ECONOMIC VALUE AND PREFERENCES FOR IMPROVED BIOMASS COOKSTOVE AMONG RURAL HOUSEHOLDS IN SELECTED DESERT FRONTLINE STATES IN NORTHERN NIGERIA

IBRAHIM KABIR

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By

IBRAHIM KABIR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

October 2018

DEDICATION

This work is dedicated to my entire family and well-wishers around the world.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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October 2018

Chairman : Associate Professor Mohd Rusli Bin Yacob, PhD
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Recently Improved Biomass Cookstove (ICS) promotion has received considerable attention in developing countries. This is primarily due to the rising adverse effects of Traditional Biomass Cookstove (TBC) usage on the one hand and benefits offered by the ICS on the other. The use of TBC in Nigeria has been widely associated with extensive environmental, socioeconomic and health related problems which to some extent, lead to chronic diseases and sometimes premature death. To address these problems, various initiatives for ICS promotion were introduced in the country. However, there is dearth of relevant information that will facilitate the success of these initiatives including the value households attached to ICS and what they like about such cooking technologies.

This study estimates the economic value and preferences for ICS among households in Desert Frontline States of Northern Nigeria. This was achieved through the application of Contingent Valuation Method (CVM) and Choice Experiment (CE) - the two most widely used stated preference (SP) economic valuation techniques. Unlike existing studies, the techniques were combined for robustness purpose. Besides, this study is the first to execute both or any of these techniques on households to study ICS in Nigeria. Based on face-to-face approach, from October, 2016 to January, 2017, the study interviewed 392 rural households in desert frontline states where the wider usage of TBC is linked with substantial deforestation, desert encroachment, socioeconomic and health related problems among others.

The results of CVM revealed that 74% of the surveyed households are willing to pay for ICS, with mean willingness to pay (WTP) of ₦66, 009.30 ($183.36) per ICS, and gender, age, income, expenses on fuelwood, cooking hours, bid price and knowledge regarding adverse effects of TBC have significant effect on households' WTP.

The result of CE revealed that the households have relatively high preferences for smoke emission reduction from cookstoves, followed by fuelwood consumption reduction, then cooking time reduction, and finally user safety. It also revealed a significant heterogeneity in the ICS preferences, with some of this variation related to the studied households' characteristics, including income, gender, education, household size and knowledge regarding adverse effects of TBC.

These study findings indicate that the surveyed rural households considerably value ICS, and have preferences for it. This signifies the possibility for implementing initiatives for ICS promotion in these areas. Based on these therefore, it is suggested that the relevant stakeholders should strengthen the implementation of initiatives for ICS promotions while taking into cognisance the households' stated value and preferences in the design and implementation so as to achieve wider uptake.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

NILAI EKONOMI DAN KEUTAMAAN BAGI KEGUNAAN DAPUR BIOJISIM DIPERBAIKI DI KALANGAN PENDUDUK LUAR BANDAR DI DAERAH KAWASAN BERGURUN TERPILIH DI UTARA NIGERIA.

Oleh

IBRAHIM KABIR

Oktober 2018

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Kebelakangan ini promosi penggunaan dapur biojisim diperbaiki (ICS) telah mendapat perhatian dikalangan negara-negara membangun. Ini disebabkan oleh peningkatan kesan sampingan daripada penggunaan dapur biojisim tradisional (TBC) disamping kelebihan positif ditawarkan daripada penggunaan ICS. Penggunaan TBC di Nigeria telah memberikan masalah dari sudut alam sekitar, sosioekonomi dan juga masalah kesihatan di mana pada suatu tahap boleh menyebabkan penyakit kronik dan kematian pra-matang. Untuk menyelesaikan masalah ini, pelbagai inisiatif mempromosikan ICS telah diperkenalkan dalam negara. Namun, hanya terdapat sedikit maklumat yang berkaitan yang akan memudahkan kejayaan inisiatif ini termasuk nilai isi rumah yang berhubung kepada ICS dan apa yang mereka suka mengenai teknologi memasak sedemikian.

