FUEL IN KENYA: AN ANALYSIS OF HOUSEHOLD CHOICES IN MAJOR KENYAN CITIES

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DECLARATION

This research thesis is my original work and has not been presented for a degree or any other award in any other university.

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This thesis has been submitted for review with my approval as University Supervisor.

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DEDICATION

To my loving wife Joyce, my two sons Aaron, Adrian and my parents, Mr and Mrs Waweru, for the encouragement and support.

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ACRONYMS AND ABBREVIATIONS

GDP	: Gross Domestic Product.
GoK	: Government of Kenya.
IAP	: Indoor Air Pollution.
IEA	: International Energy Agency.
KIPPRA	: Kenya Institute of Public Policy Research and Analysis
KNBS	: Kenya National Bureau of Statistics.
KWH	: KiloWatt Hours.
LPG	: Liquefied Petroleum Gas.
MDG	: Millennium Development Goals
PIEA	: Petroleum Institute of East Africa
TOE	: Tonnes of Oil Equivalent.
UNDP	: United Nations Development Programme
WHO	: World Health Organisation.

OPERATIONAL DEFINITION OF TERMS

Biomass Fuels: Fuels derived from organic material and include: firewood, dung and agricultural residues coal and charcoal.

Clean Fuels: Modern fuels with significantly low levels of smoke emission, and reduced environmental implications. These include: Liquefied Petroleum Gas (LPG) biogas and electricity.

Fuel Switching: The process by which a household ceases to use a customary fuel and adopts another fuel-type as a replacement. The term generally signifies the adoption of a modern fuel source.

Grid Electricity: Electricity delivered in a network from suppliers to consumers.

Gross Domestic Product: It refers to the market value of all final goods and services produced within a country in a given period.

Hydro Electricity: Electricity produced from the gravitational force of falling or flowing water

Modern Fuels: Fuels developed for utilization from 1950 to date and are more efficient and less polluting than previously used forms including: Liquefied Petroleum Gas (LPG) Biogas and electricity.

Multiple Fuel Use: The practice of using more than one fuel type as to satisfy daily energy needs.

National Energy Policy (2012): Sessional Paper that sets out the national policies and strategies for the energy sector that are aligned to the new constitution and are in tandem with the Vision 2030.

Thermal Electricity: Electricity produced from turbines run by steam generated from the combustion of petroleum products.

Vision 2030: Kenyan National long-term development blueprint to create a globally competitive and prosperous nation with a high quality of life in a clean and secure environment by the year 2030.

ABSTRACT

In the developing nations of Sub-Saharan Africa, providing households with modern energy services is a critical step towards development. A large majority of households in the region rely on traditional biomass fuels for cooking, which represent a significant proportion of energy used in the domestic setting. The disadvantages of these fuels are many: they are inefficient energy carriers and their heat is difficult to control; they produce dangerous emissions; and their current rate of extraction is not sustainable to the environment. Transition to clean fuels such as liquefied petroleum gas (LPG) or electricity would resolve many of these issues as they do not produce dangerous particulate emissions, and are commercially viable, offering a number of socio-economic advantages over traditional options. This study applies a multinomial logit model to fuel choices and patterns of cooking fuels in urban Kenyan households. A large microeconomic dataset from Kippra's Comprehensive study and Analysis on fuel consumption patterns in Kenya (2010) is employed to carry out the analysis. The results show that in addition to income, there are several socio-demographic factors such as education and sex of the head of the household, which are important in determining household fuel choice. To encourage clean fuel use, the authorities should carry out public education campaigns and ensure availability of these fuels in all areas to avoid harmful effects of biomass fuels and kerosene, more modern and efficient appliances should be made available at affordable rates to ensure more efficient use of these forms of energy.

CHAPTER 1

INTRODUCTION

The switch from traditional biomass fuels to modern, reliable and efficient energy sources has the potential to improve globally the welfare of over 2.5 billion people who continue to depend on unreliable and inefficient biomass fuel for their cooking energy needs (IEA, 2006). Traditional biomass fuels include grass agricultural residue, animal dung, firewood and charcoal. Together with the arduous task of using these fuels, the economic, health and environmental impacts are massive. It is estimated that, due to population growth, about 2.7 billion people who will be a third of the world's population, will depend on biomass fuels for their energy needs by the year 2030(IEA, 2006).

Health effects due to biomass fuel use are also massive. The World Health Organization identifies the use of solid biomass fuels as one of the major causes to global ill health. In the year 2000, it was estimated that Indoor Air Pollution (IAP) was responsible for more than 1.6 million annual deaths and 2.7% of the global burden of disease (WHO, 2006). There are various substances in biomass smoke that can damage health such as: Carbon monoxide, Sulphur oxides, Nitrogen oxides and various carcinogens such as benzene and formaldehyde (Bruce et al., 2000). Furthermore, the burning of solid biomass fuels also releases small particles into the air, which obstruct airways and lungs and impair immune response (WHO, 2006).

The World Energy Assessment of the United Nations Development Programme (UNDP) analyses the environmental impacts of traditional biomass use under two main categories: Those impacts arising out of the production and harvesting of biomass and those impacts resulting from the combustion of the traditional biomass fuels (UNDP, 2000). Production harvesting of charcoal and fuelwood lead to depletion of forest cover and additional environmental consequences such as carbon stock depletion, erosion, desertification, decreased soil moisture and quality and decreased biodiversity (Schlag & Zuzarte, 2008).

1.1 Background

As Kenya pursues its development agenda in the context of a rapidly rising and urbanizing population, the need for timely and reliable data on consumption of energy products and services is necessary. Currently, there are inadequacies in the data and statistical support for energy sector planning, with knowledge on consumption data in terms of consumers by fuel type being weak. Even though the country has several fuel types, there is still lack of knowledge on the factors that drive fuel choice and fuel switching by various consumer categories. (Kippra, 2010). Some studies have indicated a number of factors as determinants to the choice of household fuel. Heltberg (2003) found that income of the household and education level of the household head had a very significant negative impact on wood consumption while at the same time encouraging demand for LPG. Ouedraogo (2005) shows that there exist of significant

relationships between the use rates of firewood, charcoal and liquefied petroleum gas (LPG) and household size.

Accordingly, given the current consumption patterns, sustainable biomass supply is hardly possible. (Kamfor, 2002) Kamfor's study also predicts a deficit of 0.75 tonnes of biomass fuel per person per year by the year 2020. Kenya is faced with environmental problems resulting from deforestation and land degradation. This necessitates policy measures being implemented to address the reliance on biomass as an energy source for households in order to reduce the incidence and impact of environmental problems.

The five main sources of fuel for urban Kenyan households are firewood, charcoal, kerosene, LPG and electricity in that order. The various choices available to Kenyan households as well as factors that influence these choices is the key aspect in this research as detailed below and in the remaining chapters.

Table 1.1: Percentage distribution of households by main source of fuel

FUEL TYPE	**PERCENTAGE**		
	RURAL	**URBAN**	**NATIONAL**
Firewood	87.7	10	68.3
Grass	0.1	0.2	0.1
Charcoal	7.7	30.2	13.3
Biomass Residue	0.4	0.1	0.3
Kerosene	2.7	44.6	13.2
Gas(LPG)	0.7	11.9	3.5
Electricity	0.2	1.8	0.6
Other	0.4	1.1	0.6
TOTAL	100.0	100.0	100.0
Population Sampled	**5,155,105**	**1,715,269**	**6,866,374**

Source: Kenya Integrated Household Budget Survey 2006.

