Willingness to Switch From Charcoal to Alternative Energy Sources in Dar es Salaam, Tanzania

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Abstract

A majority of the developing countries are characterised by poor performance of the power sector and traditional energy, poor transition from traditional to modern energies. The aspect of cooking fuel choice has been in theory explained by energy ladder theory. According to this theory, households tend to switch from one fuel to another, climbing up a ladder towards more modern energy sources as the income level improves. However, recent observation in developing countries has shown that households do not do a complete switch but rather, consume multiple fuels. Moreover, income has been found as not the only factor influencing the switching patterns of households, thus resulting to a fuel stack hypothesis which has been supported by a number of researchers. Motivated by this fact, and using a sample of 562 randomly selected households from the three municipals of Dar es Salaam region, this study assesses factors that may influence households to switch from charcoal to alternative clean energy sources. It uses logit regression analysis to analyse the data obtained. Descriptive analysis shows that about 20 and 25 percent of the households are still not aware of charcoal indoor pollution and associated health problems, respectively. Also, about 20 percent perceive charcoal as easier to use while only 5 percent state that food cooked using charcoal tastes more delicious that that cooked using other sources of energy. Furthermore, regression analysis finds that household's head age, gender, occupation, expenditure, home ownership, convenience of charcoal and unreliability of modern fuels to be significant factors in explaining such transition.

Keywords: *Charcoal, urban, cooking fuel, switch, logit regression*

JEL Classification*: Q4, Q41*

1. Introduction

There is a wide diversity in developing countries in terms of socio-economic conditions which in one way or another influence decisions at the households level. Neoclassical economists assume that an individual is rational and can choose among available choices (Mas-Colell et al., 1995). An individual is considered as the basic decision-making unit and can rank possible alternatives in order of preference, and will always choose from available alternatives the option that s/he considers most desirable (Davidson, 1996). Thus, the rational choice theory assumes that individuals have preferences among available alternatives (Mas-Colell et al., 1995). Therefore a consumer faced with a list of alternatives should be able to have an opinion on which one s/he likes most. In light of this theory, an individual is expected to rank and make decisions regarding the specific energy sources to use among the available alternative.

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Some common energy system characteristics—such as poor performance of the power sector and traditional energies, poor transition from traditional to modern energies and structural deficiencies in the economy—are generally affected by socio-economic conditions (OTA, 1991; Urban et al., 2007). According to the prospect theory (Kahneman & Tversky, 1979), the choice process is done in two phases: the editing phase which consists of a preliminary analysis of the prospects available; and the evaluation phases where prospects are evaluated and the edited perspective with the highest value is chosen. The existence of large scale inequity and poverty, dominance of traditional life styles and markets in rural areas, transitions of populations from traditional to modern markets, existence of multiple social and economic barriers to capital flow and technology diffusion cause developing countries' energy systems to be significantly different from that of developed countries (Pandey, 2002). According to IEA (2002), about 25 percent of primary energy consumption of developing countries comes from biomass and other traditional energies, although the share varies across different regions and by countries. Although developing economies transit from traditional energies to modern energies as they climb up the income ladder, the speed at which countries move varies and, consequently, the number of people relying on such energies even in 2030 is expected to be about 2.6 billion (IEA, 2002).

The use of traditional energies poses specific problems for energy analysis. Often no estimations for traditional energy demand, prices and supply potential are available; and many poor consumers lacking purchasing power may not enter the commercial energy ladder. Ignoring these energies is inappropriate given the critical role of access to affordable, clean and reliable supply of energy for sustainable development (Ailawadi & Bhattacharyya, 2006), but incorporating them is not easy either. In addition, the changing economic structure due to industrial activities and consequent rapid urbanization of these economies add another dimension to the economic transition where a growing urban sector co-exists with a predominantly rural economy.

The nature of economic activities as well as opportunities differs significantly between urban and rural areas. Informal economic activities prevail in rural and semi-urban areas due to the existence of unemployment or part-employment, both of which sometimes produce in-kind payments as compensation and participation in barter rather than monetized transactions. Shukla (1995) and Pandey (2002) point out that the presence of informal sector in developing economies leads to non-optimal choices. Bhattacharyya (1995) emphasized on the violation of basic assumptions of the neoclassical paradigm because of incomplete markets, costly information and transaction costs in developing countries due to the existence of an informal sector and prevalence of traditional use of energies. Pandey (2002) further indicated that the transition dynamics have important implications for energy demand due to changes in life-styles, technology choices and fuel mix, which in turn impact sustainability and the environment. Therefore, understanding these dynamics and their incorporation in policies and modelling are essential in capturing the transition of developing countries.