Kajian ini menganggarkan nilai ekonomi dan keutamaan bagi ICS di kalangan isi rumah di Desert Frontline States di utara Nigeria. Ini dicapai melalui penerapan Kaedah Penilaian Kontinjen (CVM) dan Eksperimen Pilihan (CE) - dua teknik penilaian ekonomi pilihan utama (SP) yang paling banyak digunakan. Tidak seperti kajian sedia ada, teknik-teknik ini digabungkan untuk tujuan kekukuhan. Selain itu, kajian ini adalah yang pertama melaksanakan kedua-dua teknik tersebut untuk mempelajari ICS antara isi rumah di Nigeria. Berdasarkan pendekatan tatap muka, dari Oktober, 2016 hingga Januari, 2017, sejumlah 392 isi rumah luar bandar telah ditemuduga di garis depan padang pasir di mana penggunaan TBC yang lebih luas dikaitkan antaranya dengan penebangan hutan yang besar, pencerobohan padang pasir, masalah sosioekonomi dan kesihatan.

Hasil keputusan daripada CVM mendedahkan bahawa 74% daripada bancian isi rumah bersetuju untuk membayar bagi mendapatkan ICS, dengan nilai purata kesanggupan untuk membayar pada ₦66, 009.30 ($183.36) per unit ICS, dan jantina, umur, pendapatan, perbelanjaan pada kayu api, masa memasak, harga bidaan serta ilmu pengetahuan mengenai kesan sampingan TBC menunjukkan kesan yang penting kepada isi rumah kesanggupan untuk membayar.

Keputusan daripada CE mendedahkan bahawa isi rumah yang mempunyai keutamaan tinggi kepada pengurangan pelepasan asap daripada dapur konvensional, diikuti dengan pengurangan penggunaan kayu api, pengurangan jangka masa memasak serta risiko keselamatan pengguna itu sendiri. Selain itu, kepelbagaian dalam keutamaan ICS didedahkan disamping variasi yang berkait rapat dengan pencirian isi rumah, termasuk pendapatan, jantina, tarah pendidikan, saiz isi rumah serta ilmu pengetahuan yang berkaitan dengan kesan sampingan penggunaan TBC.

Hasil daripada kajian ini menunjukkan bahawa isi rumah di kawasan pedalaman menerima secara positif penggunaan ICS dan menjadi keutamaan mereka. Ini menunjukkan kemungkinan untuk pelaksanaan inisiatif untuk promosi ICS di kawasan ini. Oleh itu, kajian ini mencadangkan agar pemegang taruh yang berkaitan dapat meningkatkan pelaksanaan inisiatif untuk promosi ICS dengan mengambil kira kesedaran nilai isi rumah dan nilai keutamaan kepada reka bentuk dan pelaksanaan bagi mencapai suatu nilai tambah yang lebih meluas.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the Degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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TABLE OF CONTENTS

		Page
ABSTRACT		i
ABSTRAK		iii
ACKNOWLEDGEMENTS		v
APPROVAL		vi
DECLARATION		viii
LIST OF TABLES		xiii
LIST OF FIGURES		xv
LIST OF ABBREVIATIONS		xvi
CHAPTER		
1	**INTRODUCTION**	1
	1.1 Background of the Study	1
	1.2 Problem Statement	4
	1.3 Research Questions	6
	1.4 Objectives of the Study	6
	1.5 Scope of the study	6
	1.6 Significance of the Study	7
	1.7 Organization of the Thesis	8
2	**LITERATURE REVIEW**	9
	2.1 Introduction	9
	2.2 The Biomass Cookstove Concept and Usage	9
	2.3 Traditional versus Improved Biomass Cookstoves	10
	2.4 The Traditional Biomass Cookstove (TBC)	10
	2.4.1 Problems Associated with Traditional Biomass Cookstove	11
	2.4.2 Strategies for reducing the problems associated with TBC Usage	13
	2.5 Improved Biomass Cookstove (ICS)	15
	2.6 Historical Development of Biomass Cookstove Improvement	15
	2.6.1 Early history (time immemorial – 1950)	15
	2.6.2 The recent past (1950 - 2000)	15
	2.6.3 The new millennium (2000 to date)	17
	2.7 Initiatives for ICS promotion across continents	18
	2.7.1 Initiatives for ICS promotion in Africa	19
	2.7.2 Initiatives for ICS promotion in Asia	20
	2.7.3 Initiatives for ICS promotion in Central America and the Caribbean	22
	2.7.4 Cookstove Usage and the situation of Initiatives for ICS promotion among Nigerian Households	23
	2.8 Factors Influencing Household Adoption of ICS	24
	2.8.1 Socioeconomic factors	25
	2.8.2 Knowledge, behavioural and cultural factors	25