1.2 Sources of Fuel Energy in Kenya

As evidenced by data from table 1.1, the percentage that use unclean fuels (biomass and kerosene) is above 84% while clean fuel usage (electricity and LPG) is at 13.7% which is very low. This study aims to analyse household fuel choices in urban areas with the aim of explaining why use of unclean fuels is still high while use of clean fuels is low given availability of these clean forms in urban areas and the expectation that better incomes of urban residents should have resulted in shift to the cleaner types of fuel.

1.2.1 Biomass

Biomass fuels (firewood, charcoal, biomass residue and grass) are the most important source of primary energy in Kenya accounting for over 70% of the total primary energy consumption. (KIPPRA, 2010). Its advantage: it's relatively cheaper than other alternatives. Its disadvantage is that it contributes to environmental degradation and results in indoor air pollution adversely affecting the health of the members of the household.

1.2.2 Electricity

Urban domestic consumption of electricity as of 2011 was 4.86 billion KWH. As seen in Figure 1.1, consumption of electricity by households has been a gradual increase since the year 2000. Electricity is a clean source of household fuel however it is not available in all areas especially the informal settlements of urban

areas. It is also expensive both in terms of its cost and the appliances needed for cooking.

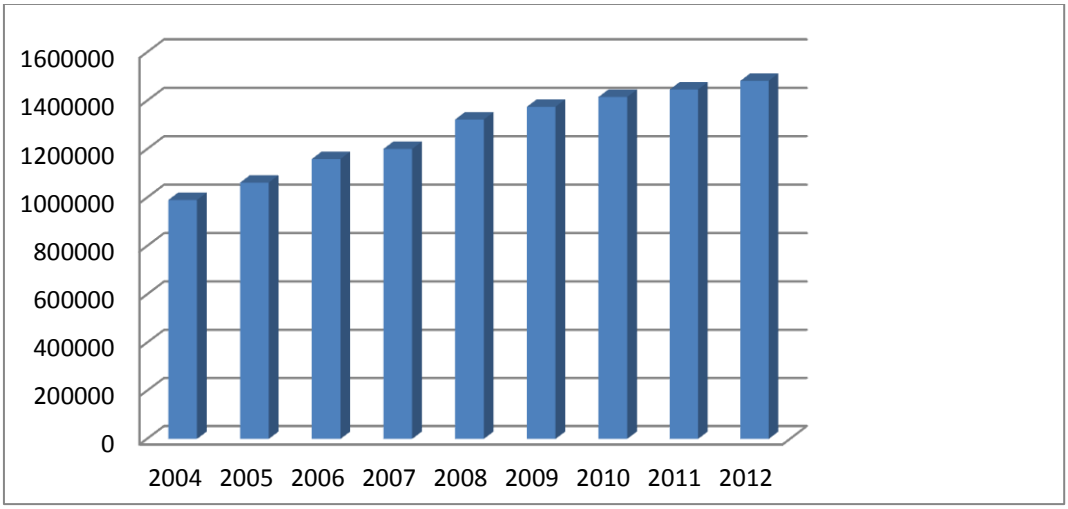

Figure 1.1: Urban Domestic Electricity Consumption in Kenya 2004-2012

Source Statistical Abstract Various Editions.(Author).

1.2.3 Petroleum Products

Kenya heavily relies on imported petroleum for its local consumption, making petroleum the major source of commercial fuel in the country. Petroleum provides about 22% of the country's fuel requirements (GoK, 2002b). It is estimated that 90 per cent of all kerosene and LPG are consumed by households for cooking activities and that their consumption continues to grow at 2 per cent per annum (PIEA{Petroleum Institute of East Africa} estimate) to 0.38 million tonnes for kerosene and 63.1 million tonnes for LPG in 2030.

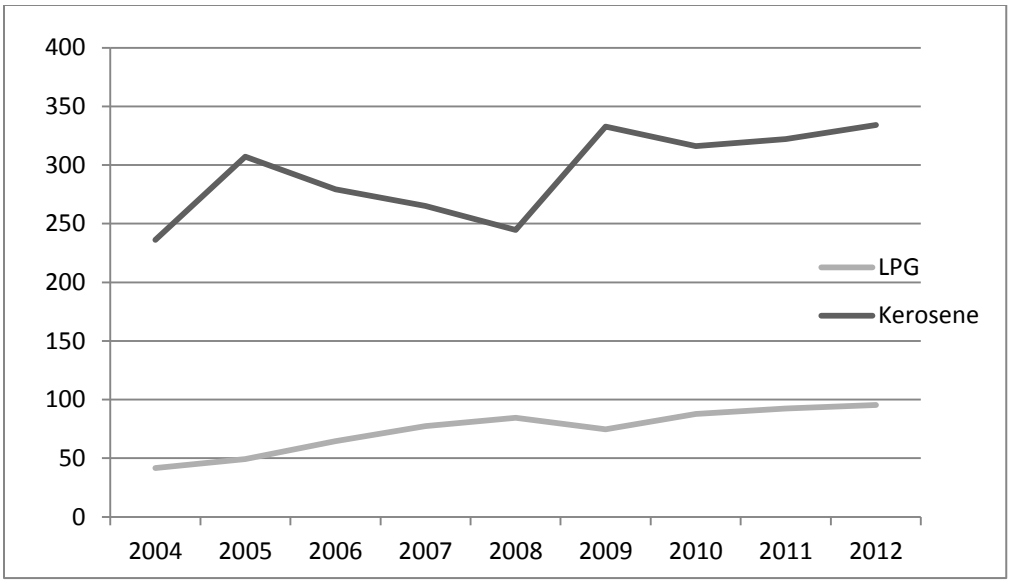

Figure 1.2: Fuel sales in Kenya by category in '000 TOE

Source: Statistical Abstract Various Editions.(Author).

Kerosene is a refined petroleum product that is highly flammable. It is mainly used for lighting, cooking and heating at the domestic level. About 40% of the urban residents use kerosene mainly for cooking and for lighting. It is an affordable source of fuel; however, it also contributes to indoor air pollution adversely affecting the health of the members of the household.

Liquefied Petroleum Gas (LPG) is an increasingly popular fuel for cooking. This is a clean source of fuel with several advantages that include: its use does not result in indoor air pollution and it is available in most of the urban areas. However, it is relatively more expensive than kerosene since it necessitates purchase of a gas cylinder and gas burner/cooker. As detailed earlier, only 11 per cent of households in urban areas use this fuel type.

1.2.4 Renewables

Kenya has a significant amount of diverse sources of renewable fuel which include biomass (explained above), wind, solar, geothermal, biogas, mini/micro hydro and co-generation (Karekezi & Kithyoma, 2005). The exploitation of large-scale renewable fuel in Kenya, apart from geothermal and to some extent, cogeneration, has largely remained low. Some of the renewable sources are explained below.

The country receives an estimated 4 to 6 KiloWatt Hours (kWh) per square metre per day of solar insolation. This is equivalent to about 300 million tonnes of oil equivalent (toe) per day. Only a tiny fraction of this resource is harnessed for commercial and household use (Karekezi & Kithyoma, 2005). Kenya has a wind fuel potential of 3 - 10 m/s. Wind fuel has been harnessed and used in the country, mainly for pumping water in remote rural areas. It has also been used, but to a very limited extent, for electricity generation with limited installations based in Ngong hills near Nairobi and in Marsabit County. (KIPPRA, 2010). Solar and wind energy are expensive due to the equipment needed to harness each of them. In the long run, they may be cheaper than other alternatives since there are no recurring charges. They also do not contribute to greenhouse gas emissions.

