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Analysis of Adoption of Improved Cookstoves by Households in Kaduna North Local Government Area, Kaduna State Nigeria

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Abstract
The level of fuel wood consumption in traditional cook stoves is on the increase due to the cost and unreliability in the supply and availability of modern forms of energy. This study focused on the adoption of improved cook stoves in Kaduna North Local Government Area. Data were collected from four sampling units (Kawo, Badarawa, Hayin banki, and Unguwar shanu) using field observation and questionnaire survey. The data collected were analyzed using t-test and the Point Biserial Correlation. Results obtained revealed a significant relationship between education levels attained and type of cook stove used. Majority of the respondents with low income (< 18,000 naira) were found to use fuel wood. A significant relationship existed between house hold size and type of cook stove used, where households with numbers greater than 4 used fuel wood in the study area. Significant difference in the amount of fuel wood consumed by improved and traditional cook stoves was observed using t-test, where traditional cook stove consumes much more fuel wood than the improved cook stove. Most respondents preferred traditional cook stoves and open fires over improved based on beliefs and culture. Awareness level about the improved cook stove was very poor. The use of improved cook stoves from this study has shown a strong relationship between its adoption and educational status, income level, household size, cultural beliefs, as well as level of awareness. Hence, there is need for enlightenment on the advantages of improved cook stoves and dangers associated with fuel wood/open fire use.
Keywords: Fuel wood, Cook stoves, Kaduna, Traditional, Energy

1. Introduction

Conventional energy, such as coal, petroleum and natural gas, is imperative in raising the living standard of the people. However, cost implication, unreliable supply, and environmental consequences have led to the search for readily available alternatives (Onyegebu, 2003). These readily available alternatives include fuel wood. In most of the developing countries, wood and other biomass fuels are still the primary source of energy for the majority of people, particularly the low income class. According to the International Energy Agency (IEA 2014), over 1.6 billion people globally live without access to electricity and 2.4 billion people are without modern energy services for cooking and heating. High dependence on fuel wood for energy is chiefly because of its relatively low price and easy accessibility, as well as constraints in the supply of the conventional fuels and growing population (Sambo, 2005). In the year 2000, a new method of improved cook stoves has been employed to decrease fuel wood related problems, where a special group 'Global Alliance for Clean Stoves' was adopted to create awareness so that the use of this new method can increase to a hundred million households by 2020 (Smith et al., 2000). Daily consumption of fuel wood in Nigeria by the rural communities is estimated to be about 27.5 million kg/day (Ogunsanwo and Ajala, 2002). This opinion was strengthened by another topical data published by The Solar Cooking Archive (2011) which placed the estimate of Nigeria's fuel wood consumption as percentage of energy at approximately 87%. Fuelwood in Kaduna State is the most highly consumed fuel, accounting for about 1,722,904 tons/year consumed per person in the State (Tukur et al., 2013). Within the background of global and national energy crisis leading to persistent demand and supply gap of cooking energy in Nigeria, there is a need to investigate and analyze the adoption of efficient cook stoves, not only as an alternative but as a means of minimizing fuel wood consumption and related problems in Kaduna North local government area of Kaduna State. Traditional cook stoves and open fires are the major means of cooking and heating for approximately 3 billion people in developing countries (FAO 2001). The smoke from such traditional stoves causes about 1.9 million premature deaths annually with women and children commonly affected (WHO, 2006). The majority of traditional cook stoves in the study area are used inside the houses, which fill the living space with smoke, and they transform only a small percentage of the combustion energy into cooking energy. Moreover, in addition to carbon dioxide, the incomplete combustion of the fuel wood releases carbon monoxide, methane and other hydrocarbons which contribute to the greenhouse effect. Indoor air pollution is always believed to be a major health hazard resulting from smoke produced by biomass fuels as it accounts for an estimated 2 million deaths annually (WHO, 2006). According to the Food and Agriculture Organization of the United Nations (2005), exposure to smoke from traditional cook stoves amplifies the risk of respiratory infections and might increase the incidences in Africa. In spite of the problems associated with the use of

traditional cook stoves, there seems to be few studies carried out on the use and adoption of improved cook stoves in Kaduna North Local Government area. This is the major gap that this research intends to address.

