ECONOMICS OF URBAN HOUSEHOLDS' COOKING FUEL CONSUMPTION IN ARUSHA CITY, TANZANIA

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A DISSERTATION SUBMITTED IN PARTAIL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE.

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ABSTRACT

The study was conducted in Arusha City, Tanzania. The aim of the study was to analyse the socio-economic factors that influence urban households' choice of primary cooking fuel and its share to the total household expenditure. The specific focus of the study were (i) to investigate households' cooking fuel(s) consumption pattern (ii) to analyse factors affecting households' choice of cooking fuel (iii) to examine households' cooking fuel consumption intensity (iv) to develop a Liquidified Petroleum Gas (LPG) consumption descriptive model. A cross sectional research design was adapted for this study. Primary data was collected using semi-structured questionnaires administered to 200 households. Furthermore, Interview and checklist were used to collect information from 2 key informants and 25 cooking fuel dealers. The data obtained was analysed using Descriptive Analysis, Binary Logistics Regression, and Log-Linear Regression. The findings suggested that there are four cooking fuels used and available in the study area (firewood, charcoal, Kerosene and LPG). The principal cooking fuels as stated by the respondents were charcoal and LPG at 35.5% and 57.5% respectively. Most households prefer to use LPG to charcoal at 97.7% and 11.6% respectively. The study further revealed that the choice of the principal cooking fuel is influenced by socio-economic and demographic factors such as education level $(p < 0.01)$, marital status $(p < 0.01)$, occupation of respondent $(p < 0.05)$, household size $(p < 0.05)$, Residence ownership $(p < 0.05)$, and age of respondent $(p < 0.05)$. It is recommended that a policy instrument should be created to help improve households' welfare and ensure availability of diverse modern fuels, government subsiding households energy sector mostly for modern fuels by creating a dependable energy distribution towards modern fuels.

DECLARATION

I, Semmy Thadeo Mokiti, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award to any other institution.

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The above declaration is confirmed

Dr Lusambo L.P Date

(Supervisor)

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DEDICATION

I would like to dedicate this work to my beloved parents, Prof. Thadeo, T. C. Mokiti and Dr. (Mrs) Frida, T. Mokiti and my sister Selina Thadei for their moral and financial support. I also wish to dedicate this dissertation to my best friend and love Ms Monica Michael for her comfort, love, patience and endless support towards completion throughout my academic journey.

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LIST OF ABBREVIATIONS

APC	Average Propensity to Consume
EWURA	Energy and Water Utility Regulatory Authority
IEA	International Energy Agency
LPG	Liqudified Petroleum Gas
MW	Mega Watt
PIH	Permanent Income Hypothesis
URT	United Republic Of Tanzania
WEO	World Energy Organisation

WORKING DEFINITIONS OF SELECTED TERMS

Charcoal:	A carbonaceous material obtained by heating Wood in the earth-mound kiln, in the absence of air
Complete switch:	household using modern fuels only
Consumption:	choice and use
Crop residue:	Remnants after harvesting and/or processing Crops
Firewood:	Wood intended to be burned, typically for heat
Household income:	Total income of father and mother only
Modern fuels:	all non- solid fuels
No-switch:	household using traditional fuels only
Partial switch:	household using traditional and modern fuels
Respondent:	Household head either father or mother
Traditional fuels:	All solid fuels

CHAPTER ONE: INTRODUCTION

1.1 Background

The energy balance in Tanzania and other less developed countries (LDCs) is dominated by biomass, especially traditional solid biomass; firewood, charcoal and residuals which are used for cooking and heating (WEO, 2006). Also it is estimated that by year 2015 biomass user will be 2.6 billion people (IEA, 2007). Moreover, it has recently been shown that biomass accounts for 90% of total household primary fuel in Tanzania which is used in both rural and urban areas as it is more accessible and cheaper than other energy sources (Damian, 2009). However the pattern of biomass consumption vary by locality; for example, firewood is the main source of energy in rural households whereas charcoal is more frequently used in urban households (Damian, 2009).

In rural areas, choices are constrained by lack of access to more commercial fuels and markets for energy using equipments and appliance. Often, the choice of fuel is determined by local availability, transaction and opportunity cost involved in gathering the fuel (mostly wood, dung and other biofuels) rather than budget constraint, prices and costs (Farsi *et al*., 2005).

In contrast to rural area, urban households have a wider diversity of fuels to choose from. They have greater accessibility to modern commercial fuels such as Liquidified petroleum gas (LPG) and electricity, and energy end-use equipments and appliances. The demand of urban household fuel is triggered by rapid growth of urban areas both in terms of its population and development. Also changing in urban lifestyle has great implication in the quantum and pattern of energy use in household residing in these areas (Farsi *et al*., 2005). Therefore with increase urbanization and population over time, urban household energy is an important issue in developing countries in general and for poorer developing countries, such as Tanzania in particular.

