2 explains the coefficient of determination or goodness of fit. The hallmark of the PLS regression method is that it forms components that capture most information in the predictor variables that is vital for predicting the dependent variables while reducing the size of the regression problem by adopting fewer components than the number of Predictor

variables (Garthwaite, 1994). The result of the loading of the 14 factors is presented below in Figure 7.

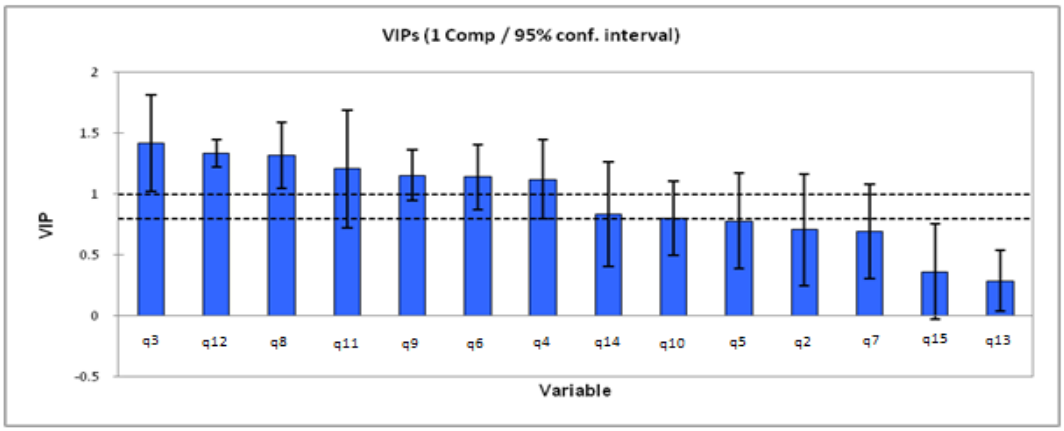


Figure (7) PLS Result of Critical Predictors
Source: XLSTAT output of Authors' Survey, (2016).

The probability plot showing a scale of loading for the explanatory variables revealed that q3, q12, q8, q11, q9, q6, q4, are the possible strong predictor of the dependent variables (see Table 3). The critical values (probability value) of the explanatory variables are presented in Table 4. The critical values are expected values of the predictors with 95% degree of confidence.

Overall, the result of the PLS shows that out of the 14 factors only q3, q12, q8, q11, q9, q6, q4 were strong predictors, while the others are low predictors (see Figure 8). On the basis of this, the null hypothesis is rejected and the alternative hypothesis is accepted at a 0.05 level of significance.

Table 4 Critical Value of Predictor Variables

Variable	VIP	Standard deviation	Lower bound (95%)	Upper bound (95%)
q3	1.378	0.189	1.003	1.753
q12	1.290	0.059	1.173	1.406
q8	1.277	0.130	1.019	1.534
q11	1.184	0.229	0.731	1.637
q9	1.114	0.104	0.908	1.320
q6	1.104	0.131	0.845	1.363
q4	1.071	0.161	0.752	1.391
q14	0.812	0.208	0.400	1.223
q10	0.782	0.147	0.492	1.073
q5	0.739	0.191	0.361	1.118
q2	0.677	0.228	0.226	1.128
q7	0.666	0.189	0.292	1.040
q13	0.284	0.122	0.042	0.526
q 15	0.364	0.196	-0.025	0.752

Source: XLSTAT output of Authors' Survey, (2016).

Test of Hypothesis Two

H_{02}: The 14 identified factors do not affect the adoption of CCS by households in Lagos State collectively.

To test the second hypothesis, the T-test statistics was employed on the entire multiple regression equation. Here, the estimates of the regression equation were tested to examine the reliability of estimates as predictors. The results (Table 5) also revealed that all the estimates were significant at 0.05 level (given the degree of freedom 106 (120; 14) and the tabulated T statistics of 1.6660, except for q7 (custom & belief) where obtained T-statistics is 1.622.

Based on this, the null hypothesis is accepted and the alternative hypothesis is rejected that these 14 factors collectively affect the variation in the dependent variable.

Table (5) Result of the T-test Model

Variable	Coefficients	VIP	Standard deviation	Std Error of est.	T-stat	Sig. 0.05
q3	0.06	1.378	0.189	0.0173	3.476	>.05
q12	0.207	1.29	0.059	0.0054	38.418	>.05
q8	0.074	1.277	0.13	0.0119	6.233	>.05
q11	0.06	1.184	0.229	0.0209	2.869	>.05
q9	0.059	1.114	0.104	0.0095	6.212	>.05
q6	0.035	1.104	0.131	0.0120	2.926	>.05
q4	0.068	1.071	0.161	0.0147	4.625	>.05
q14	0.056	0.812	0.208	0.0190	2.948	>.05
q10	0.043	0.782	0.147	0.0134	3.203	>.05
q5	0.107	0.739	0.191	0.0174	6.134	>.05
q2	0.074	0.677	0.228	0.0208	3.554	>.05
q7	0.028	0.666	0.189	0.0173	1.622	< 05
q13	0.111	0.284	0.122	0.0111	9.963	>.05
q 15	0.046	0.364	0.196	0.0179	2.570	>.05

Source: XLSTAT output of Authors' Survey, (2016).