The aim of this study is to assess the extent of preference for the improved cook stoves compared with the traditional cook stoves, among households in the study area.

2. Materials and Methods

The study is limited to households in four selected wards in Kaduna North Local Government Area. This is to enable the researcher make comprehensive assessment of improved cook stoves adoption in the study area.

2.1 Study Area

The wards are Kawo, Hayin Banki, Badarawa and Unguwar Shanu. Within Kaduna north local government area, the four sampling units selected for this study are shown in figure 1. The Geographical location of Kaduna North lies between latitudes 10^0 04 and $10^0$30 North of the Equator and between longitude 7^0 20'' and 7^0 30'' East of the Greenwich Meridian.

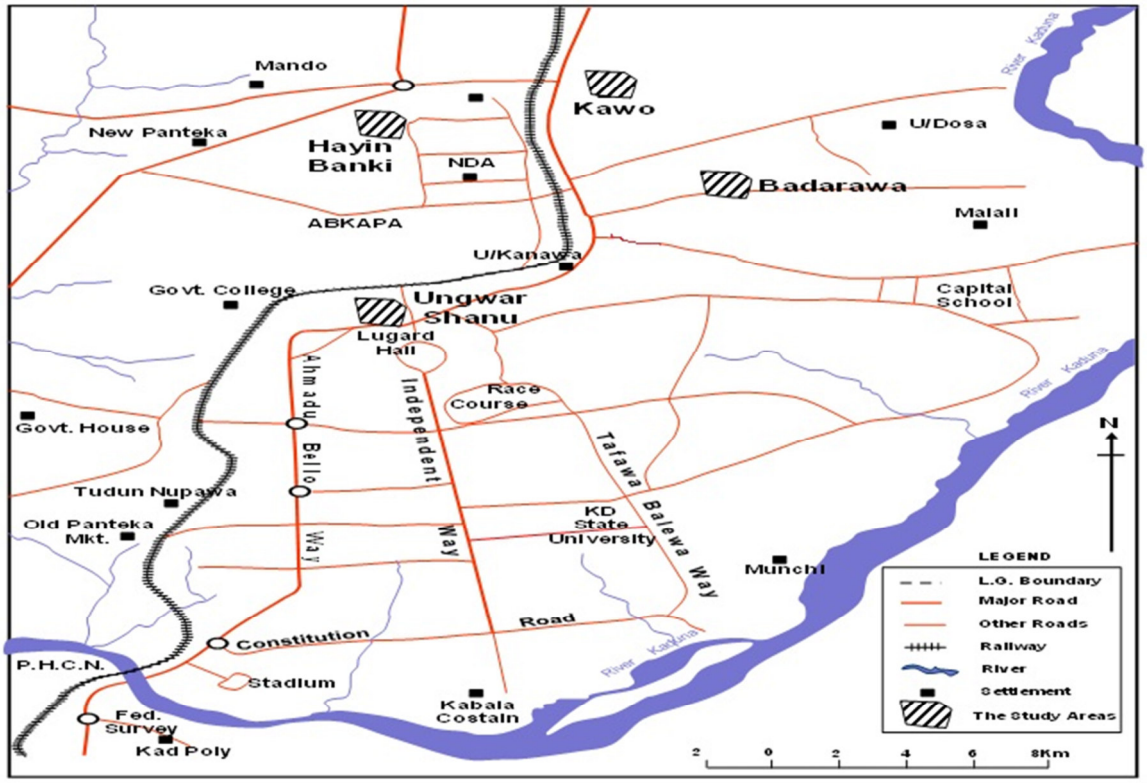

Figure 1. Kaduna North Local Government Area Showing the Study Areas

2.2 The Improved Cook Stove

This is a device that is designed to consume less fuel and save cooking time. It is convenient in cooking process and creates smokeless environment in the kitchen or reduces the volume of smoke produced during cooking as against the traditional stove. Improved cook stoves are portable and are made mostly with metal, although there are some that are made of mud and fixed in the kitchen. An improved cook stove has different types which include Envirofit, Stove Tec, Philips, Vesto and Save 80. The one employed in this research was the Save 80 (Plate 1, Appendix VI). Save 80 is an efficient cook stove, which is made of stainless steel weighing about 4 kg. The stove basically has three components i.e. a cylindrical container, two integral pots and a wonder box. It has a metal pot in the middle that serves as a fire bowl; a small opening is made in front, at the center which creates an opening for fuel wood. Only 250g of small wood sticks are sufficient to bring 6 litres of water to the boil using the Save 80 stove, which is about 80% less compared to traditional fire places such as the three stone fire stove. Save 80 stove has been reported to significantly reduce carbon monoxide emissions (Adria, 2014). The 'wonder box' device (a complimentary accessory) of the stove allows additional energy saving. When the food reaches boiling temperature, it can be transferred from the integral pot to the wonder box, which keeps the high temperature for an increased period without using direct heat sources. The food in the wonder box can keep cooking (or stay hot) because the temperature falls at a very slow rate (e.g. after two hours the temperature would fall from 100 to about 90^0C and after 12 hours it could still be at 65^0C). These stoves have been

distributed in several countries including Indonesia and Nigeria, where distribution of 120,000 stoves has been estimated to cause a reduction in 350,000 tons of carbon dioxide emission per year in Indonesia (Adria, 2014).

2.3 Data collection