Furthermore, as the economy develop urbanization and population increase, more and more cleaner energy is consumed and demanded. Household energy consumption for better fuel is expected to increase in the future along with growth in economy and rise in per capital income. This theory has further been explained through the energy ladder model which argues that people tend to switch from traditional fuels such as firewood, charcoal and other biomass fuels to more modern and efficient fuel such as kerosene, LPG and electricity which have good health and environment implications, as a result of per income increase (Heltberg, 2005).

However, it has been disagreed that households in developing countries do not switch to modern energy sources but instead tend to consume both traditional (firewood, charcoal and dung) and modern fuels (kerosene, LPG and electricity). Thus, instead of moving up the ladder step by step as income rises, household choose to use different fuels at the same time. They tend choose a combination of high-cost and low cost fuel depending on the fuel prices, preference and need (World Bank 2003). This has led to the concept of fuel stacking (multiple fuel use) as opposed to fuel switching or an energy ladder (Masera, 2000; Heltberg, 2005). In addition to this other literatures on household energy demand and choice has showed that households with low levels of income rely on biomass, such as wood and dung, while those with higher income consume energy that is cleaner and efficient, such as gas and electricity (Heltberg, 2005). However this has not been the case as argue earlier showing that household fuel choice depends on other factors rather than income only. Now this makes the knowledge of determinants of urban households' fuel choice of fuel important as it is clear that not only increase of income alone act as a exclusively factor that determines a particular use of cooking fuel but there are other factors that affects the choice of cooking fuel from traditional to modern fuels.

1.2 Problem statement and Justification of the Study

To date, research regarding the determinants of fuel choice at the household level has focused mainly on income. This has further been conceptualized using an "energy ladder" model that elucidate people propensity to switch from one less efficient fuel to the next better fuel basing on income increase (Hosier and Kipondya, 1993; Masera 2000; Hetlberg 2005) . Most of the literatures in household energy demand and choice in developing countries, has argued that households with low levels of income rely on biomass, such as wood and dung, while those with higher income consume energy that is cleaner, such as gas and electricity and this depends on the household budget. However, it has recently been argued that households in developing countries do not switch to modern fuel source but instead tend to consume a combination of fuels rather than completely switching from one fuel to another (Davis, 1998; Moses, 2006; Hetlberg 2005).

Thus as the energy ladder model fails to explain this phenomenon of fuel switching clearly, this study was set to answer the question of what factors rather than income alone that influences urban households' primary cooking fuel choices and its contribution to the household budget. This study provides data on the adoption of modern fuel and additional information on household fuel consumption behavior. Besides , it provide a basis towards policy intervention in the household energy sector through which will help in changing the focus on combating deforestation and desertification and help policy framing that will help promote the use of modern fuels.

1.3 Objectives

1.3.1 General objective

The main objective of this study was to analyse the socio-economic factors that influence urban households' choice of primary cooking fuel in Arusha city, Tanzania.

1.3.2 Specific objectives

The specific objectives of this study were to:

(i) investigate households' cooking fuel consumption pattern in the study area,

(ii) analyse factors affecting households' choice of cooking fuel,

(iii) examine households' cooking fuel consumption intensity, and

(iv) develop LPG consumption descriptive model.

1.4 Hypotheses of the Study

This study put forward the following hypotheses

(i) Household socio-economic and demographic factors have no effects on cooking fuel consumption

(ii) Household socio-economic and economic factors have no effect on cooking fuel choice

1.5 Limitations of the Study

The research was done with a lot of care and the findings presented by this study are fairly robust, detailed and empirical. Despite that in mind it was worth acknowledging some limitations. The study was cross- sectional which made it difficult to capture various in household cooking fuel consumption over time. Also during questionnaire interviews the respondents relied most on memory, which could have suffered low precision and/or accuracy. Furthermore, lack of records made it difficult for respondents to recall and make account on various consumption issues, which result in some of them being unable to answer some of the question and some time respondents deliberately underestimated or overestimated their monthly income. In addition, some respondents refused to be interviewed due to political issues that resulted into change of sample units from time to time.

In order to undertake various analyses with the limitation as stated above some assumption where made to counter them. The *first assumption* made was that households have constant intensities of fuel consumption throughout the year and this was prompted due to the nature of the study (cross-sectional). The *second assumption* was that households did not deliberate adjust their fuel consumption to impress the researcher. And the *third assumption* was that all information provided by households during questionnaire administration was authentic and that respondents spoke out their minds to the best of their knowledge

1.6 Conceptual Framework Underlying this Study

According to Miles and Huberman (1994) a conceptual framework is used in research to outline possible courses of action or to present a preferred approach to an idea or thought and it represent key ideas and complex interactions of a number of important constructs on the outcome variables. Furthermore, it represents the system of concepts, assumptions, expectations, beliefs, and theories that supports the research.