Theoretically, the aspect of cooking fuel choice has been explained by the energy ladder theory. According to this theory, households tend to switch from one fuel to another, climbing up a ladder towards more modern energy sources as income levels improve. Thus, household energy transition involves a movement from primitive fuels (animal dung and firewood) to transition fuels (charcoal and kerosene), and then to advanced fuels (gas, electricity) (Heltberg, 2003).

However, recent observations in developing countries have shown that households do not do a complete switch, but rather consume multiple fuels. Moreover, income has been found as not the only factor influencing the switching patterns of households, thus resulting to fuel stack hypothesis that has been supported by a number of researchers (Masera et al., 2000; Heltberg, 2005; Mekonnen & Kohlin, 2008). As such, according to this hypothesis households may choose a combination of high cost and low cost fuels depending on their budget, preferences and needs (World Bank, 2003; Mensah & Adu, 2013). Also, other social and cultural factors may influence the switching pattern.

Specifically in Tanzania, charcoal consumption occupies a significant proportion of households cooking profile among other cooking fuels. However, the largest share of charcoal consumption is in urban areas compared to rural areas that rely more on firewood (Kaale, 2005; NBS, 2012). As in other developing countries, the use of charcoal is normally complemented with the use of other fuels like kerosene, liquefied petroleum gas or electricity. The significant use of charcoal in urban areas is attributed to its high calorific value, easy transportation, easy storage, availability and ability to purchase in small amounts, low initial investments, non-liable to deterioration by insects and fungi, and less smoke and sulphur-free compared to firewood (Kaale, 2005; Mwampamba, 2007; World Bank, 2009).

Notably, Tanzania is one of the countries in the world that has high charcoal production and consumption. As at 2012, Tanzania had 3.2 percent share of the global production of charcoal, thus ranking 8th globally in regard to charcoal production.[3] In general, charcoal is produced from woodlands, plantations, trees outside forests, coconut shells and crop residues. However, most charcoal is produced from dry woodlands simply because they produce more concentrated fuel. Furthermore, woodlands that are preferred are those with high recovery percent, high calorific value and which do not break easily during transportation (Malimbwi & Zahabu, 2008).

As regards charcoal consumption, urban areas constitute higher demand compared to rural areas where firewood is used as the main cooking fuel. However, overall charcoal demand seems to have nearly doubled over the past ten years as a result of rapid urbanization and high prices of alternative fuels, especially kerosene, electricity, biogas, biomass briquette and LPG (NBS, 2013).

[3] Source: www.factfish.com as cited on 19th July 2014

Among all urban regions in Tanzania, Dar es Salaam is the leading consumer of charcoal. Around 90 percent of the population in Dar es Salaam relies on charcoal as its primary energy source for cooking (TaTEDO, 2004).[4] There is a huge demand of charcoal in Dar es Salaam compared to other regions due to fact that it is the economic hub of Tanzania with many economic activities that raise energy demands. In addition, the high population level compared to other regions also contributes to high charcoal demands. According to the NBS (2012), Dar es Salaam harbours 4.3m people, which is about 10 percent of the country's total population. Moreover, a majority of the people are low-income earners who consider charcoal as 'cheaper' compared to alternative sources, which further raises charcoal demands. In general, charcoal is sold to final consumers in the form of sacks, tins or heaps. Thus, an individual has an opportunity to choose the amount s/he can afford. Usually, high income earners prefer buying in sacks while low income earners buy mostly in heaps or tins.

Although charcoal has been useful as a cooking fuel for most urban dwellers, as well as a source of income and employment for both producers and traders, its production and use has adverse impacts to the environment, deforestation being one of them. According to the Ministry of Natural Resources and Tourism (2001), forests have been reduced from 44.3m hectares in 1961 to 33.5m hectares in 1998. CHAPOSA (2002) records a reduction of forest cover from 29,268 hectares to 23,308 hectares of closed woodland and a reduction of 92,761 hectares of open woodland. Moreover, UN-REDD (2009) accounts for a reduction of 14.9 percent of forest cover from 1990 to 2005. Thus, this extent of deforestation reduces the amount of rainfall, destroys the ecology (flora and fauna), and makes the soil susceptible to erosion, and destroys watersheds as well.

Furthermore, increased charcoal demands—especially in urban areas such as Dar es Salaam—propagates charcoal production which also contributes to greenhouse emission. According to the World Bank (2009), 9m of carbondioxide are released every year in Tanzania as a result of charcoal production. Other emissions from charcoal production include carbonmonoxide, methane, ethanol and particulate matter. All these are dangerous to human life and the environment. This amount of pollution can be more depending on the type of kiln used, temperature during the carbonization process and the moisture content of the wood.