Data collection was in two phases; direct field observation and questionnaire survey. In the case of direct observation, survey of households that use improved cook stoves, traditional, or both were carried out. The structured questionnaire was divided into two sections. The first section covered information regarding gender, age, educational qualification, occupation, marital status as well as income. Section two was concerned with type of stove used by household, fuel wood consumption pattern, time taken while cooking, preference, and satisfaction level from use of the cook stove currently owned, amongst others. The study was conducted in Kawo, Badarawa, Hayin banki, and Unguwar shanu wards of Kaduna North Local Government Area.

The questionnaire was administered using the convenience sampling technique. By this method, sampling unit was selected based on easy access and convenient location. To administer the questionnaire, the number of people paying tax as at 2016 was obtained from the Kaduna State Internal Revenue Service. An overall sample size of 5% was used for the study considering the number of people recorded in all the units. This formed the basis for determining the number of copies of questionnaire to be distributed in each of the sampling unit. Two hundred (200) copies of the questionnaire were distributed among the sampling units (wards) of the study area; sixty-six (66) copies in Kawo, sixty copies (60) in Badarawa, thirty-four (34) copies in Hayin Banki and forty (40) copies in Unguwar Shanu. It should be noted however that, not all people were captured according to the data. In each sampling area, the first residential unit to be encountered was made the starting point using the convenience sampling approach.

2.4 Data Analysis

The data collected in this study were analyzed using the statistical tools of t-test and the Point Biserial Correlation to examine the statistical relationship that exist in the amount of fuel wood consumption between improved and traditional cook stoves among households as determined by type of cook stove used, in the different sampling wards. Results were presented as tables.

3. Results

3.1 Educational status and the type of cook stove used

Data obtained are presented in tables. The relationship between educational status and type of cook stove used was determined. The results revealed significant variations among households with regard to the type of cook stove used, based on their educational attainment, in our study area (Appendix II)

In Kawo sampling unit, the type of cook stove used by households varied with the level of education. Those with no formal education constitute the larger percentage that uses traditional cook stove, whereas those who attained beyond secondary school education had the higher percentage of improved cook stove use (Table 1). Similarly, the use of cleaner fuels such as kerosene and liquefied natural gas as well as improved cook stove was observed more in the latter than the former. In Badarawa sampling unit; most of the respondents used traditional cook stove. Only ten percent (10%) of the respondents were found to use improved cook stove (Table 1). This is similar to that of Hayin banki and Unguwar shanu sampling units, where only two percent (2%) and three (3%) of the respondents were found to use improved cook stoves respectively (Table 1). Educational status and income may be related to the ability to purchase improved cook stove or other cleaner fuels.