2.8.3 Other external factors 26
2.9 Economic Valuation Techniques 27
2.9.1 Revealed Preference (RP) Techniques 28
2.9.2 Stated Preference (SP) Techniques 29
2.9.3 Contingent Valuation Method (CVM) 29
2.9.4 Choice Modelling (CM) 31
2.10 Theoretical framework 33
2.10.1 Random Utility Theory 33
2.10.2 Characteristics demand Theory of Value 34
2.11 Welfare measures 35
2.11.1 The Consumer Surplus 36
2.11.2 The compensating variation 37
2.11.3 Equivalent variation 37
2.12 Empirical studies of ICS Valuation 38

3 RESEARCH METHODOLOGY 40
3.1 Introduction 40
3.2 Conceptual Framework 40
3.3 The Study Area 42
3.4 Sampling 43
3.4.1 Sampling Population 43
3.4.2 Sample Frame 44
3.4.3 Sample Size 44
3.4.4 Sampling Technique 45
3.4.5 Data Collection Technique 47
3.4.6 Sampling Unit 48
3.5 Focused group discussion 48
3.6 Questionnaire Design 50
3.6.1 Pattern of Cookstove Usage and Related Cooking Practices 50
3.6.2 Knowledge and behaviour regarding the adverse effects of TBC 51
3.6.3 Choice Experiment (CE) 52
3.6.4 Contingent Valuation Method (CVM) Questions 58
3.6.5 Socio-demographic Characteristics Questions 59
3.7 Pre-test of the Questionnaire 60
3.8 Survey Implementation 61
3.9 Data Analysis 61
3.10 Econometric Model 62
3.10.1 CVM Model 62
3.10.2 Choice Experiment Model 63

4 RESULTS AND DISCUSSION 65
4.1 Introduction 65
4.2 Households' Socio-demographic Characteristics 65
4.3 Pattern of Cookstove Usage and Related Cooking Practices among Households 68
4.4 Households' knowledge and behaviour towards adverse effects of TBC 71

4.4.1 Respondents distribution based on knowledge regarding adverse effects of TBC 71
4.4.2 Knowledge Categories and Mean Score 72
4.4.3 Respondents distribution on behaviour towards adverse effects of TBC 74
4.4.4 Behaviour categories and mean score 75
4.4.5 Association between knowledge regarding adverse effects of TBC and Behaviour towards adverse effects of TBC 76
4.5 Contingent Valuation Method (CVM) 77
4.5.1 Distribution of respondents based on responses to WTP Questions 77
4.5.2 Households' reasons for willing or unwilling to pay for ICS 77
4.5.3 Description of variables included in the logit model 78
4.5.4 Binary logit regression for the CVM model 80
4.5.5 Households WTP (ICS Value) 81
4.6 Choice Experiment Analysis 81
4.6.1 Basic Conditional Logit Model (CLM) 83
4.6.2 Incorporating Levels Conditional Logit Model (CLM) 84
4.6.3 Interactive Conditional Logit Model (CLM) 87
4.6.4 Basic Random Parameter Logit (RPL) Model 90
4.6.5 Incorporating Levels RPL Model 92
4.6.6 Interactive RPL Model 93
4.6.7 The Marginal Rate of Substitution (MRS) 95
4.6.8 Households' Preferences for ICS Attribute and Attribute Levels 96

5 SUMMARY, CONCLUSION AND RECOMMENDATION 98
5.1 Introduction 98
5.2 Summary 98
5.3 Conclusion 100
5.4 Policy Implication 102
5.5 Limitation of the Study 103
5.6 Recommendations for Further Studies 103