The technical potential of Geothermal Energy has been estimated at about 6,000 MW across the whole Kenyan Rift Valley, (KIPPRA, 2010). In Kenya,

geothermal fuel has mainly been used for electricity generation and to a limited extent, for greenhouses heating. This form of energy is expensive to implement. However it does not contribute to air pollution.

1.2.5 Summary of Energy Sources

From table 1.1, a large percentage of urban households still use unclean fuels. Over 85 per cent still use traditional biomass fuels or kerosene for their energy needs. This situation is precarious and needs to be addressed if Kenya is to avoid the environmental impact of biomass fuel use; and also to improve the health by avoiding indoor pollution within the household. These two aims are in line with the millennium development goals.

Information on drivers of household fuel choice is needed and a major aspect of this study is to provide vital information on what factors determine household fuel choice with the aim of enabling predictability of future patterns of choice as prices of the fuel type and/ or income of the household, which are thought to be the most significant factors in determining choice, change. This will thus enable policy actions to ensure availability of the fuel types that are deemed to be in line with the government's aims and goals. The study will also provide valuable information to allow forecasting of future consumption patterns and enable provision of fuels into the future in a manner that is affordable to the households and sustainable in terms of supply.

1.3 Statement of the Problem

Use of biomass fuels in households is a major cause of health problems in developing countries due to indoor air pollution (Bruce et al., 2000). For example, the World Health Organization (WHO) estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels (IEA 2006). Recognizing the adverse effects of use of traditional biomass fuels, the United Nations Millennium Project recommends halving the number of households that depend on traditional biomass for cooking by 2015, which involves about 1.3 billion people switching to other fuels (IEA 2006). Kenya needs to be on the frontline in combating the negative effects of these polluting fuels. To do this requires information on reasons why unclean fuels are still in use.

Despite the operationalization of the Energy Policy in 2007 and enactment of the Energy Act (2007) with the resultant ambitious investment programmes, including improved access to electricity through creation of the Rural Electrification Authority, increased hydrocarbon prospecting, provision of fiscal incentives to promote renewable energy and increased private sector participation in the sector. Despite this, Kenya still is lagging behind in relation to its comparator countries. For example, electricity access in Kenya stands at 14 % nationally and 54% in urban access compared to 97.8 % in Malaysia, 100 % in Singapore and 99 % in Thailand among others. (KIPPRA, 2010). Kenya

aspires to be a middle level economy by 2030. This necessitates use of sustainable and clean fuel types.

Information on fuel choice in urban areas of Kenya is inadequate. There are few studies that focus on fuel choices in any or a number of the urban areas. Osiolo (2009) focuses on determinants of fuel choice and substitution without focus on urban areas whereas Kippra (2010) stops short of determining the importance of each of the factors determining fuel choice. This study aimed to fill this gap by providing information on fuel choice in urban areas. This will assist in revealing the patterns of fuel use and further detail the underlying reasons behind these choices. This will assist in judging how far implementation of policies has resulted in the shift to modern fuel and also assist in policy formulation towards encouragement of households to adopt cleaner fuel types.

1.4 Objectives of the Study

The overall objective of this study is to perform an econometric analysis of fuel consumption by urban households in Kenya in order to identify their determinants and determine probability of selecting clean over unclean fuels. The specific objectives are:

i. Investigate the probability of selecting clean fuels over unclean fuels in urban Kenyan households;
ii. Determine the estimates of the determinants of fuel choices in major Kenyan urban centres;

iii. Suggest policies and actions that will encourage shift to cleaner fuels.

1.5 Research Questions

i. What is the probability that a household selects clean fuels over unclean fuels?

ii. What are the estimates of the determinants of fuel choices in Kenyan urban households?

iii. What are the policy options that could be formulated and or implemented to enable shift to cleaner fuels?

1.6. Significance of the Study

The United Nations Millennium project recommends halving the number of households that depend on traditional biomass for cooking by 2015. One set of factors necessary for switching to other fuels particularly in developing countries (like Kenya) is better availability of alternative fuels other than traditional biomass fuels. The study aimed to identify the various alternatives available to urban Kenyan households and further explain the factors that determine the choice of the alternatives with the aim of policy formulation towards adoption of clean fuels.

The level and the intensity of fuel use in a country a key indicator of economic growth and development. The Kenya Vision 2030 identified fuel as one of the infrastructure enablers of its social economic pillar. Sustainable, affordable and reliable fuels for all citizens are key factors in realization of the Vision. The

study analyzed the options available to Kenyan households towards establishing the factors that lead to the choice of the various forms. This will assist the government in formulating policies that encourage consumption of specific types of fuel according to the aims and goals of Vision 2030.

1.7 Scope of the Study

The study covered all major urban areas in Kenya including Nairobi, Mombasa, Kisumu and Nakuru.

1.8 Organisation of the Study

The rest of the study is organized as follows: Chapter two reviews related literature to the study, chapter three presents the research methodology used to collect data. Chapter four contains empirical findings and discussions of results. Chapter five gives summary, conclusions and policy recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There have been numerous studies in developing countries trying to explain household fuel choice. Many of these studies have found that household fuel choice depends on numerous factors. In the literature on household energy demand and choice, it has been argued that households with low levels of income rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive, such as electricity. Those households in transition between traditional and cleaner (and more efficient) energy sources consume what are called transition fuels, such as kerosene and charcoal. This chapter looks into some of these studies and also examines theories on household fuel choice.

2.2 Theoretical Literature

Household fuel choices have been analysed by numerous studies. One set of factors necessary for switching to other fuels particularly in developing countries (like Kenya) is better availability of alternative fuels other than traditional biomass fuels. Such alternative fuels are generally available in the major cities of the developing countries, but access to such fuels is much more limited in rural areas and smaller cities in these countries (IEA, 2006). Household fuel choice also depends on other factors, which makes knowledge of the determinants of urban households' choice of fuel important.

Household fuel choice can be explained using the Energy Ladder model which argues that households with low levels of income rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive, such as electricity. Those households in transition—between traditional and cleaner (and more efficient) energy sources—consume what are called transition fuels, such as kerosene and charcoal. (Heltberg, 2005). This is explained in the Figure 2.1 below.

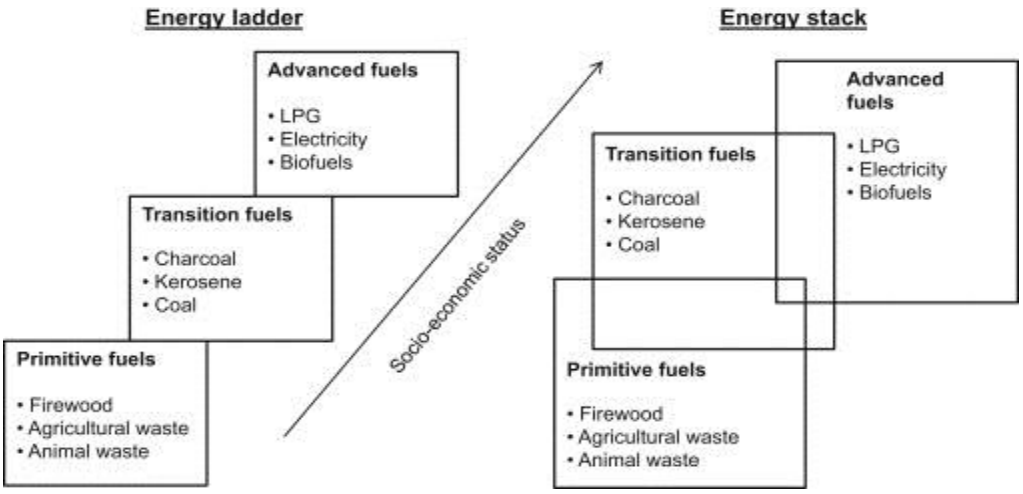

Figure 2.1: Energy ladder and energy stack models

Source Schlag et al., 2008:2.