Figure 1 illustrates part of the conceptual framework. According to this framework, households' choice and demand of fuel may be governed by economic and social factors. Whereby, the economic factors include household income and market price of fuel and the non- economic factors which include both household demographic and infrastructure factors which include Gender of head of household; Education level, Occupation of Head of household, Household size, Type of food commonly cooked, Availability of alternative fuel, Accessibility Cooking habitat, Location, Gender composition (Moses, 2006).

Household fuel choice and demand have often been conceptualized in terms of the energy ladder model. The model purport that both fuel choice and switch is a function of income growth. It is further perceived that household with low- income tend to consume most on biomass especially traditional solid fuel. But as income increase people tend to demand more modern and effective fuel such as LPG and electricity (Hosier and Kipondya, 1993; Masera, 2000; Hetlberg, 2005).

However, this linear relationship between income and energy demand has been criticized as there are other factors rather than income that could equally explain fuel choices and demand. For example, supply factor, which has influence on the availability of fuel when a fuel(s) is scarce its price normally goes high hence making less available. Moreover, people may not completely switch to another fuel just because of income increase but rather use a combination of modern and traditional fuels and stack fuel for specific purposes (Davis, 1998).

The literature on household choice and demand of fuel has shown that there are other factors more than income that can influence households choice and demand of fuel which include; age, gender composition of household, gender of household head, education level, location, type of commonly cooked food, household size and fuel market price (Moses, 2006).