The air pollution that is emitted during charcoal consumption may result into respiratory infections like pneumonia to children, chronic bronchitis, chronic obstructive pulmonary diseases, low birth weights, perinatal mortality, asthma, tuberculosis, and laryngeal cancer (Norconsult, 2002). In the case of Tanzania, health problems associated with the use of biomass constituted of 4.4 percent of environmental health-related problems (WHO, 2007). Thus, this paper aims to determine factors influencing households' willingness to switch from charcoal to modern sources of energy, to examine households' awareness on charcoal indoor pollution and associated health problems and to explore households' perceptions that influence charcoal consumption.

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[4] Source: www.tatedo.org as cited on 19th July 2014

2. Methodology

2.1 Theoretical Framework

Energy demand is a derived demand that arises to satisfy some needs which are met through the use of appliances. Energy demand describes a relationship between price (or income or such economic variable) and quantity of energy either for an energy carrier (e.g., electricity) or for final use (such as cooking). Hence, the demand for energy then depends on the demand for energy services and the choice of energy using processes or devices. Any commercial energy requires monetary exchanges and the decisions to switch to commercial energies can be considered as a three stage decision making process (see Hartman, 1979; Stevens, 2000; and Bhattacharrya, 2000). First, a household has to decide whether to switch or not (*switching decision*); second, decides about the types of appliance to be used (*appliance selection decision*); and at the third stage, consumption decision is made by deciding the usage pattern of each appliance (*consumption decision*). All these stages in one way or another influence energy demand.

Once a buying decision is made, two important parameters are to be decided next. If alternative fuel choices are available, which fuel would be used and what type of appliance for this fuel? Once a decision is made to buy an appliance and the appliance is purchased, the only variable left in the hand of the user is its utilization. From an economic point of view, the principle for estimating and analysing the demand for energy is not different from that of any other commodity. There are characteristics of energy demand, institutional features of energy markets and problems of measurement that requires particular attention in analysing energy markets. But the microeconomic foundation of energy demand is the same as for other commodities. From the basic microeconomic theory, the demand for a good is represented through a demand function which establishes the relationship between various amounts of the good consumed and the determinants of those amounts. The main determinants of demand are: price of the good, prices of related goods (including appliances), prices of other goods, disposable income of the consumer, preferences and tastes, etc.

Demand for end-use appliances depends on the relative prices of the appliances, relative cost of operation, availability of appliances, affordability, climatic conditions, etc. The factors driving energy demand differ across economic agents and sectors. Households consume energy to satisfy certain needs and they do so by allocating their income among various competing needs so as to obtain the greatest degree of satisfaction from total expenditure. The microeconomic basis for consumer energy demand relies on consumers utility maximization principles. Such an analysis assumes that consumers know their preference sets and the ordering of preferences. It also assumes that preference ordering can be represented by some utility function, and that the consumer is a rational one in that s/he will always choose a most preferred bundle from a set of feasible alternatives (Pindyck, 1979)

Following the consumer theory (Mas-Colell et al., 1995), it is considered that an incremental increase in consumption of a good—keeping consumption of other goods constant—increases the satisfaction level, but this marginal utility (or increment) decreases as the quantity of consumption increases. Moreover, maximum utility achievable given the prices and income requires marginal rate of substitution to be equal to the economic rate of substitution. This in turn requires that the marginal utility per dollar paid for each good be the same. If the marginal utility per dollar is greater for good A than for good B, then transferring a dollar of expenditure from B to A will increase the total utility for the same expenditure (Jehle & Reny, 2001). It follows that a reduction in the relative price of good A will tend to increase the demand for good A and vice versa. An individual demand curve shows the relationship between the price of a good and the quantity of that good purchased, assuming that all other determinants of demand are held constant. The market demand function for a particular good is the sum of each individuals demand for that good. The market demand curve for a good is constructed from the demand function by varying the price of the good, while holding all other determinants constant.

Globally, it is estimated that about 2bn people are without access to electricity, and an equal number continue to use traditional solid fuels for cooking. As shown in the next section, cooking with poorly vented stoves has significant health impacts. Limited income may force households to use traditional fuels and inefficient technologies. For low-income households, firewood is the dominant fuel. At higher incomes, wood is replaced by commercial fuels and electricity, which offer much greater convenience, energy efficiency, and cleanliness. Because convenient and affordable energy can contribute to a household's productivity and income-generating potential, its availability can become a lever for breaking out of a poverty cycle.