More recently, it has been argued that households in developing countries do not switch to modern energy sources but instead tend to consume a combination of fuels, which may include combining solid fuels with non-solid fuels as sources of energy. Thus, instead of moving up the ladder step by step

as income rises, households choose different fuels from a range of fuels. They may choose a combination of high-cost and low-cost fuels, depending on their budgets, preferences, and needs (World Bank, 2003). This led to the concept of fuel stacking (multiple fuel use), as opposed to an energy ladder (Masera et al., 2000; Heltberg, 2005). As in the case of Mexico, as shown in Masera et al., (2000), fuel stacking could be important in urban Kenya because households have limited options for fuel.

Kippra's Comprehensive study and analysis on energy consumption patterns in Kenya done in 2010, revealed the major determinants for household fuel expenditure. These include: the prices of the various fuels, income of the household head, education level of the household head as well as family size and the gender of the household head. It however, did not reveal how these factors influenced the choice of fuel.

2.3 Empirical Literature

Cuthbert and Defournaud (1998) by use of pooled cross-sectional - time series data, estimated income and price elasticities of fuel wood demand in Sub-Saharan Africa. They found that income and price elasticities conformed to conventional economic theory – income is positively related whereas price is negatively related to fuelwood demand. The income elasticity was found to be equal to 0.39 whereas the price elasticity was found to be equal to -0.28, suggesting that, an increase of 1 % in household income yielded a 0.39 %

increase in fuelwood demand whereas an increase of 1% in price of fuelwood yielded a 0.28 % decrease in fuelwood demand.

Heltberg (2003) in examining factors determining household fuel choice in Guatemala found that education level of the household head had a very significant negative impact on wood consumption while at the same time encouraging demand for LPG (clean fuel), the study also found that price of wood had a significant negative impact on firewood demand of both rural and urban sectors. Regional imbalances were manifest where in urban areas household consumption of fuelwood declined while consumption of LPG generally increased with the increase in expenditure.

Ouedraogo (2005) in his study of household fuel preferences for cooking in urban Ouagadougou, Burkina Faso showed the existence of significant relationships between the use rates of firewood, charcoal and liquid petroleum gas (LPG) and household size. He found that households with large family size were the poorest were the main users of firewood. Conversely, the richest households had smallest family size and were the main users of charcoal. In general, this depicted the fact that poor families have large family size and are likely to rather use firewood than charcoal whereas rich families are likely to use mainly charcoal at the expense of firewood. The study also established that households with a head that had higher education level had lower firewood adoption probability than the household with a head with lower education. Further to this, the household fuel preferences for cooking in urban

Ouagadougou in Burkina Faso found that as standards of living improved, the use of firewood declined whereas the use of charcoal and use of LPG increased.

A study by Pundo and Fraser (2006) in Kisumu District now Kisumu County, reveals a set of important factors that determine household cooking fuel choice. The study shows that the level of education of wife, whether or not the household owns the dwelling unit, and whether or not the dwelling unit is traditional or modern type are all significant factors in determining the probability of switching from firewood to charcoal or to kerosene. The study also shows that firewood is by far the cooking fuel of choice for a majority of households in Kisumu District. This study used primary data and which were analyzed using a multinomial logit model.

Mekonnen and Kohlin (2009) did a study to find out the determinants of household fuel choice in major cities of Ethiopia. The study used multinomial logit analysis with secondary data from the household survey. This study found households with large family size were more likely to consume charcoal, wood and less likely kerosene. However, they found that households with small family size consumed more kerosene whereas electricity consumption did not depend on family size. The same study also found that higher education (secondary and post-secondary) engendered households to more likely use electricity and kerosene than wood and charcoal as cooking fuel. Households with older heads in major Ethiopian cities were more likely

to use wood and kerosene than electricity and charcoal while demand of wood increased with age. This finding was attributed to the role of habits on the part of older people reflected in their resistance to change if they grew up with wood as their main fuel as well as limited access to other fuel types such as electricity.

Osiolo (2009), in her study on enhancing household fuel choice and substitution in Kenya, used panel data from the household survey done by KNBS in 2006. The analysis was done using the Heckman selection model and discovered in addition to total household expenditures, gender of the household head, fuel price, household, location of residence and distance to fuel source, education and houses with chimney are factors considered by households in making decision on fuel use. Other factors include education of household head and electricity access.

Nyembe (2011), using a Heckman selection model with household survey panel data while analyzing the factors determining charcoal use, found various factors that affect the consumption of charcoal in urban Zambia. Among the socio-economic factors are the economic (price and income), the housing conditions (the type of material the roof, floor is made out of; and if the house has modern plumbing), the wealth of the household (having a refrigerator) and the household characteristics (household size, age, gender and education of the household head). Other variables the study looked into as determinants of charcoal consumption were seasonality (if in the dry or rainy seasons), if the

household had electricity and in which residential area (low income, medium income and high income) the household was located.

2.4 Critique of the Literature

The various studies have investigated the factors responsible for household fuel choices. Many have found that price of the fuel type, price of fuel types, household size, income, education level of the household head to be important factors in explaining the type of household fuel used. Other factors include location of the household, wealth of the household as well as gender of the household head. Most of these studies are not within Kenya but from countries with similar characteristics to Kenya i.e. are developing nations and are in the process of developing policies that will ensure energy sustainability. This study will focus on Kenya and specifically on urban areas.

Osiolo (2009) reveals the factors that determine the choice of particular fuels. Her study analysed the country as a whole without any focus on rural or urban areas. Fuel choice and incomes are higher in urban areas. As such, it is important to isolate urban areas in this study since these factors, according to previous studies, are significant in determining household fuel choice.

The study by Kippra in 2010 reveals the factors that determine expenditure on each of the forms of energy. This study analysed each fuel type to determine amongst other factors that influence expenditure on the particular energy type, price elasticity of the fuel type, threshold willingness to pay for the energy

services, share of household income spent on energy. However, it does not determine the importance of each of the factors which hinders policy formulation due to lack of specific information on the important determinants of fuel choice, it also comes short of estimating the coefficients which is one of the objectives of this study.

2.5 Research Gaps

Numerous studies in developing nations have endeavoured to identify the factors that determine household fuel choice. Some have analysed these factors using econometric techniques and others have done this with descriptive statistics. In Kenya, studies have mainly focused mainly on fuelwood, charcoal and kerosene; LPG and electricity have been left out. Many studies in Kenya have also studied fuel choice in a few urban areas using econometric techniques and none has focused specifically on urban areas. This study intends to focus on fuel choice within urban households in Kenya and will be analysed using a multinomial logit model with the aim of establishing the factors behind household fuel choice and the importance of each of these factors in determining fuel choice.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Theoretical Framework

The household's fuel choice consumption decision can be formally derived from the utility maximization problem. The starting point is to consider household preferences, on which, together with household possibilities, consumer behaviour is built. In the classical consumption theory, a consumer is assumed to have a stable preference system which can be described by means of a utility function. Varian (1996) developed the theory of consumer behaviour by deriving demand functions based on model of preference, which is, maximizing behaviour coupled with a description of the underlying economic constraints. The basic hypothesis about consumer behaviour according to Varian (1996) is that a rational consumer will always choose a most preferred bundle from a set of feasible alternatives. This is the hypothesis adopted in this study, that is, utility maximization. Consumer behaviour is commonly presented in terms of preferences on one hand, and possibilities on the other. Preferences provide the justification for the existence of demand functions (Varian 1996).