REFERENCES 106
APPENDICES 127
BIODATA OF STUDENT 139
LIST OF PUBLICATIONS 140

LIST OF TABLES

Table		Page
2.1	Compensating and Equivalent Variation	38
3.1	Estimated sampling population based on total rural households	44
3.2	Outline of the Questionnaire Contents	50
3.3	Reliability Test Coefficients	52
3.4	Attributes and Attribute Levels used in the study	54
3.5	Sample of choice set used for this study	57
4.1	Households' Socio-demographic Characteristics	67
4.2	Pattern of Household Cookstove use and Related Cooking Practices	70
4.3	Households' Knowledge	72
4.4	Knowledge categories and mean score	73
4.5	Households' Behaviour	74
4.6	Behaviour categories and score	75
4.7	Association between households' knowledge categories and their behaviour	76
4.8	Summary of Households' WTP Responses	77
4.9	Reasons for households' WTP for ICS (N=290)	78
4.10	Reasons for households' unwillingness to pay for ICS (N=102)	78
4.11	Description of variables included in the logit model	79
4.12	Estimated binary logit model for CVM	80
4.13	Summary Statistics of Attributes and their Levels	82
4.14	Estimated basic CLM	84
4.15	Attribute Levels and their recoding	85
4.16	Estimated incorporating levels CLM	86
4.17	Estimated Interactive CLM	90

4.18 Estimated Basic RPL Model 91

4.19 Incorporating Levels RPL Model 93

4.20 Estimated Interactive RPL Model 94

4.21 Marginal Willingness to Pay 96

LIST OF FIGURES

Figure		Page
1.1	Typical TBC: A – 'three stone fires' & B – 'built-in cookstove'	2
2.1	Distribution of population primarily relying on TBC usage	11
2.2	Percentages of people having access to ICS in selected developing countries	18
2.3	Percentage of households with ICS across Africa	20
2.4	Percentage of households with ICS across Asian countries	21
2.5	Percentage of households with ICS in Central American and the Caribbean	22
2.6	Percentage of Nigerian households by cooking fuel	23
2.7	Diagrammatic representation of Economic Valuation Techniques	28
2.8	Graph of Budget and Utility Function	35
2.9	Consumer Surplus	36
3.1	Conceptual Framework	41
3.2	Location of the surveyed communities in the selected Desert Frontline States of Bauchi and Jigawa	43
3.3	Outline of Multi-stage Sampling Technique	46
4.1	Hierarchy of Households' Preferences for ICS Attributes and Attribute Levels	97

LIST OF ABBREVIATIONS

ARC	Aprovecho Research Centre
CBA	Cost-Benefit Analysis
CDM	Clean Development Mechanism
CE	Choice Experiment
CLM	Conditional Logit Model
CM	Choice Modelling
CO	Carbon monoxide
COPD	Chronic Obstructive Pulmonary Diseases
CVM	Contingent Valuation Method
DC-CVM	Dichotomous Choice Contingent Valuation Method
EFA	Exploratory Factor Analysis
FGD	Focus Group Discussion
FGN	Federal Government of Nigeria
GACC	Global Alliance for Clean Cookstove
GBD	Global Burden of Diseases
IAP	Indoor Air Pollution
ICS	Improved Biomass Cookstove
IIT	India Institute of Technology
LGAs	Local Government Areas
MNRE	Ministry of New and Renewable Energy
MRS	Marginal Rate of Substitution
NAGGW	National Great Green Wall
NISP	National Improved Stoves Programme
NOAA	National Oceanic and Atmospheric Administration

NPIC	National Programme on Improved Chulhas
PM	Particulate Matter
RP	Revealed Preference
RPL	Random Parameters Logit
SAARC	South Asian Association for Regional Cooperation
SIF	Social Investment Fund
SP	Stated Preference
TBC	Traditional Biomass Cookstove
TEV	Total Economic Value
UN	United Nation
TSF	Three stone Fires
WTA	Willingness to Accept
WTP	Willingness to Pay

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Traditional biomass cookstove (TBC) exists since time immemorial and widely used across the developing world. A typical TBC exists in form of 'three stone fires' (TSF) or built-in cookstove. A 'three stone fires' is simply designed with three suitable stones of relatively same height on which a cooking pot is placed over a fire, while 'built-in cookstove' is a provisional mud structure that surrounds fire from at least three directions, other than the ground itself (Figure 1). The TBC is primarily fuelled by fuelwood and/or leaves, wood sticks, crop residues such as rice husk, rice straw, jute sticks, sawdust, sugarcane bagasse and dung cake (Al Mamun et al., 2009; Begum, 2015).