Poor people tend to rely on a significantly different set of energy carriers than the rich. The poor use proportionately more wood, dung, and other biomass fuels in traditional ways, and less electricity and liquefied petroleum gas (LPG). Households seem to make choices among energy carrier options on the basis of both households socioeconomic characteristics and attitudes and the attributes of alternative carriers. Income is the main characteristic that appears to influence household's choice of carrier (Leach, 1992; Reddy & Reddy, 1994). Relevant attributes of energy carriers include accessibility, convenience, controllability, cleanliness, efficiency, current cost, and expected distribution of future costs. Because different fuels require different appliances stoves, lamps, and so on, with varying costs and durability, fuel costs have both fixed and variable components. This study employs the random utility theory as a base theory for econometric estimation.

The random utility theory is a theory that assumes that utility is not perfectly observable to a researcher, as such it consists of two main elements that are systematic (explainable) and random component, which is random (unexplainable) (Louviere et al.,2010). This is algebraically written as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad \text{.........(1)}$$

Where:

U_{i} = the utility for individual n for choosing n
V_{i} = the systematic (explained) utility for individual n for choosing n
ε_{i} = the unexplained (random) utility for individual n for choosing i

The random utility theory assumes that an individual will choose an alternative that yields the highest level of utility. Thus, assuming there are two utilities—say U_{i} and U_{j} —an individual will select U_{i} only if $U_{i} > U_{j}\ \forall j \neq i$ from the choice set, namely C_{n} (n is a decision maker, i and j are choices). Due to this a researcher cannot observe an individual's utility as it consists of random elements: s/he can just predict the probability that an individual n will select an alternative $\boldsymbol{i}$. But this may not be the exact alternative that an individual may choose. This may be written as $P(i/C_{n} = \Pr(U_{i}) \geq U_{j}, \forall j \in C_{n}$ (Wittink, 2011).

Now, taking account of a binary choice model of this study that consists of only two alternatives, namely switching away from charcoal and not switching, then the probability of choosing either of the alternative can be formally written as:

$P_{n}(\boldsymbol{i}) = P\ (U_{i}) \geq U_{j}$ ……………………………………………….(2)
$P_{n}(j) = 1 - P_{n}(\boldsymbol{i})$ ……………………………………………………(3)

Where:

i = is willingness to switch from charcoal to alternatives
j = is unwillingness to switch from charcoal to alternatives
n = is the individual

We derive the probabilistic choice model and estimate a Logit model. This approach is chosen as a matter of convenience as it provides a meaningful interpretation and is simpler in estimation (Pindyck & Rubinfeld, 1981).

3. Source of Data

This study employed a household survey to elicit household's willingness to switch from charcoal to alternative energy fuels. The study was conducted in Dar es Salaam city from the three municipals of Temeke, Kinondoni and Ilala. The choice of Dar es Salaam city was based on the fact that it is the commercial city of Tanzania with a relatively higher per capita income per residence. Hence, it was expected to have less consumption of dirty energy compared to other regions. On the contrary, however, Dar es Salaam region is the leading charcoal consumption region in the country, estimated to consume more than half of the charcoal produced in the country (CHAPOSA, 2002: NBS, 2011). Moreover, the target sample of this study is households; this is motivated by the fact that households are the major consumers of charcoal compared to the commercial and service sectors (CHAPOSA, 2002; Beukering et al., 2007).

A random sample was conducted in all the three municipal councils of Dar es Salaam to find out if there were any significant differences across municipal councils that could explain the willingness to switch from charcoal to alternative fuels. A total sample of 562 households from 12 wards was randomly selected. Table 1 summarizes the detail of the sampled population.

Table 1: Distribution of Sample Size Across Wards

Ward	Population	Sample Size
Magomeni	24,400	39
Tandale	54,781	48
Kibamba	28,885	43
Sinza	40,546	47
Ukonga	80,034	50
Tabata	74,742	51
Buguruni	70,585	48
Kipawa	74,180	45
Mbagala	52,582	51
Kiburugwa	78,911	43
Keko	35,163	50
Kurasini	26,193	47
Total	**641,002**	**562**

4. Empirical Findings

4.1 Descriptive Analysis

The results shows that like many other developing countries, a majority of the households are male-headed (77 percent). On the average, the household size is 4 members, which is a little less than the national average. Education-wise the results show that Kinondoni municipal is leading with above primary education by 76 percent, followed by Ilala municipal by 74 percent and lastly by Temeke municipal with 64 percent. Further analysis shows that Kinondoni and Temeke municipals are leading in terms of white collar jobs by 98 percent for each, followed by Ilala district with 96 percent.