Consider a consumer faced with possible consumption bundles in some set Q. The consumer is assumed to have preferences on the consumption bundles in Q, that is, the consumers can rank the bundles as to their desirability. We assume that for the preference system to order the bundle q in Q, the

household has a set of axioms that guide such ordering. Once preferences respect the axioms, there exists a continuous utility function which represents these preferences. Given the foregoing, the household aims at maximizing the utility function represented as:

$$U(q) = U(q1,\ldots,qn) \qquad (3.1)$$

from the consumption of commodities qi, i=1….n.

The maximization model requires the household to choose values of q1, …,qn that satisfy the budget constraint and also give larger values of u (q1, …, qn) than other values of q1, …, qn within the consumption possibilities of the consumer. The limits of the household are imposed by a budget constraint, which specifies the total expenditure x, which is to be spent. When p1, …,pn are the prices of the n commodities, then the standard utility maximization can be expressed as:

$$\text{Max } u(q) \text{ subject to } \_piqi = x. \qquad (3.2)$$

A fuel-focused household utility function may then be derived from the standard constrained utility function by extending it to capture non-economic constraints as well (Browning et al., 2003). Non-economic factors include a set of household demographic and infrastructural factors (such as level of educational attainment, kitchen/cooking practices amongst others.

Energy is provided by a multiplicity of sources. Each energy source is a commodity with multiple attributes and purposes. Purposes include cooking, heating, lighting, and entertainment and so on. Attributes include energy content, convenience, safety, speed of cooking, taste given to food, quality of light, and smoke emitted when burned. Energy sources are intermediate inputs into the utility function. Utility is derived from the final goods such as cooked food, heat, entertainment, and light, which energy sources help to produce. The study follows Pundo and Fraser (2006) by expressing the household choice model as follows:

$$U^* = U[Qw\ (Pw, Pa, Y, \Omega)\ Qa\ (Pw, Pa, Y, \Omega)\ ] \qquad (3.3)$$

where:

$U^*\ (Pw, Pa, Y, \Omega)$ is the maximum attainable utility;

Qw is the units of firewood purchased;

Pw is the per unit price of firewood;

Pa is the unit price of firewood alternatives;

Y is household income;

Ω is a set of social factors, and

Qa indicates the units of firewood alternatives purchased.

The regional experience suggests that market prices are insufficient indicators of fuel choice in this region since some fuels can be consumed without being bought in the market. Other factors may play a significant role in determining fuel choice. Availability of the fuel type, availability and cost of burners/stoves that are needed to utilize the energy form and income of the household are other factors that may determine fuel choice. Since prices of market fuels are to a greater or lesser extent the same for all households in the same region, equation 1 is reduced to exclude price and income variables. The reduced form is:

$U^* = [Q_W(\Omega)\ Q_A(\Omega)]$(3.4)

Where:

U^* (Pw, Pa, Y, Ω) is the maximum attainable utility;

Ω is a set of social factors;

Qw is the units of firewood purchased and

Q_A indicates the units of firewood alternatives purchased.

Equation 3.4 shows that a household's choice of fuel is affected by a set of social factors (Ω). In this study, the social factors considered are: age in years of the household head, the level of education of household head, and the number of people making up the household.

Theoretically, the above social factors are expected to influence household fuel choice in the following manner: The age of household head is expected to influence fuel choice through developed loyalty for firewood. The older of household head(other things being equal), the more likely the household will continue using firewood. The level of education of household head is expected to have a positive effect on the choice of firewood alternatives. This is because level of education improves knowledge of fuel attributes, taste and preference for better fuels, and income, which then can be used to purchase the fuels which are comparatively expensive. In addition, a highly educated household head is likely to lack time to collect firewood or require his spouse to collect firewood due to their involvement in other activities and may thus prefer to use firewood alternatives.

Household size is theoretically expected to negatively affect choice of firewood alternatives. This is because larger household sizes may mean larger labour input, which is needed in firewood purchase and preparation. Also, preparation of large quantities of food may necessitate use of firewood since it may be cheaper.

3.2 The Model

The study used multinomial logit model to estimate the significance of the factors believed to influence a household's choice of primary fuel in urban Kenya. Multinomial logit model describes the behaviour of consumers when they are faced with a variety of goods with a common consumption objective.

The choice of the model is based on its ability to perform better with discrete choice studies (McFadden, 1974 and Judge et al., 1985). However, the goods must be highly differentiated by their individual attributes. For example, the model examines choice between a set of mutually exclusive and highly differentiated fuels such as firewood, charcoal, kerosene, gas, and electricity.

The probability that a household chooses one type of fuel is restricted to lie between zero and one. The model assumes no reallocation in the alternative set and without changes in fuel prices or fuel attributes. The model also assumes that households make fuel choices that maximize their utility (McFadden, 1974). The model can be expressed as follows:

$$\Pr[Y_i = j] = \frac{\exp\left(\beta'_j X_i\right)}{1+\sum_{j=0}^{J} \exp\left(\beta'_j X_i\right)} \quad (3.5)$$

Where:

- Pr[Yi = j] is the probability of choosing either firewood, kerosene, gas or electricity with charcoal as the reference household fuel category;
- J is the number of fuels in the choice set;
- j = 0 is firewood;
- Xi is a vector of the predictor (exogenous) factors(variables)
- βj is a vector of the estimated parameters.

Re-arranging equation 3.5, the following is obtained:

$$\mathrm{P_i} = \frac{e^{(b_0+b_1x_1+b_2x_2+\cdots b_nx_n)}}{1+e^{(b_0+b_1x_1+b_2x_2+\cdots b_nx_n)}} \quad (3.6)$$

Further re-arrangement using the odds ratio gives the empirical model as:

$$\ln[\frac{P_i}{1-P_i}] = b_0 + b_1x_1 + b_2x_2 + \cdots b_nx_n \quad (3.7)$$

This can also be stated as

$$[\frac{P_i}{1-P_i}] = \mathrm{e}^{\left(\mathrm{b_0+b_1x_{1+}b_2x_2+\cdots b_{nx_n}}\right)} \quad (3.8)$$

In equation (3.7), the quantity Pi/(1 – Pi) is the odds ratio. The equation (3.7) has expresses the logit (log odds) as a linear function of the independent factors (Xs). Equation (3.7) allows for the interpretation of the logit elasticities for variables in the same way as in linear regressions. This equation expresses the odds ratio of selecting a fuel type with respect to the reference category. Differentiating equation (3.5) we obtain the marginal effects (Greene, 2003).

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j\left(\beta_j - \sum_{k=0}^{J} P_k\,\beta_k\right) = P_j\left(\beta_j - \overline{\beta}\right) \quad (3.9)$$

The marginal effects measure the expected change in the probability of choosing one fuel alternative with respect to a unit change in an explanatory variable. For instance, the expected change in probability of choosing a particular fuel type with respect to a one-year change in age of household

head. For example, e^{b1}(in equation 3.6) is the multiplicative factor by which the odds ratio would change if X_1 changes by one unit.

The model follows from the assumption that the random disturbance terms are independently and identically distributed (McFadden, 1974). In addition, Judge et al., (1985) show that even if the number of alternatives is increased (from 2 to 3 to 4) the odds of choosing an alternative fuel remain unaffected. That is, the probability of choosing the particular fuel type remains the same if it is compared to one alternative or if it is compared to two or three or four alternative fuels.