The TBC's simplicity in design, maintenance and operation as well as fuel availability makes it popular and widely used among various populations in many developing countries. It is used for water heating, space heating, home lighting, meat smoking, fish smoking, flour roasting, and grain roasting. The same TBC, depending on cultures, food habits and location of usage, is used for various purposes rather than the above outlined usages (Kshirsagar & Kalamkar, 2014).

However, TBC is noted to be widely used as it offers several advantages to the users in terms of simplicity, fuel affordability and availability, its general attributes such as very low heat-transfer, low combustion ability and low estimated thermal efficiencies ranging from only 5–20% make its usage an issue of concern (Ekouevi et al., 2014). The TBC usage thus, has wider adverse effects particularly on the environment, human health and socioeconomic development (Pant et al., 2014; Jeuland & Pattanayak, 2012; Mamuye et al., 2018).

Figure 1.1 : Typical TBC: A – 'three stone fires' & B – 'built-in cookstove'

The inefficient nature of TBC particularly at converting energy into heat for cooking makes it consumes huge quantity of solid biomass fuel, mainly fuelwood. The annual amount of fuelwood required for basic cooking per household can be at least 200kg (WHO & UNDP, 2009). Also, the average daily time for collecting this fuelwood is approximately an hour (Rural Integrated Development Services, 2012). The increasing consumption of fuelwood contributes immensely to the chances of deforestation, ultimately leading to other severe environmental problems such as climate change and global warming (Bailis et al., 2003; Johnson et al., 2009). Due to the TBC's huge fuel demand, this fuelwood which was in abundance and accessible to the poorest of the poor in both forest and non-forest communities around the world, is almost exhausted and costly to purchase nowadays (Urmee & Gyamfi, 2014).

The usage of TBC is also associated with drudgery and gender inequality issues. Fuelwood is mainly collected by women and children in various populations in developing countries (World Bank, 2011; Jeuland & Tan, 2016). They spend their precious time searching for fuelwood, bearing the risk of physical injuries, insecurity, having encounter with vectors of communicable diseases and denied from all other beneficial engagements like education and economic activities (Bolaji, 2012). Similarly in a situation where the households purchase fuelwood, it exert huge financial burden to the households (Garcia-Frapolli et al., 2010).

The low combustion ability of TBC makes it releases harmful pollutants responsible for indoor air pollution (IAP) which consequently results in health problems and to some extent contributes to global warming. There is growing evidence in the literature that emission from TBC usage contributes to health related issues such as acute respiratory infection (ARI) in children and cancer in women (Smith, 2000; Parikh et al., 2001; Kammen et al., 2003). The IAP from TBC usage is estimated to account for about 2 million deaths annually with more than 99% occurring in developing countries (WHO & UNDP, 2009). Additionally, the emissions from TBC contribute in build-up

of greenhouse gases (GHGs), as well as other climate-threatening pollutants, including black carbon (BC), in the atmosphere (Venkataraman et al., 2010 & Gymfi, 2014).

Nevertheless this knowledge, TBC remains the most widely used particularly among rural communities of developing countries where more than 80% of the population rely mainly on solid biomass fuel for cooking (Malla & Timilsina, 2014;Urmee & Gyamfi, 2014). Both in literature and practice, two potential approaches are noted for softening cooking energy issues in rural areas of developing countries; promoting more efficient and sustainable traditional biomass usage; and motivating TBC users to switch to modern cooking fuels and technologies. However, for many households, switching from TBC to modern cooking technologies may not be feasible in a short-term due of high capital costs coupled with high level of poverty (World Bank, 1996; Urmee & Gyamfi, 2014; Mamuye et al., 2018), improving the way biomass fuels are procured and/or utilised could go a long way in subsiding the cooking energy challenges among various populations in developing countries.