Table 1:Distribution of Respondents according to their Educational Status and Type of Cook stove used in the Study Area.

SU	Types of cookstove used	Educational Status					Total	
		NFE	AL	P	PP	T	SU	Study area as a whole (%)
K	Improved	0	0	2 (3%)	3 (4%)	6 (9%)	11 (16%)	5.5
	Traditional	25 (38%)	18 (2%)	8(12%)	2 (3%)	2 (3%)	55 (84%)	27.5
	Total	25 (38%)	18 (28%)	10 (15%)	5 (7%)	8 (12%)	66 (100%)	**33.0**
B	Improved	0	0	1 (1%)	2 (3%)	4 (6%)	7 (10%)	3.5*
	Traditional	25 (42%)	8 (14%)	12 (20%)	5 (8%)	3 (6%)	53 (90%)	26.5
	Total	25 (42%)	8 (14%)	13 (21%)	7 (11%)	7 (12%)	60 (100%)	**30.0**
HB	Improved	0	0	0	0	1 (2%)	1 (2%)	0.5*
	Traditional	12 (36%)	8 (24%)	6 (18%)	4 (12%)	3 (8%)	33 (98%)	16.5
	Total	12 (36%)	8 (24%)	6 (18%)	4 (12%)	4 (10%)	34 (100%)	**17.0**
US	Improved	0	0	0	0	1 (3%)	1 (3%)	0.5*
	Traditional	19 (47%)	9 (22%)	8 (20%)	2 (5%)	1 (3%)	39 (97%)	19.5
	Total	19 (47%)	9 (22%)	8 (20%)	2 (5%)	2 (6%)	40 (100%)	**20.0**
	Grand Total						**200**	**100**

Sampling Units (SU); K (Kawo), B (Badarawa), HB (Hayin banki), US (Unguwar shanu), NFE (No formal education); AL (Adult literacy); P (Primary); PP (post primary); T (Tertiary)
*= 5% level of significance using t test and biserial correlation. Significant difference was observed between educational status and type of cook stove used in Badarawa, Hayin Banki, and Unguwar shanu wards.

3.2 Household Size, Income and the Type of Cook stove Used in the Study Area

Data presented here revealed the relationship that may exist among household size, income and the type of cook stove used. No statistical significant variations exist in the types of cookstoves used and household sizes. The distributions of respondents in all sampling units with regard to these variables are presented in Tables 2 and 3. Majority of households with sizes above 4 were found to use traditional cook stove compared to households with fewer numbers (less than 4) who were found to use improved cook stove (Table 2).

Table 2: Household Size and The Type of Cookstove Used in The Study Areas.

Sampling Unit	Type of Cook stove	Household Size			TOTAL	
		2-4	4-6	7 and above	Sampling Unit	Study area as a whole (%)
Kawo	Improved	9 (13%)	6 (9%)	2 (3%)	17 (25%)	8.5
	Traditional	4 (6%)	16 (24%)	29 (43%)	49 (75%)	24.5
	Total	**4 (6%)**	**24 (44%)**	**38 (56%)**	**66 (100%)**	**33.0**
Badarawa	Improved	7 (12%)	5 (9%)	2 (3%)	14 (24%)	7.0
	Traditional	1 (1%)	18 (30%)	27 (45%)	46 (76%)	23.0
	Total	**1 (1%)**	**24 (42%)**	**35 (58%)**	**60 (100%)**	**30.0**
Hayin Banki	Improved	1 (2%)	0	0	1(2%)	0.5
	Traditional	4 (12%)	11 (34%)	18 (52%)	33(98%)	16.5
	Total	**5 (14%)**	**11 (34%)**	**18 (52%)**	**34 (100%)**	**17.0**
Unguwar Shanu	Improved	0	1 (2%)	0	1 (2%)	0.5
	Traditional	2 (5%)	13(33%)	24(60%)	39 (98%)	19.5
	Total	**2 (5%)**	**14 (35%)**	**24(60%)**	**40 (100%)**	**20.0**
	Grand Total				**200**	**100**