4.1.1 Energy Sources

Electricity Connectedness

Out of the surveyed households, about 79 percent were connected to electricity, while the rest 21 percent were not connected to electricity at all. Interestingly, the data from the survey shows that although there is high electrification rate in Dar es Salaam, yet charcoal is being used as a major cooking fuel contrary to arguments that have been posed by other researchers (Heltberg, 2004; Ouedraogo, 2006; Schlag & Zuzarte, 2008) that there will be less use of fuel woods for households that are connected to electricity.

Cooking Fuels

Charcoal is found to be the primary cooking fuel to the majority of the households, with 88 percentage indicating the use of charcoal as the major source of energy. Furthermore, about 1 percent of the household used firewood as their primary cooking fuel, 2 percent use paraffin as the primary cooking fuel, while 8 percent households use LPG as the primary cooking fuel. Only 0.2 percent use electricity as a primary cooking fuel, suggesting that despite the large number of households with electricity connection very few use electricity as their main cooking energy as Fig. 1 illustrates.

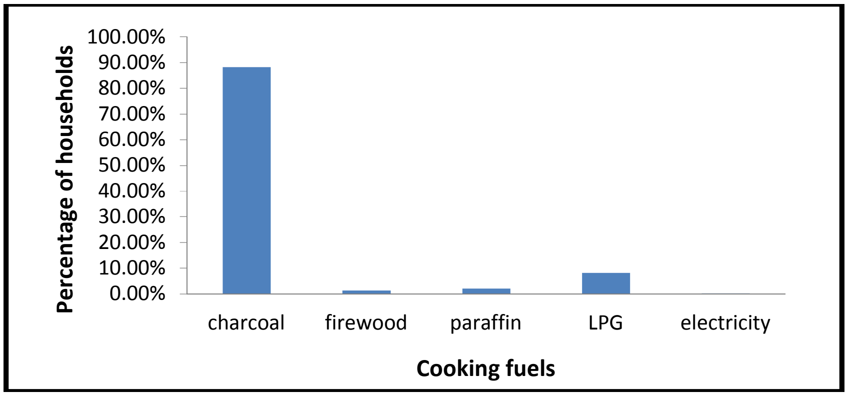

Figure 1: Primary Cooking Fuels

More importantly, it is observed that low income households using charcoal as their main cooking fuel consists of 80 percent, while middle income households using charcoal as a primary fuel consists of only 18 percent, and only 2 percent of those using charcoal as a primary fuel are high income households. This suggests that charcoal use is an important source of energy among the poor households.

4.1.2 Awareness on Charcoal Indoor Air Pollution

A majority of households are aware that charcoal brings indoor pollution. As the Table 2 shows, approximately 80 percent of the households generally agrees that indoor pollution is caused by charcoal. Yet, there are few percentages of households that still disagree and others who do not know completely as Table 2 indicates. Specifically, the Temeke municipal comprises of higher percentage of households that are not aware of charcoal indoor air pollution.

Table 2: Belief on charcoal as bad for indoor air quality

	Municipal		
	Kinondoni	**Ilala**	**Temeke**
Strongly Agree	51.4	49.0	41.4
Agree	29.4	33.4	34.6
Disagree	4.5	5.7	6.8
Strongly Disagree	2.8	0.0	0.5
Maybe	6.2	3.6	6.3
Don’t know	5.6	8.8	10.5

4.1.3 Awareness on Health Problems Caused by Charcoal

Results show that only 39 percent strongly agrees on the fact that charcoal causes health problems, and 36 percent just agree. Combining the two figures forms 75 percent who generally agree on the subject. So, this shows that at least a majority of people are aware of the health problems caused by charcoal. A small percentage of the household (11 percent) were not aware of the problems, and about 7 percent disagreed that charcoal can cause health problems. Also, even in this case still the Temeke municipal was leading with a higher percentage of households who did not know of the health problems caused by charcoal. However, the percentage is almost the same for Ilala municipal, with a difference of just 0.2 percent. As such, awareness was very low in Temeke and Ilala municipals as Table 3 shows.

Table 3: Awareness on Charcoal Health Problems

	Municipal		
	Kinondoni	***Ilala***	***Temeke***
Strongly Agree	39.0	40.7	38.2
Agree	40.1	33.5	34.6
Disagree	6.8	7.7	6.8
Strongly Disagree	1.1	1.0	2.1
Maybe	6.8	7.7	6.8
Don't know	6.2	12.4	12.6

4.1.4 Fuel Switching

Out of the whole sample, 74 percent were willing to switch from charcoal to alternative energy sources, while 26 percent were not willing to do so. Generally, household males were more willing to switch from charcoal compared to females. Of all males household heads, 77 percent were willing to adopt alternative fuels while in the case of female household heads only 64 percent were willing to adopt alternative fuels. Also, Pearson chi-square test shows a significant relation between gender and willingness to switch from charcoal as $p = 0.004$.