The Improved Biomass Cookstove (ICS) is one of such efforts of improving biomass usage. It is developed to address the highlighted TBC's problems (Adkins et al., 2010; Urmee & Gyamfi, 2014; Mamuye et al., 2018). Similar to TBC, ICS is fuelled by solid biomass, predominantly fuelwood, however it is designed to improve thermal and fuel efficiency, reduce emission of harmful pollutants and enhance user safety (United Nation Environment Programme, 2010; Urmee & Gyamfi, 2014). Growing evidences suggest that widespread adoption of various forms of ICS technologies could offer lot of benefits particularly in mitigating adverse human health, environmental and socioeconomic consequences of TBC usage (Masera et al., 2007; García-Frapolli et al., 2010; Pine et al., 2011; Bielecki and Wingenbach, 2014; Mamuye et al., 2018).

Related field studies provided empirical evidences on benefits derived from various ICS technologies in many developing countries. These include ICS's benefits in terms of reduced emission of harmful pollutants and greenhouse gases (Zhang et al., 2000), reduced fuelwood consumption and collection time, fuelwood savings (Bwenge, 2011; DeWan et al., 2013; Jacob, 2013; Bielecki and Wingenbach, 2014) and reduced concentration of particulate matter (PM) and carbon monoxide (CO) (Pine et al., 2011). Also, ICS was also noted to significantly improve users living conditions, create wealth, and improve respiratory systems and eye comfort (Masera et al., 2007; García-Frapolli et al., 2010).

These potential benefits of ICS placed it as the most promising option to address the TBC's related concerns. In fact, such potentials gave an impetus for various initiatives for ICS promotions; ranging from the first generation initiatives for ICS which were primarily concerned with fuelwood savings to the current initiatives that inculcate the health and climate change issues in the agenda (Eckholm, 1975; Arnold et al., 2003; García-Frapolli et al., 2010; Venkataraman et al., 2010; Urmee & Gyamfi, 2014). In that direction, Ruiz-Mercado et al. (2011) gathered that more than 160 initiatives for ICS promotion supported by governments, donor agencies and Non-Governmental Organizations (NGOs) are on-going in developing countries.

Additionally, while initiatives for ICS promotion receive attention and support from many sectors, there are also various academic contributions. These range from the seminal study by Rumford in 1802 (Rahman, 2010) which detailed studies on fireplaces, ovens and boilers which provided the first turning point for academic works on modern cooking technologies to the recent works by Urmee and Gyamfi, (2014) and Kshirsagar and Kalamkar, (2014) that comprehensively reviewed studies on ICS technologies, programmes and related studies on the technical and adoption aspects of ICS.

In these recent reviews among others, emphasis were made on the significance of ICS adoption with particular need for more studies in that aspect, as no initiative for ICS promotion could be successful unless users willingly adopt and sustain the cookstove usage (Ruiz-Mercado et al., 2011). Hence, the current study which focused on the ICS adoption aspect through the estimates of economic value and preferences for ICS among rural households in the Desert Frontline States in Northern Nigeria is one contribution. The study applied contingent valuation method (CVM) and choice experiment (CE) – the two most widely used stated preference economic valuation techniques to provide information on how households value ICS, which attribute they like about it, and what are the significant factors influencing households' valuation and preferences for ICS. In general, this information has significant role in facilitating wider adoption of ICS, which will eventually improve the environmental, health and socioeconomic condition of the households in the study area, Nigeria and entire world environment.