The relationship between income and type of cook stove used is presented in Table 3. Results revealed that income was found to significantly influence the adoption level for cookstove type among respondents in the study area. In terms of income, none of the respondents earning less than eighteen thousand naira (₦18, 000) per month was found to be using improved cookstove. However, minority who fall within the eighteen thousand naira (₦18, 000 - ₦50, 000) income group, were found to adopt the improved cooking device and this increased with rise in income as presented in Table 3.

Table 3: Income Level and the Type of Cook stove Used in the Study Area.

Sampling Unit	Type of Cook stove used	Income level			TOTAL	
					Sampling Unit	Study area as whole (%)
		<₦18,000	₦18,000 – ₦50,000	>₦50,000		
Kawo	Improved	0	2 (3%)	9 (13%)	11 (16%)	5.5*
	Traditional	25 (38%)	18 (28%)	12 (18%)	55 (84%)	27.5
	Total	**25 (38%)**	**20 (31%)**	**21 (31%)**	**66 (100%)**	**33.0**
Badarawa	Improved	0	1 (2%)	6 (10%)	7 (12%)	3.5*
	Traditional	24 (40%)	11 (18%)	18 (30%)	53 (88%)	26.5
	Total	**24 (40%)**	**12 (20%)**	**24 (40%)**	**60 (100%)**	**30.0**
Hayin Banki	Improved	0	0	1 (2%)	1 (2%)	0.5*
	Traditional	15 (45%)	11 (32%)	7 (21%)	33 (98%)	16.5
	Total	**15 (45%)**	**11 (32%)**	**8 (23%)**	**34 (100%)**	**17.0**
Unguwar Shanu	Improved	0	0	1 (20%)	1 (2%)	0.5*
	Traditional	21 (53%)	12 (30%)	6 (15%)	39 (98%)	19.5
	Total	**21 (53%)**	**12 (30%)**	**7 (17%)**	**40 (100%)**	**20.0**
	Grand Total				**200**	**100**

*= 5% level of significance using t-test and biserial correlation. No statistical significant difference was observed between household size and type of cook stove used in all sampling units.

3.3 Fuel wood Consumption by type of Cook stove

To determine the difference in fuel wood consumption between the traditional and improved cook stoves, households of different/the same sizes using either of the cook stoves investigated, were selected from the sampling units. Table 4 shows the differences in daily fuel wood consumption between improved cook stove and traditional cook stove. This difference in the amount of fuelwood consumed by improved and traditional cookstoves in the sampling units were found to be significant after subjecting them to a t-test statistical analysis.

Table 4: Difference in Fuel wood Consumption between Improved and Traditional Cook stove

S/No	Sampling Unit	Household Size	Improved Cookstove Quantity of Fuelwood Consumed weekly (kg)	Per Capita Consumption	Household Size	Traditional Cookstove Quantity of Fuelwood Consumed weekly (kg)	Per Capita Consumption
1.	Kawo	5	7	1.4	5	14	2.8
2.	Kawo	5	7	1.4	5	14	2.8
3.	Kawo	6	10.5	1.75	6	21	3.5
4.	Kawo	7	10.5	1.5	7	21	3.0
5.	Badarawa	5	10.5	2.1	5	14	2.8
6.	Badarawa	4	7	1.75	4	14	3.5
7.	Badarawa	5	7	1.4	5	14	2.8
8.	Badarawa	6	10.5	1.75	6	21	3.5
9.	Hayin Banki	4	7	1.75	4	14	3.5
10.	Unguwar Shanu	6	14	2.3	6	21	3.5
		Total		**17.1**	**Total**		**31.7**

3.4 Reasons for Choice of Cook stove Type

Majority of the respondents preferred the use of Traditional cook stoves which may be due to its relatively cheap cost and availability. They strongly believe that the smoke from traditional cook stoves add more aroma and flavor to the dishes prepared while the improved cook stove only produce less or no smoke. Some also testified that, the smoke from such fires serve as insects' deterrent in their households (Table 5).