Discussion

The findings of the study show that factors identified in this study explain the role of several factors as significant in the adoption of CCS by households in Nigeria. The results of the descriptive statistics reveal that the CCS and fuels (LPG and kerosene) have been adopted substantially in Lagos Mainland; however, the adoption of the complete CCS, which is known to have the highest potential impact on achieving a green ecosystem, is at a low level. This is in line with the study of Njenga et al. (2016) and The World Bank Report (2014) that renewable energy fuels such as ethanol fuel, biogas, and solar oven are uncommon in SSA countries. Furthermore, some socio-demographic factors such as educational status, occupation; gender and family size play a major role in describing the types of households that have adopted the CCS and fuels.

The test of the study's hypotheses described the predictive factors that affect and are significant to the adoption of CCS in Lagos State. Findings from test of hypothesis one (H_{01}) demonstrate that out of the fourteen predictive factors identified in this study, seven of them (users preference, households affordability of CCS, CCS suitability, perceived benefits of using CCS, transition to CCS, level of education and accessibility of CCS) are strong predictors of CCS and fuels adoption. The remaining predictive factors are weak predictors. Users' preference was ranked the highest among respondents. The high preference for the CCS and fuels (LPG and Kerosene) by the respondents may possibly be that CCS and fuels

are clean, modern and efficient and are suitable to the taste; social status and environmental settings of the study respondents (see Table 1). The second highest predictor shows that the respondents can afford the CCS and fuels because of their occupational background, which also reveals their income status (see Table 1).

The other high predictors show that the respondents attach social and economic status, as well as environmental benefits to the adoption of CCS and fuels. It is difficult to use TCS and fuels in this location because of health hazards attributed to it; the smoke from these solid fuels is also an issue for these types of individuals. However, the results of the study show that the respondents still use firewood for major outdoor cooking, particularly, when engaging in large cooking for social functions such as naming ceremonies and weddings. Additionally, respondents living in the slum areas of Lagos Mainland (for example Iwaya, Agege and Makoko) are prone to using firewood as their main source of cooking, especially when smoking fish for commercial purposes (see Simon, Adegoke & Adewale, 2013; Bobadoye & Fakere, 2013).

The perception of benefits of using the CCS and fuels makes them attractive to the respondents whose educational background might have given them exposure to the need for a clean and modern form of cooking technologies. Accessibility to the clean and modern fuels makes them reliable and creates a high tendency for their adoption.

The study, therefore, reveals that there are socio-economic, cultural and behavioural factors predicting the choice of cooking fuels by households. This is in line with Malla and Timilsina (2014); Ruiz-Mercado et al. (2011); Bielecki and Wingenbach (2014); Bansal et al. (2013); Fatihiya and Kenneth (2015), and Riley (2014) that posit that pollution, lifestyle, food tastes, social class, accessibility, availability, level of awareness, education, preference influence the adoption rate of cooking fuel/technology choices by households in many developing countries. Majority of the strong predictors falls within the socio-economic factors.

Results from the test of hypothesis two (H_{02}) show that the predictive factors were significant to the adoption of CCS as shown by the results of the T-test expect for customs and beliefs. Custom and belief of the respondents do not play an important role in their choice of cooking technologies. However, the researchers posit that all the predictive factors can interact together if viewed from the angle of the value chain framework and they should not be treated in isolation as studies have shown that value-added interactions of factors are fundamental to the adoption of a new product or technology as proposed by Trienekens (2011).

Overall, CCS (such as LPG and Kerosene) is common, available, readily accessible, and affordable in Lagos Mainland areas. This perhaps reveals that people living in Lagos region have preference for the CCS and can also afford these modern and clean energies. Based on the study, the demographic characteristics of respondents showed that many of the respondents can afford the CCS and fuels because many of them have good educational background and are either self-employed or employees. Another point to note is that the low usage of the complete CCS and fuels, which is the highest and the greenest form of clean cooking, is due to their non-availability and non-accessibility (such as Biogas and Ethanol) in Lagos State; though the use electric stoves is present.

Limitations of the Study

The classification of kerosene as CCS is dependent on the availability of well-designed cookstoves; this was not captured in the study. The researchers did not also capture all the types and categories of CCS and fuels as depicted in Figure 2. In addition, the study sample was limited to Lagos Mainland; other areas in Lagos State were not investigated. The income level of respondents was also not measured directly in the study.

5.0 Conclusion and Recommendations

CCS technologies provide the solutions needed to solve health and environmental threats and therefore it addresses social issues. Clean, modern and renewable cookstoves and fuels play a major role in improving health conditions of individuals, poverty reduction, clean and environmental sustainability, reduction in air and households pollution and improved living conditions of households especially women and children. However, certain predictive factors, which are socio-economic, cultural and behavioural factors, play a major role in the adoption of clean, modern and efficient cooking solutions in many developing countries, particularly in SSA countries. Users' preference, households' affordability of CCS, CCS suitability, perceived benefits of using CCS, transition to CCS, level of education and accessibility of CCS are critical in determining the adoption of CCS and fuels in Lagos State while factors such as social class, safety of CCS, family and clan and customs and beliefs are less critical. Customs and beliefs do not play an important role in determining the adoption of CCS and fuels in some parts of Lagos State. The study recommends that the 14 identified predictive factors are important (inclusive of custom and belief) and should not be treated in isolation as the value-adding interactions of predictors are vital to achieve a successful implementation of CCS and fuels. The study also recommends that the strong predictive factors should be given the highest priority.

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