On the basis of income categories, the middle income category was more willing to adopt alternative fuels. Out of low income households, around 73 percent were willing to switch to alternative fuels, while of all the middle income households, 76 percent were willing to switch. But out of high income earners only 67 percent were willing to adopt alternative fuels. A Pearson chi-square test shows insignificant association ($p = 0.656$) between income categories and willingness to switch from charcoal.

Most of the male-headed household were willing to switch from charcoal, with those beyond-primary levels of education showing more willingness to do so compared to those of primary-level of education or below. The data shows that 78 percent of household heads with above-primary education were willing to adopt alternative fuels, while out of the households with below-primary education just 63 percent were willing to switch from charcoal. On this case, a Pearson chi-square test shows a strong association between education and the willingness to switch from charcoal as $p = 0.000$.

Furthermore, the occupation of a household is shown to have a role in the decision to adopt clean energy. Households with at least a member with a white collar job were more willing to switch from charcoal compared to those without a member with a white collar job. According to the data, 75 percent of household heads with white collar jobs were willing to adopt alternative fuels, while in the case of households with casual works only 36 percent were willing to switch from charcoal. There is a strong association between occupation and willingness to switch from charcoal as explained by the results of $p = 0.001$ in the Pearson chi-square test (see Appendix I). A lot of factors could possibly explain this.

4.1.5 Willingness to Switch to Electricity

On average, out of the households that accepted to adopt alternative energy sources, only 66 percent accepted electricity as one of the alternative they can adopt as a cooking energy. The willingness to adopt electricity was higher in Ilala municipal (68%) compared to the rest municipals. Table 4 elaborates the details.

Table 4: Willingness to Adopt Electricity as an Alternative energy source

	Municipal		
	Kinondoni	***Ilala***	***Temeke***
No	33.1	31.4	36.1
Yes	66.9	68.2	63.9

4.1.6 Willingness to Switch to Liquefied Petroleum Gas (LPG)

On the other hand, out of the households that were willing to adopt energy alternatives, 99 percent were willing to adopt LPG as the alternative cooking energy. Willingness to adopt LPG is quite higher compared to that of electricity. This may be explained by the fact that LPG is expected to be more reliable compared to electricity. Although the willingness is overall higher across the three municipals with very slight variation, it is highest in Ilala municipal (Table 5).

Table 5: Willingness to adopt LPG as an alternative

	Municipal		
	Kinondoni	***Ilala***	***Temeke***
No	0.8	0.7	1.5
Yes	99.2	99.3	98.5

4.1.7 Unwillingness to Switch

However, out of the sampled households, 26 percent were not willing at all to stop using charcoal. The leading reason was the high cost of other alternative (31 percent), followed by the perception that charcoal is easy to purchase in small amounts (28 percent). The percentage of other reasons is as shown in Table 6. It is interesting to note that the widely claimed reason that households were reluctant to use electricity or gas for cooking because the food cooked by these sources of power does not become delicious appears to be strongly supported by our study. Only about 7% of the respondent attributed unwillingness to switch to abiding by tradition or because of food taste.

Table 6: Reasons for not Switching from Charcoal

Reasons for not switching from charcoal	Percentage
The food tastes delicious when cooked with charcoal	5.4%
Abiding by the traditions	1.4%
Easy to use (Convenience)	19.8%
Easy to purchase in small amounts	28.4%
Low initial investment costs compared to other sources	7.6%
Other alternative sources are expensive	30.6%
Other alternatives are unreliable	6.8%
Total	**100.0%**

4.2 Econometric analysis

4.2.1 Logit Regression Results

Looking at the goodness of fit tests, (Table 8), there is no evidence of gross deficiencies with the model. The small p-value (<.0001) for the LR chi-squared statistic implies that one or more of the identified effects in the model is important for predicting the probability of adopting clean energy sources. The tests for parameters suggest that the majority of the effects in the model are significant. For a binary regression model it is more meaningful to interpret the marginal effects. The results are shown in Table 7.