Table 5: Reasons for Choice of Cook stove Type

Sampling Wards		Kawo	Badarawa	Hayin Banki	Unguwar Shanu	Total
Traditional	Cheaper	39	36	22	26	
	Food taste Better	10	9	6	8	
	Smoke & Insecticide	6	8	5	5	
Total:		**55**	**53**	**33**	**39**	**180**
Improved	Energy Efficiency	1	1	0	0	
	Cooks Faster	3	1	0	0	
	Less Smoke	7	5	1	1	
Total:		**11**	**07**	**01**	**01**	**20**

3.5 Level of Awareness on the Improved Cook stove Among Respondents

Awareness level about the improved cook stove among the respondents was found to be very poor as only few people claimed to know about its existence. The results revealed that majority of the respondents are not aware about the existence of the improved cook stove (Table 6).

Table 6: Awareness Level on the Improved Cook stove Among Respondents.

Sampling Unit	Aware	Unaware	Total
Kawo	14	52	66
Badarawa	8	52	60
Hayin Banki	6	28	34
Unguwar Shanu	3	37	40
Total	**31 (15.5%)**	**169 (84.5%)**	**200 00%)**

4. Discussion

Fuel wood remains the major source of domestic energy in most parts of the developing world (Babanyara and Saleh, 2010). Due its significance, it has been anticipated that world consumption would be greater than that from hydroelectric power, nuclear power and geothermal sources combined. In Nigeria, 70% of households use solid fuels and even most use open fire/stove without chimney or exhaust hood (Desalu et al., 2012). This has been associated with deforestation, soil erosion, flooding, global warming, declining agricultural productivity, and health of especially mothers and children. Apart from reducing the high demand of fuel wood, improved cook stoves have been reported to be associated with reduced emission of dangerous pollutants released by fuel wood and improved. These pollutants have been reported to affect human health and climate (Abex et al., 2007). Improved stoves have been reported to cause less respiratory problems compared to traditional cook stove (Clark et al., 2009). Biomass and fuel fossil cook stoves emit certain percentage of global black carbon which also contributes largely to global warming (Sagar and Kartha, 2007). This study reported the relationship between fuel wood consumption and improved cook stove; preference level, level of awareness, relationship with income class, as well as level of education. In this study, the use of improved cook stove was common among those with higher education attainment. This may be as a result of the awareness on the dangers associated with pollutants released from fuel wood. Though, the use of fuel wood may not be from illiteracy alone but from other factors like income, lack of knowledge of health implications of indoor air pollution and poor awareness of existing alternative domestic energy conversion technology such as improved cook stoves (Cordes 2011, Duflo et al 2008). The study also reported that the adoption of improved cook stove depended on the income and household size, where those with low income and large household size preferred the use of fuel wood over improved cook stove. A similar study has been conducted in South Western Nigeria, where the choice of cook stove depended on price of the relevant energy source, availability of substitutes, fuel preference of the consumer, rural-urban migration, household income and size, cultural factors, cost and performance of end-use equipment (Ayodele et al., 1996). From the study, majority of the respondents preferred the use of traditional cook stoves which may be due to its relatively cheap cost, availability, as well as their strong believe. They believe that the smoke from traditional cook stoves add more aroma and flavor to the dishes prepared and the smoke from such fires can serve as insects' deterrent in their households. Cultural beliefs and cost/affordability has been a main concern in adopting new/improved cooking strategies (Masera et al., 2000). Poor awareness level about the improved cook stove reported in this study may be the reason for its use among few respondents. This was in agreement with a study conducted by Fajola and colleagues, where few respondents knew/heard about the improved cook stove, with even fewer number that have seen one (Fajola et al., 2014). Other possible reasons reported by Mitchell, 2010 are non-suitability with customs/beliefs, poverty, poor distribution channels, and/or insufficient social marketing (Mitchell, 2010). Holmes (2010) examined the implementation, technical performance, and effectiveness of improved cook stoves and barriers to their broader acceptance in Tanzania, where her findings

suggests that successful implementation strategies for improved cook stove projects include use of local materials, community participation, education and training. Studies have shown that improved cook stoves cooks faster and save more fuel wood compared to traditional cook stove (Bikram, 2008; Akpootu et al., 2014).