A positive marginal effect implies an increase in the likelihood that a household will choose the alternative fuel. A negative marginal effect indicates that there is less likelihood that a household will change to alternative fuel. P-value indicates whether or not a change in the predictor significantly changes the logit at the acceptance level. If P-value is greater than the accepted confidence level, then there is insufficient evidence that a change in the predictor affects the choice of response category from reference category.

3.3. Data Types and Sources

The study intends to use secondary data from Kippra's comprehensive study and analysis on fuel consumption patterns in Kenya done in 2010. The study focused on the trends in consumption of the various energy products within Kenya. This study utilised a sampling frame created by KNBS (Kenya National Bureau of Statistics) after the 1999 Population Census. This sampling frame consisted of

1,800 clusters, each on average with 100 households, with the aim of conducting socio-economic surveys. Out of 1,800 clusters, 540 of them were urban and 1,260 were rural. Kippra's comprehensive study and analysis on fuel consumption patterns in Kenya (2010) used a 20% sub-sample of the clusters, resulting in 108 urban clusters and 252 rural clusters. Traditionally, KNBS has randomly selected 10 households in each cluster for any study. Therefore, 1,080 urban households and 2,520 rural households were interviewed. For the purpose of this study, only the urban households totalling 1080 were considered. The sample of clusters was allocated to the districts using the relative household strength of the district within a province. This minimised bias in the selection of the household clusters. The study also interviewed 857 energy providers.

The Kippra study identified the main source of fuel used by each household. It further identified the main source of energy for cooking and main source for lighting. This study intends to use this main source for analysing the probability that the household selects a clean versus the probability that a household selects an unclean source of fuel as its main source of energy. This main source will also be the basis of analysis for the determinants and the coefficients of the determinants of the fuel choices.

3.4. Definition and Measurement of Variables

The study will focus on a number of variables that affect household fuel choice.

The endogenous variables are the various fuel types available to urban Kenyan households.

Table 3.1: Variables included in the model and their measurement

Variable	Listing	Measurement	Model Listing	Expected Size	Study that shows result
Household Expenditure on Energy Type	X_1	Continous in Kenya Shillings	Costmonth	Ksh 50.00-35,000.00.	Osiolo(2009), Kippra(2010)
Gender of household Head	X_2	Binary 1=Male;0= Other	Gender	1 or 0	Osiolo(2009)
Household Size	X_3	Continous Number	Hhmember	1-19	Ouedraogo(2005), Mekonnen and Kohlin (2009).
Age of Household Head	X_4	Continous Number	Agehead	18- 90	Osiolo(2009), Kippra(2010)
Education of Head	X_5	Continous Number	Education	Years: 1-21	Ouedraogo(2005), Mekonnen and Kohlin(2009)
Household income	X_6	Income in Kenya Shillings.	Income	Kshs 1000.00 - 300,000.00	Kebede (2002)

These include: firewood charcoal, kerosene, LPG and electricity. In the model, the probability of choosing each fuel type is what was estimated using multinomial logit model.

3.5 Data Cleaning

The data were verified and cleaned. This entailed deletion of observations missing entries on any of the variables included within the model. Also, variables that had grouped data like age which was stated in a range the average age in the range was taken to ensure a continuous variable. This was also effected for income. Education was stated in categories and this was converted to a continuous variable by using the number of years equivalent to the category.

3.6 Data Processing and Analysis

The data were analysed using a logit model to estimate the probability of a household selecting an unclean clean fuel as its main source of energy versus the probability of selecting a clean source of fuel. The data were also analysed by the multinomial logit model to estimate the determinants of household fuel choice. This enabled, as stated earlier, to determine the probability of choosing one fuel type over the default type (charcoal) and give the factors responsible for this probability. It also gave the marginal effect which is the increase or decrease in probability of choosing one type of fuel over the default given a unit change in one of the variables that affected fuel choice. Findings from previous studies indicate that households may use a combination of fuels. Most studies indicate that households use two or more fuels to satisfy the need for energy. Due to this, only the main source as depicted in the data was used for the analysis.

CHAPTER 4

EMPIRICAL FINDINGS

4.1 Introduction

This section contains the findings of the study. These include the data on each of the variables to indicate the descriptive statistics of the data. It also contains the results of the regression that was run with the data that were collected. Explanations on the results of the regression are also presented in this chapter.

Data was obtained from KIPPRA's comprehensive study and Analysis on fuel consumption patterns in Kenya done in 2010. The data was cleaned and sorted to obtain the data relevant for this study. Some variables that were in discrete form were converted to continuous so as to ease calculation and eliminate numerous variables. An example is age which was converted from categories of ten to twenty years to the average age in the category. Education level was converted from level attained to years of education. Some observations were deleted due to no entry or inaccurate entry in one or more variables in the observation.

Table 4.1: Variables and their properties

Variable	Observations	Mean	Std. Dev	Min	Max
Fueltype	1170	2.15641	1.302881	0	5
Cost Month	1170	1044.164	1629.412	50	34000
HHMembers	1170	4.300855	2.299273	1	15
Income	1170	28607.05	34898.35	1250	250000
Education	1170	13.65299	4.143606	1	21
Agehead	1170	36.4906	11.06861	24	80
Gender	1170	0.232479	0.422593	0	1

The average number of household members was 4 while the average level of education was 13.6 years which translates to a diploma level education. The average income of Ksh 28607.05 could have been skewed upwards by the high income earners some who earned above Ksh 200,000.00. Majority of the household heads were male which is 76.7% of the total households. The average cost spent on the main source of fuel was slightly above Ksh 1000.00.

Table 4.2: Summary of descriptive results

Fuel Type Chosen	**Number of Households**	**Percentage of Households**
Firewood	82	7.0
Charcoal	402	34.4
Kerosene	200	17.1
LPG	227	19.4
Electricity	255	21.8
Residues	4	0.3
Total	**1170**	**100**

The fuel highest in use as main source of fuel was charcoal while the least used was Residues. Residues included grass, materials like plastics and sawdust. This source however, accounted for less than one per cent of the total sample. Households that selected unclean fuels (residues, firewood, charcoal and kerosene) as their main source of fuel accounted for 58.8% of the total households while 41.2% of the households chose clean fuels (LPG and Electricity) as their main source of fuel. This in probability terms was: Probability a household chose an unclean fuel as main source of energy was 0.588 while the probability a household chose a clean fuel as main source of energy was 0.412.

The results revealed the odds ratio of selecting clean versus unclean fuels and the change in probability as a result of the change in one of the variables presented. Clean fuels included Electricity and LPG while unclean fuels included residues, firewood, charcoal and kerosene

Table 4.3: Logit regression results for unclean and clean fuels

Logistic Regression						
Observations	1170		Prob>chi2		0.0000	
LR chi2(6)	533.64		Pseudo R2		0.03366	
LogLikelihood	-525.931					
Variable	**Coeff**	**Std Error**	**z**	**P>IzI**	**95%Conf Interval**	
CostMonth	0.0006601	0.0001221	5.40	0.000	0.0004207	0.0008995
HHMembers	-0.234314	0.0419659	-5.58	0.000	-0.3165653	-0.152062
Income	0.0000622	0.0000006	10.63	0.000	0.0000507	0.0000737
Education	0.1561377	0.0235172	6.64	0.000	0.1100448	0.2022306
Agehead	-0.008748	0.0080377	-1.09	0.276	-0.0245015	0.0070059
Gender	0.1101256	0.1816801	0.61	0.544	-0.2459609	0.4662121
cons	-3.370627	0.4307729	-7.82	0.000	-4.214926	-2.526328

Cost per month represented the total amount spent by the households monthly on the particular (main) fuel. The coefficient was positive meaning an increase in the amount that the households spend in a month would lead to an increase in probability that the household would choose a clean source of fuel as its main fuel.