1.2 Problem Statement

Household cooking consumes about 80% of the total domestic energy in Nigeria (Gujba et al., 2015). This coincides with the practices in over 100 developing countries, where cooking alone consumes the higher portion of domestic energy (Merson et al., 2006). Although, the alternative cooking energy sources such as kerosene, liquefied petroleum gas (LPG) and electricity are produced and used in Nigeria, they are expensive to more than 60% of the population earning below $1 (₦360) daily (Bello et al., 2010; Gujba et al., 2015). The accessibility to these alternative energy sources is also a main challenge, particularly in rural areas. In the case of electricity for instance, an estimated 60% of the population in the country has no connection to the electricity, while the connected portion of the population tussles with intermittent power supply and unjustifiable bill increases by the power supply companies (Babatunde et al., 2009; Sambo, 2009; Eleri et al., 2012; Gujba et al., 2015; Ifegbesan et al., 2016). This situation not only excludes the electricity among the viable sources of cooking energy, but also necessitates the wider usage of TBC among households (Gujba et al., 2015; Ifegbesan et al., 2016).

Inevitably, households' reliance on TBC increases loss of forest resources, deforestation and eventually contributes to desertification in some parts of the country (Adelekan & Jerome, 2006; Nasiru, 2007; Ifegbesan, 2016). According to Food and Agricultural Organization, (2014) indiscriminate cutting of trees and shrubs for

household cooking and charcoal production results into annual loss of about 45,000 ha of forest in Nigeria. It was warned that if these practices persist, the entire forest resources in the country would be lost by the year 2020 (FAO, 2014). Also households members particularly women and children are reportedly exposed to harmful pollutants from indoor cooking emission as they spend many hours close to cooking fires daily. World Health Organization (WHO) reported that indoor air pollution produced by TBC usage caused annual deaths of 79,000 people in Nigeria (WHO, 2007).

In an effort to address the highlighted problems in the country, particularly the health issues and pressure on already limited forest resources, a number of initiatives for ICS promotion supported by government, donor agencies and Non-Governmental Organizations (NGOs) were introduced (Gujba et al., 2015). Consequently, ICS begins to be obtainable in some parts of the country. However, there is dearth of relevant information that will facilitate the success of these initiatives including the value households attached to ICS and what they like about such cooking technologies. The current study was therefore conducted to provide an insight from the households' demand, particularly of what value do households attached to ICS and what attribute of it do they prefer.

This study is deemed necessary for two broad reasons. Firstly, the experiences from various developing countries confirmed that many of the past initiatives for ICS promotion failed mainly due to the lack of proper understanding of what potential users need about the ICS (World Bank, 2011). Thus, this study was conducted particularly at the initial stage of the initiatives for ICS promotion in Nigeria in order to fill this understanding gap of the users' demand.

Secondly, the study was also motivated by the inadequacy of information, particularly on ICS valuation that could serve as significant input to the initiatives for ICS promotion in Nigerian context. Most of the ICS valuation studies were conducted in countries like South Africa (Mare, 2013), India (Jeuland et al., 2014), Ghana (Dickkinson et al., 2015) and Ethiopia (Takama et al., 2012; Kooser, 2014). Studies related to cooking practices in Nigeria focused on describing cooking fuel usage pattern, determinants of cooking fuel choice, cooking fuel accessibility, evaluation of cooking energy cost and potentials and/or impacts of some fuels over the others (Anozie et al., 2007; Akpan et al., 2010; Ohimain, 2012; Ifegbesan et al., 2015; Gujba et al., 2015). Thus, no published study on economic valuation of ICS particularly using contingent valuation method (CVM) and/or choice experiment (CE) – the most widely used stated preference (SP) based economic valuation techniques was found in the literature.

It is against this background that the current study was conceived and conducted to estimates the economic value and preferences for ICS among rural households' in the Selected Desert Frontline States of Northern Nigeria, where the wider usage of TBC is linked with substantial deforestation, desert encroachment, socioeconomic and health related problems among others. This was achieved using CVM and CE. In

general, this study seems to be the application of these techniques on households to study ICS in Nigeria.

1.3 Research Questions

The highlights in the problem statement for this study lead to the following research questions:

1. What is the pattern of cookstove usage and related cooking practices among rural households in Selected Desert Frontline States of Northern Nigeria?
2. What is the level of the rural households' knowledge and behaviour regarding adverse effects of TBC?
3. What is the rural households' mean WTP for ICS?
4. What are the rural households' preferences for various attributes of ICS?