5. Conclusion

Results obtained from this study revealed that there are significant variations among households based on educational status and the type of cook stove used. Households' incomes and sizes greatly determine the type of cook stoves. Awareness level was also an important factor in the study which affected the wide use of improved cook stoves. Ways to improve awareness among populations should be improved so as to reduce the hazards associated with fuel wood. The use of improved cook stove should be encouraged by making it available and affordable, thus minimizing the consequences of excessive fuel wood use. Massive enlightenment campaign and media programs should be mounted to create awareness not only on the existence but also on the advantages of adoption and use of the improved cook stoves.

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Appendix I

SAMPLE QUESTIONNAIRE
ANALYSIS OF ADOPTION AND USE OF IMPROVED COOKSTOVES IN KADUNA NORTH LOCAL GOVERNMENT AREA, KADUNA STATE

1. Location – Ward/Unguwa – Street/Layi _____
   _____
2. Number of People in Household?_____
3. Which of these do you use primarily for cooking?
   (a) Gas (b) Kerosene (c) Fuel wood (d) Electric (e) Others
4. Reason(s) for choice *(you can tick more than one)*
   (a) Economic (b) Environmental (c) Hygiene (d) Convenience
5. What type(s) of cook stove do you use?
   (a) Traditional (b) Improved (c) Both
6. Reason(s) for choice *(you can tick more than one)*
   (a) Economic (b) Environmental (c) Hygiene (d) Convenience
7. If you use both, which do you prefer?
   (a) Improved (b) Traditional
8. Please give reason(s) _____
   _____
9. Age: 18 – 25 26 – 40 41 – 55 56 – 70 Over 70
10. Gender: Male ☐ Female ☐
11. Marital Status: Single ☐ Married ☐ Divorced ☐
12. Religion: Islam ☐ Christianity ☐ Traditional ☐ Others ☐
13. Educational Level: (a) No Formal Education (b) Adult Literacy
    (c) Primary Education (d) Secondary Education (e) Tertiary
14. Occupation: _____
15. Monthly Income
    (a) <18,000 (b) 18,000 – 40,000 (c) 40,000 – 60,000 (d) >60,000
16. How often do you purchase fuelwood?
    (a) Monthly (b) Weekly (c) Daily
17. Amount spent on fuelwood?
    (a) >1,000 (b) <1,000
18. Improved cook stoves are environmentally and health friendly, do you agree with this statement? (a) Yes (b) No (c) Partially (d) Don't know
19. Traditional cook stoves usage is harmful to health and environment, do you agree?
    (a) Yes (b) No (c) Partially (d) Don't know
20. Improved cook stoves save more fuel and time compared to traditional one?
    True ☐ False ☐
21. There is a difference in the unit of fuelwood consumed by both types of stoves do you agree? (a) Yes (b) No (c) Don't know
22. If 21 above is yes, which one consumes more fuel?
    (a) Improved (b) Traditional
23. If you use the improved version, are you satisfied with its performance?
    (a) Yes (b) No (c) Partially
24. How efficient are improved cook stoves in terms of fuelwood consumption?
    (a) Highly Efficient (b) Efficient (c) Not Efficient
25. Which of these have you heard of *(you can tick more than one)*

(a) Indoor Air Pollution (b) Climate Change
(c) Deforestation (d) Desertification

26. Use of traditional cook stoves can cause one or all of the above, are you aware?
(a) Yes (b) No (c) Don't know (d) Don't care much

27. Would you like to know how to be more environmentally friendly?
(a) Yes (b) No (c) Don't care much

Appendix II

Plate 1: The improved cook stove