HH members represented the number of persons in the household. It was large and negative and this implies that as the number of persons in the household decreased, the higher the probability that the household used a clean source of

fuel as its main fuel. Due to its size, it was the most significant influence on the probability of choosing a clean source of main fuel.

Income was the monthly household income. The coefficient was not as large and was positive and this means an increase in the household income led to an increase in probability that the household used a clean source of fuel as its main fuel choice.

Educ short for education and it represented number of years of formal education the household head had completed. The coefficient was also positive but larger than income and this means the older the household head, the more likely he/she will choose a clean source of fuel as the main household fuel. Education was the second most significant influence on probability of choosing a clean fuel source.

Age represented the age of the household head in years. The coefficient was negative meaning the older the household head, the probability that he/she was to choose a clean source of fuel as the main household fuel type. Gender was the gender of the household head the positive coefficient means a male head increases the probability that the household will utilise a clean source of fuel as the main household fuel type.

The determinants of whether a household used a clean or unclean fuel as its main source in order of importance were: number of household members, education, gender, age, cost and income.

Table 4.4: Multinomial logit regression results for main choice of fuels

Multinomial Logistic Regression						
Observations		1170		Prob>chi2		0.0000
LR chi2(30)		686.11		Pseudo R2		0.1923
LogLikelihood =		-1441.0952				
Variable	**Coeff**	**Std Error**	**z**	**P>IzI**	**95%Conf Interval**	
Firewood						
CostMonth	-0.0003412	0.0002562	-1.33	0.183	-0.0008434	0.0001611
HHMembers	0.1007519	0.0534103	1.89	0.059	-0.0039303	0.2054341
Income	-0.0000324	0.0000127	-2.56	0.010	5.73E-05	7.63E-07
Education	-0.0501595	0.0289627	-1.73	0.083	-0.1069253	0.0066063
Agehead	0.0494663	0.0111197	4.45	0.000	0.0276721	0.0712606
Gender	-0.0296644	0.02985073	-0.10	0.921	-0.6147279	0.5553992
cons	-2.7673550	0.6255705	-4.42	0.000	-3.99345	-1.541259
Charcoal	Base Outcome					
Kerosene						
CostMonth	0.0001212	0.0001757	0.69	0.049	-0.0002233	0.0004656
HHMembers	-0.3433989	0.0528918	-6.49	0.000	-0.4470648	-0.239733
Income	-0.0000023	0.00000874	-0.26	0.799	-0.0000193	0.0000149
Education	0.0010901	0.0250202	0.04	0.965	-0.0479485	0.0501287
Agehead	0.0032959	0.0093427	0.35	0.724	-0.0150153	0.0216072
Gender	0.0991872	0.2096825	0.47	0.636	-0.311783	0.5101574
cons	0.4754173	0.4506887	1.05	0.291	-0.4079163	1.358751
LPG						
CostMonth	0.0004622	0.0001545	2.99	0.003	0.0001593	0.000765
HHMembers	-0.3286171	0.0541352	-6.07	0.000	-0.4347202	-0.222514
Income	0.0000612	0.00000662	9.25	0.000	0.0000483	0.0000742
Education	0.1599729	0.0304021	5.26	0.000	0.1003858	0.21956
Agehead	0.0099139	0.0101919	0.97	0.331	-0.100619	0.0298897
Gender	0.1451255	0.231866	0.63	0.531	-0.3093235	0.5995744
cons	-3.737455	0.5743894	6.51	0.000	-4.863237	-2.611673
Electricity						
CostMonth	0.0008431	0.0001464	5.76	0.000	0.0005561	0.0011301
HHMembers	-0.3190949	0.0530683	-6.01	0.000	-0.4231069	-0.215083
Income	0.0000575	0.00000663	8.67	0.000	0.0000445	0.0000704
Education	0.1434382	0.0293707	4.88	0.000	0.0858726	0.2010037
Agehead	-0.0159312	0.0104811	-1.52	0.129	-0.0364739	0.046115
Gender	0.1927495	0.2273186	0.85	0.396	-2527868	0.6382858
cons	-2.789678	0.5450435	-5.12	0.000	-3.857943	-1.721412

Variable	Coeff	Std Error	z	P>IzI	95%Conf Interval	
Residues						
CostMonth	0.0004595	0.006737	0.68	0.050	-0.0008609	0.0017799
HHMembers	-0.2366082	0.2402668	-0.98	0.325	-0.7075226	0.2343061
Income	0.00000603	0.0000403	0.15	0.881	-0.0000729	0.0000849
Education	0.0203924	0.1252294	0.16	0.871	-0.2250526	0.2658374
Agehead	0.0667684	0.0367777	1.82	0.069	-0.0053144	0.1388513
Gender	1.168159	1.030996	1.13	0.257	-0.8525566	3.188874
cons	-7.375567	2.641407	-2.79	0.005	-12.55263	-2.198505

The results of the multinomial regression below reveal the following: The base category was charcoal and this could have been because more residents used charcoal in urban areas due to its availability and it was relatively cleaner and easier to use than firewood. Thus, the comparisons of the fuel were all compared to charcoal as the base category.

Seven per cent of households chose firewood as their main source of fuel. The coefficients for firewood were negative for monthly cost income and education and this implied as one or more of these factors increased the probability that one chooses firewood over charcoal decreased. If the household head was male, the lower the probability for him to choose firewood over charcoal. An older household head and or a large household increased the probability that the household chose firewood over charcoal as its main source of fuel.

Almost twenty per cent of households chose kerosene as their main source of fuel. The factors that led to an increase in probability that a household would select kerosene over charcoal include lower household members, increased years of

education, increased monthly cost, increased age of household head and male household head. An interesting finding was an increase in income led to a decrease in probability that one would choose kerosene over charcoal; this however, was of very low significance.

LPG and electricity were also found to be popular among the residents. The most significant factors that encouraged households to either of them over charcoal are: increased monthly cost of fuel, increased income, more years of education, male household head and a smaller household. However, an older household head meant an increase in the probability that one would choose LPG over charcoal but a decrease in the probability that one would choose electricity over charcoal.

4.2 The Results Explained

The regression results revealed the factors and their coefficients. These results indicated which factors are the most significant in determining household fuel choice.

4.2.1 Monthly Cost

An increase in the amount spent monthly led to a increase in probability of choosing kerosene, LPG and electricity over charcoal but led to a decrease in probability of choosing firewood over charcoal.

4.2.2 Household Members

An increase in the household members led to a decrease in probability of choosing LPG, kerosene, and electricity over charcoal but led to a increase in probability of choosing firewood over charcoal.

4.2.3 Income

An increase in the household income led to an increase in probability of choosing

LPG and Electricity over Charcoal but led to a decrease in probability of choosing kerosene and firewood over charcoal.

4.2.4 Education

An increase in the household income led to an increase in probability of choosing LPG and Electricity over Charcoal but led to a decrease in probability of choosing kerosene and firewood over charcoal

4.2.5 Age of Household Head

An older household head was more likely to choose LPG and kerosene over Charcoal but found to be less likely to choose electricity and firewood over charcoal

4.2.6 Gender of the Household Head

A male household head was more likely to choose electricity, LPG or kerosene over charcoal and found to be less likely to choose firewood over charcoal.

4.3 Marginal Effects

The marginal effects show the percentage change in the odds ratio attributable to a unit change in one of the variables. An example i in row 1 column 2 -0.997 shows that the odds ratio of selecting firewood over the default fuel type (charcoal) decreased by 0.997% after income of the household increased by one unit.