1.4 Objectives of the Study

The general objective of this study is to estimate the economic value and preferences for ICS among rural households in Selected Desert Frontline States in Northern Nigeria. The specific objectives are:

1. To determine the pattern of cookstove usage and related cooking practices among rural households in Selected Desert Frontline States in Northern Nigeria.
2. To evaluate the rural households' knowledge and behaviour regarding adverse effects of TBC.
3. To estimate the rural households' mean willingness to pay for ICS.
4. To estimate the rural households' preferences for various attributes of ICS.

1.5 Scope of the study

This study involved only rural households due to the wider usage of TBC among them compared to their urban counterpart. Households were also considered in this study due to their policy relevancy to initiative for ICS as compared to the commercial or industrial TBC users. The methodology employed in this study is mainly restricted to the established procedures for the application CVM and CE techniques. Therefore, the outlined of the objectives, conceptual framework, instrumentation and further analyses in this study were guided by these techniques.

1.6 Significance of the Study

This study has several potential contributions to the design and implementation of initiatives for ICS promotion particularly among rural households in Nigeria and similar developing countries. It is envisaged to contribute to literature and policy, particularly related to initiatives for ICS promotion. Firstly, the study makes a substantial addition to the thin literature on economic valuation of households' demand for ICS by being the first to estimate the value attached to the ICS in form of willingness to pay (WTP) and preferences for ICS, specifically among rural households in Desert Frontline States of Northern Nigeria, where the lingering environmental degradation is linked to the excessive extraction of forest resources for household cooking.

Secondly, the study provides better understanding of the households' preferences for ICS options with different improvement levels. It also provides insight on households' heterogeneity in these preferences by interacting the observed households' characteristics with cookstove attributes in the CE models. This interaction revealed the effects of these characteristics on ICS preferences. This information specifically revealed the important demand-side features of the potential market for ICS, which are critical for product development and market segmentation needed for the dissemination of ICS technologies.

Thirdly, the study has determined the pattern of cookstove usage and related cooking practices (while synthesizing the households' characteristics that may affect economic value and preferences for ICS) as well as evaluated knowledge and behaviour regarding adverse effects of TBC among rural households. Findings from these sections also have far-reaching direct relevance for policy and practice. The sections describe the extent of TBC usage, the absence of other alternative cookstoves including ICS in the area, what households know about adverse effects of TBC and how they respond to these effects. Initiatives for ICS promotion will find this information useful in coming-up with intervention strategies.

Finally, these contributions collectively provide a framework required particularly while setting-up initiatives for ICS promotion among households in the study area and Nigeria as a whole. The households' preferences for ICS reported in this study will guide ICS design, while the reported WTP will guide pricing policy or subsidy required to enhance ICS uptake. Such information is particularly unavailable for the study region, a targeted area for most initiatives for ICS promotion as cooking energy usage practices of millions of people in the area lead to a range of health, environmental and development concerns.

1.7 Organization of the Thesis

This thesis is organized based on five chapters. Chapter 1 presents background about TBC and ICS with emphasis on related problems associated to the former and potential benefits of the later respectively. The chapter contains background of the study, problem statement, research questions, study objectives, scope and significance of the study.

Chapter 2 provides review of literatures related to the biomass cookstove concept, usage and types. It also covers the concerns over TBC, necessity and probable strategies for its improvement as well as the potential benefits of ICS among households in developing countries. The chapter also discusses historical development of biomass cookstove improvement, some initiatives for ICS promotion as well as application of CVM and CE ICS studies. The chapter established a theoretical basis that could appropriately guide the outlined objectives of this study.

Chapter 3 discusses the step-by-step methodological approaches employed in this study. It describes the conceptual framework of the study, the study area, sampling population, sample frame, sample size, sampling technique, data collection technique, sampling unit, focus group discussion, questionnaire design and pretest, survey implementation and data analysis. It also outlines the econometric model specifications for CVM and CE as they are applied in this study.

Chapter 4 presents and discusses the findings of this study. The results presentation was in order of the study objectives. The chapter also presents summaries of findings in forms of tables and charts, and then together with detail discussions and interpretations of the findings.

Chapter 5 summarized and concluded the study. It also stressed points on policy implication of the study outcomes, and highlighted limitations and recommendations particularly for future studies related field.

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