Table 7: Logit regression results

Variables	Coef.	Std. Err.	Z	P>z
Ilala	0.282	0.320	0.88	0.378
Temeke	0.248	0.321	0.77	0.439
Age	-0.027**	0.012	-2.25	0.025
Gender	0.718**	0.290	2.47	0.013
Education	0.684**	0.272	2.52	0.012
Occupation	1.375**	0.674	2.04	0.042
Expenditures	0.004**	0.006	2.48	0.013
Householdsize	-0.080	0.081	-0.99	0.324
Unreliability	-4.645***	1.056	-4.4	0.000
Perception	-5.909***	1.037	-5.7	0.000
Homeownership	0.554*	0.335	1.66	0.097
_Cons	-0.341	0.813	-0.42	0.675
No. Obs	562			
Pseudo R2	0.365			
Prob>chi	0.000			

Table 8 presents the marginal effects after logit regression. The results shows that the age of the head of a household is negative and significant at 5 percent; suggesting that one year increase in age decreases the probability of households to switch to alternative fuels by 0.5 percent. The significance of age is due to the fact that as age increases an individual becomes more reluctant to adapt to changes because of already formed habits. Thus, even in the case of cooking fuels, as an individual gets older and is used to traditional fuels it becomes uneasy to switch to modern fuels. Similar findings are found by Mensah and Adu (2013) and Nlom et al. (2014).

As regards gender, the results show it is positive and significant at 5 percent. Males seem to be more willing to switch to alternative fuels compared to females. The results show that being a male household head increases the probability of switching to alternative fuels by 15 percent compared to being a female household head. This can be explained by the fact that given the nature of charcoal, which in most cases has to be burnt outside the house and emits a lot of smoke, a majority of males find this to be shameful. This is on top of the fact that the role of cooking is reserved for females in African traditions. On account of this, most males are likely to switch to more cleaner and efficient cooking fuels like electricity or gas as they are more convenient compared to charcoal.

Moreover, the results show education is positive and significant at 5 percent in influencing households' willingness to switch from charcoal to alternative fuels. Specifically, the results indicate that in households where the maximum level of education is above primary education, the probability of switching to alternative fuels increases by 14 percent compared to households in which the maximum education level is below primary education. This would imply that more education increases knowledge on the attributes and advantages of modern fuels over traditional fuels. This result is consistent with findings of previous studies (see, for example, Heltberg, 2003; Ouedraogo, 2006; Rao & Reddy, 2007; Schlag & Zuzarte, 2008; Nlom et al., 2014).

Table 8: Marginal Effects After Logit

Variable	dy/dx	Std. Err.	Z	P>z
Ilala	0.0	0.058	0.9	0.366
Temeke	0.046	0.058	0.79	0.429
age	-0.005**	0.002	-2.24	0.025
Gender	0.147**	0.064	2.32	0.02
Education	0.138**	0.058	2.39	0.017
Occupation	0.317*	0.165	1.92	0.054
expenditures	0.003**	0.000	2.53	0.012
householdsize	-0.015	0.015	-0.99	0.324
Unreliability	-0.744***	0.042	-17.68	0.000
Perception	-0.826***	0.024	-34.58	0.000
Homeownership	0.100*	0.058	1.74	0.000

Taking into account household head occupation, it is positive and significant at 5 percent; implying that having white collar jobs increases the probability of switching to alternative fuels by 32 percent, compared to household heads with casual works. This is attributed to the fact that an individual with a better occupation earns more income compared to when one has a casual work. In this study, households with members having white collar jobs are characterized with higher income compared to those with casual workers.

Furthermore, household expenditure is positive and significant at 5 percent, which entails that an increase in expenditure by TZS1 increases the likelihood of switching to alternative fuels by 0.2 percent. Household expenditure was used as a proxy of income, thus supporting the fact that increasing income increases the probability of switching to alternative fuels, which is consistent with the energy ladder hypothesis.

Unreliability of alternative fuels is negative and significant at 1 percent, suggesting that when alternative fuels are unreliable, the probability of switching to such fuels decreases by 74 percent compared to when they are reliable. This is confirmed in this study as it was been observed that people claimed experiencing electricity power blackout on the average of five hours a day. This explains that the reliability of fuels is one of the very important aspects that households are concerned with when they are making a choice of fuels.

Also, perception that charcoal is easier to use is negative and significant at 1 percent. Results in Table 8 show that the perception that charcoal is easier to use decreases the probability of switching to alternative fuels by 83 percent compared to when it is otherwise. This shows that peoples' perceptions have a significant bearing on a decision to switch from charcoal. Furthermore, house ownership is positive and significant at 1 percent. Accordingly, owning a house seems to influence the probability of switching to alternative fuels by 10 percent compared to a household living in a rented house. This resonates from the fact that owning a house gives one the freedom of making choices, fuels choices inclusive.

Unlike in previous studies (see, for example, Mekonnen & Kohlin, 2008; Bello, 2011; and Mensah & Adu, 2013) this study could not find household size explaining the decision to switch to alternative and more efficient energy sources. The variable of household size is insignificant. Also, individual municipals (Ilala and Temeke municipals) compared to Kinondoni municipal are not significant in explaining the switching decision. This may be explained by the fact that all the alternative fuels are accessible in all districts. Thus, living in either of the districts enables one to access electricity as well as LPG in the respective markets.