Table 4.5 Marginal Effects

	Firewood		Kerosene		LPG	
Variable	Coefficient	Change on Odds Ratio	Coefficient	Change on Odds Ratio	Coefficient	Change on Odds Ratio
CostMonth	-0.0003	0.9997	0.0001	1.0001	0.0005	1.0005
HHMembers	0.1008	1.1060	-0.3434	0.7094	-0.3286	0.7199
Income	0.0000	1.0000	0.0000	1.0000	0.0001	1.0001
Education	-0.0502	0.9511	0.0011	1.0011	0.1600	1.1735
Agehead	0.0495	1.0507	0.0033	1.0033	0.0099	1.0100
Gender	-0.0297	0.9708	0.0992	1.1043	0.1451	1.1562
cons	-2.7674	0.0628	0.4754	1.6087	-3.7375	0.0238

	Electricity		Residues		Charcoal
Variable	Coefficient	Change on Odds Ratio	Coefficient	Change on Odds Ratio	Base Category
CostMonth	0.0008	1.0008	0.0005	1.0005	
HHMembers	-0.3191	0.7268	-0.2366	0.7893	
Income	0.0001	1.0001	0.0000	1.0000	
Education	0.1434	1.1542	0.0204	1.0206	
Agehead	-0.0159	0.9842	0.0668	1.0690	
Gender	0.1927	1.2126	1.1682	3.2161	
cons	-2.7897	0.0614	-7.3756	0.0006	

The magnitude is measured by the coefficient size while the negative sign implies an inverse relationship i.e. when the variable increased the odds ratio decreased or when the variable decreased the odds ratio increased. It is important to remember that the odds ratio was the odds of selecting a particular fuel compared to the default category which in our case is charcoal.

The marginal effects can be explained in terms of their effects on the probability of selecting a given fuel type with respect to the default category.

4.3.1 Monthly Cost

The marginal coefficients all fuels are all about 1% this means that monthly cost is quite significant in households decision on the fuel choice.

4.3.2 Household Members

These coefficients are slightly lower than 1% but are all negative except for firewood. This means that household fuel choice is a significant factor in determining household fuel choice.

4.3.3 Income

The marginal coefficients all fuels are all about 1% and all are positive this means that monthly cost is quite significant in households' decision on the fuel choice.

4.3.4 Education

The marginal coefficients all fuels are above 1% and all are positive this means that education is more significant in households' decision on the fuel choice than the other factors.

4.3.5 Age of household head.

The marginal coefficients all fuels are all above 1% and for kerosene LPG and residues and about 1% for electricity and firewood positive this means that this variable is quite significant in households' decision on the fuel choice. It is the second most significant after years of education of the household head.

4.3.6 Gender of the Household Head

The marginal coefficients all fuels are all above 1% for all the fuels this is a significant factor in determining household fuel choice ranking just after age of the household head.

4.4 Comparison of Results with Previous Studies

The results of this study were compared to the results of previous similar studies. One of particular importance was Osiolo's study in 2009 and Kippra's study done in 2010.

4.4.1 Monthly Cost

This study found monthly cost to be important in determining choice of main fuel. This finding was in line with both Osiolo (2009) and Kippra (2010) findings though the coefficient value was lower in this study thus less important compared to the previous studies.

4.4.2. Household Members.

The two previous studies Osiolo (2009) and Kippra (2010) found households with numerous members likely to choose firewood and charcoal while those with fewer members chose LPG and electricity. This study's findings are similar to the previous studies thus larger households are more likely to select unclean fuels as their main fuel choice.

4.4.3 Income

This study found that increase in the household income led to an increase in probability of choosing LPG and electricity over charcoal and a decrease in probability of choosing kerosene and firewood over charcoal. Kippra (2010) found that an increase in income led to an increase in the probability that a household selects electricity LPG and Kerosene over firewood. Thus, household income was important in determining whether a household would select a clean source of fuel as its main fuel type. Osiolo(2009) did not use income but instead chose household expenditure on fuel and as expenditure increased, so did the likelihood that a household will select a clean source of fuel as its main fuel type.

4.4.4 Education

This study revealed increase in the education in years of the household head led to an increase in probability of choosing LPG and electricity over charcoal but led to a decrease in probability of choosing kerosene and firewood over charcoal. Both Kippra (2010) and Osiolo (2009) found household heads with more years of education or those who had completed university were more likely to select LPG and electricity(clean fuels) over firewood (unclean fuel) .

4.4.5 Age of Household Head

This study revealed an older household head was more likely to choose LPG and kerosene over charcoal but less likely to choose electricity and firewood over charcoal. Osiolo (2009) did not consider age in the regression but Kippra (2010)

found older household head to be more likely to choose electricity over kerosene firewood or charcoal.

4.4.6. Gender of the Household Head

This study found a male household head was more likely to choose electricity, LPG or kerosene over charcoal and less likely to choose firewood over charcoal. Osiolo (2009) found that gender was not an important determining factor while Kippra (2010) found that male head is likely to choose only electricity over other fuels.

CHAPTER 5

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This study applied logit model to determine the odds ratio of selecting clean versus unclean fuel as the main household fuel choice and multinomial logit model and investigated factor estimates on choices of cooking fuel in urban Kenyan households. A large microeconomic dataset from KIPPRA's Comprehensive study and Analysis on fuel consumption patterns in Kenya (2010) was employed to carry out the analysis. The results showed that in addition to income, there are several socio-demographic factors such as education and sex of the head of the household, were important in determining household fuel choice. This chapter delves into the policy implications of the above results.

5.2 Summary

This study undertook to establish the probability of choosing clean fuels over unclean fuels by urban Kenyan households. The households were found to be more likely to choose unclean fuels at a probability of 0.588. This study also undertook to establish the coefficients of the factors determining household fuel choice. The most significant factors were found to be the number of members in the household and years of education of household head.

5.3 Conclusions

The factors most significant in determining household fuel choice include years of education of the household head and number of members of the household. These increased the probability of choosing electricity, LPG and kerosene over charcoal. Other factors include income and monthly cost. As these increased, the probability that a household chose electricity, LPG and kerosene over charcoal decreased the probability that a household will choose firewood over charcoal. A male household head was more probable of choosing electricity, LPG and kerosene over charcoal less probable of choosing firewood over charcoal.

5.4. Policy Implications

Due to the fact that some households still used firewood as their main choice of fuel, it would be advisable to encourage use of more efficient wood stoves. Education on the availability and benefits of these stoves will go a long way in ensuring that these stoves are utilized effectively. Effective use will result in a decreased demand for firewood. This will minimize the environmental impacts of firewood use. It will also ensure households suffer less from indoor air pollution since the burning of the firewood will be more efficient thus produce less smoke.

The probability of clean fuel use was still about 20 per cent lower than unclean fuel use. It was recommended that the local and central government educate the population on the harmful effects of the unclean fuels and also make adequate plans to ensure these clean forms are affordable and available in all areas. Also, payment plans that ensure the upfront cost of appliances like gas cookers and

electric cookers if reduced, will assist the population in utilizing more of clean forms of energy.

Education on the benefits of clean energy to the environment and to health of household members should be emphasized. This will ensure majority of the population know the harmful effects of unclean energy and make informed decisions on choice of fuel for household use.

5.5 Areas for Further Research

The study focused on the main fuel choice within urban centres. Further research may focus on the second and third fuel option used in households. Other factors other than the ones considered in this study could be considered. Also, the effect of household fuel choice on the environment is another area of study that may be considered. One may also focus on effects of household fuel choice on health of the household members.

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