Conclusion

This study aimed at analysing factors that determine households' willingness to switch from charcoal to alternative fuels, the status of households' awareness on charcoal indoor pollution and associated problems, as well as perceptions on the use of charcoal. This is because despite various government initiatives so far, the rate of charcoal consumption is still high in urban areas, and especially in Dar es Salaam.

The findings of the study suggest the need to improve the reliability of alternatives fuels sources. Unpredictability of alternative fuels, especially electricity, makes people to continue using charcoal even though they were willing to switch. For instance, according to the sampled households, people claimed an average of 5 hours of power blackout per day. This is why the study found out that electricity is used mainly as a lighting fuel, with only very few using it for cooking. Also, other respondents cited accidents due to the explosive nature of LPG gas as hindering them to switch to this source of fuel. Thus, reliability can be enhanced by ensuring reliable supply of electricity and improving the technology of LPG stoves so as to meet consumer demands.

Moreover, the affordability of alternative fuels cannot be overemphasized. Low prices for alternative fuels should be stressed as high costs of using alternative fuels are one among the constraints that makes consumption of charcoal persistent. Actually, the trend of prices of alternative fuels has been rising at a higher rate compared to charcoal prices. According to the findings of this study, 76 percent of household heads surveyed are low income earners; and similarly a majority of low income earners are casual workers whose earnings are not only low but also irregular income. This shows that for transition to modern fuels to be made possible, the alternative fuels need to be more affordable.

There is also a need to have awareness programs that will educate people on the convenience of using alternative fuels over charcoal. This is because the perception of the easy of using charcoal compared to alternatives seems to be one of the important factors that hinder households from switching to alternative fuels. People perceive wrongly that it is easier to use charcoal compared to alternative fuels while in reality this is not the case. This is attributed to the fact that some people are not aware of the ease of using electricity or LPG over charcoal. Thus, awareness programs are necessary to free people from such wrong perceptions. One way to achieve this is through the use of the mass media such as radios, televisions and magazines. Moreover, the use of leaders of local government authorities can also be effective as most can easily reach out to people at the grassroots.

Another important policy implication is that there is a need to improve what is taught in primary schools as regards to cooking energy fuels. The study results show that households with maximum level of education beyond primary school level are more willing to switch to alternative fuels compared to those who whose maximum education is below primary schools. This is due to the fact that people with education above primary school level are well informed on the adverse impacts of traditional fuels such as charcoal on the environment and human health. Thus, there is a need to widen what is taught in primary education as regards to cooking energy so that at least those who cannot go beyond that level of education will also come out educated on the importance of using clean fuels. However, given the importance of education, government efforts to encourage people to move to higher levels education through the establishment of more schools and school facilities should be strengthened, coupled with quality education. This is necessary because education has a bearing on peoples' understanding abilities, thus facilitating easy adoption to change; in this case the adoption of cleaner fuels (electricity and LPG).

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Appendix

Diagnostic tests

Multicollinearity Test

Since, Logit regression is normally sensitive to high correlation among variables then multicollinearity test is undertaken. The presence of severe multicollinearity tends to inflate standard errors for coefficients as such results of the model become unreliable. Thus, to examine if multicollinearity problem exists, correlation matrix is used. The results are as shown in Table 7. Generally, correlation matrix shows that there is no high correlation among the variables to be used in Logit regression as results for each individual variable the correlation is less than 0.5.

Table 7: Correlation matrix

	Ilala	Temeke	age	gender	education	occupation
Ilala	1					
Temeke	-0.521	1				
age	-0.0739	0.0198	1			
gender	-0.0189	0.0283	0.0333	1		
education	0.0379	-0.1104	0.0639	0.0631	1	
occupation	-0.052	0.0183	0.0426	0.0206	0.126	1
expenditures	-0.0206	-0.1415	0.2381	0.0948	0.2587	0.0946
householdsize	-0.0455	0.0629	0.4966	0.175	0.1408	0.0393
unreliability	0.0091	0.0113	0.0852	-0.0375	0.0096	0.0299
perception	-0.0502	0.0671	-0.0023	-0.0607	-0.0562	-0.101
homeownership	-0.0207	-0.0363	0.4856	-0.0476	0.1184	0.0194

	expenditure	householdsize	unreliability	perception	Homeownership
expenditures	1				
householdsize	0.3108	1			
unreliability	-0.0022	0.1018	1		
perception	-0.055	0.0108	0.0047	1	
homeownership	0.1267	0.3177	0.072	0.0771	1