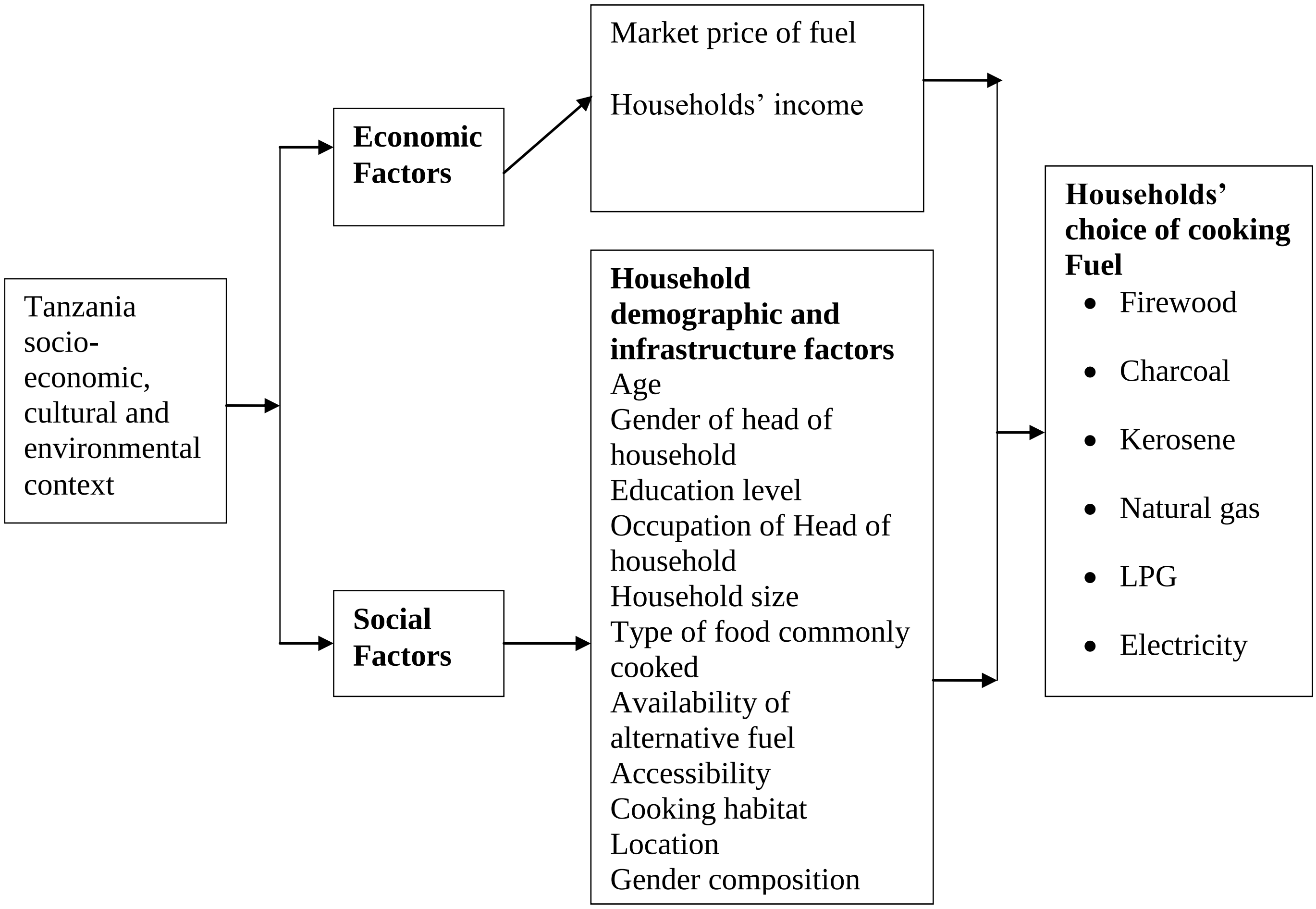

Figure 1: Conceptual framework of factors affecting urban households' choice and consumption of cooking fuel.

CHAPTER TWO: LITERATURE REVIEW

This chapter reviews the general literature pertinent to the present study. It concisely gives an overview of the study area (country) profile, and the energy situation in both Tanzanian and global contexts. It also highlights various factors affecting energy choice and consumption intensities.

2.1 Energy Situation in Tanzania

2.1.1 Energy supply

Tanzania has abundant and diverse indigenous energy resources but so far poorly developed. These sources include: wood fuel and other biomass-fuels, hydropower, natural gas, coal, uranium, wind, geothermal and solar, (URT, 2003; Uisso and Mwihava, 2005). Natural gas, coal, petroleum and hydropower are Tanzania main source of commercial energy. Solid biomass energy such as forest/ agro residue and wood fuels are used throughout the country which accounts for 90% of the total energy consumption while modern energy contributes less. In rural areas biomass energy is the main dependable source of energy while in urban areas they depend on gas, biomass and electricity. According to Casmiri (2009) the main source of cooking energy in urban area is biomass especial wood charcoal (about 80%). The current supply situation from different energy sources is highlighted as follows:

Biomass Energy

Biomass fuel supply in Tanzania mainly comes from forests. Other biomass includes crop residues, forests residue and animal dung (Uisso and Mwihava, 2005). Also, there are few biomass generating plants in Tanzania: sugar processing mills (about 32.2MW), wattle (tanning) processing plant (2.5MW), and Sao Hill Sawmill with the capacity of 1.025MW (URT, 2005).

Electricity

TANESCO owns transmission lines of different voltage capacities across the country: 2624.36km of 220kV, 1441.5km of 132 kV, and 486km of 66kV making a total of 4551.86 km as of 2006. The transmission system faces problems including vandalism of towers and voltage loss due to deterioration of the transmission system.

Distribution infrastructure faces even greater challenges including the theft of transformer oils and conductors, meter tempering, and illegal connections. About 60% of total electricity generated comes from hydropower plants (Kidatu-204MW, Kihansi-180 MW, Mtera-80MW, New Pangani Falls-68MW, Hale-21MW and Nyumba ya Mungu-8MW).

In 2001 the hydropower contributed about 97.5%. Levels dropped precipitously to 50% in 2005 and then to 30% in 2006 due to severe drought conditions. The result was a high level of load shedding across the country. Some parts of the country are supplied with electricity from isolated grids as well as from Uganda (8MW) and Zambia (5MW) (Uisso and Mwihava, 2005; Sawe, 2005; Lyimo, 2006).

Natural Gas

Natural gas reserves are found in the Southern part of Tanzania and are expected to become a reliable and economical source of energy to replace coal and petroleum, particularly in the electricity and industry sectors. The gas is extracted from Songosongo and Mnazi Bay. It is then transported by pipeline (about 232 km) from Songosongo to Dar es Salaam.

Petroleum

Imported petroleum and related products are widely used in the household, transport and industrial sectors. It is also used to generating electricity in isolated grid-diesel power stations that have an installed capacity of 33.8 MW[6] and are located in Mtwara, Lindi, Songea, Masasi, Tunduru and Kilwa Masoko, Kigoma, Mpanda, Ikwiriri, Mafia, Ngara, Biharamulo, Njombe and Liwale (Casmiri, 2009). Petroleum and related by-products are imported and distributed by private companies regulated by EWURA which controls the price and standard.

Coal

Coal is found in Kiwira and Mchuchuma and has been used in limited quantities for electricity generation as well as in some industries such as cement factories. Low coal consumption is due to huge investment costs and the quality of the coal itself.

2.1.2 Energy Demand

The current energy demand and supply in Tanzania is significant low. Sectors such as Transport, commerce, industry and households especially urban households depend on a considerable amount of energy such as electricity and petroleum products. There is an expected increase in demand for energy due to population growth, urbanization and change in life style. According to Uisso (2005) sectors such as transport, agriculture, industry and households consume petroleum and electricity as shown in Figure 2 and 3 below.

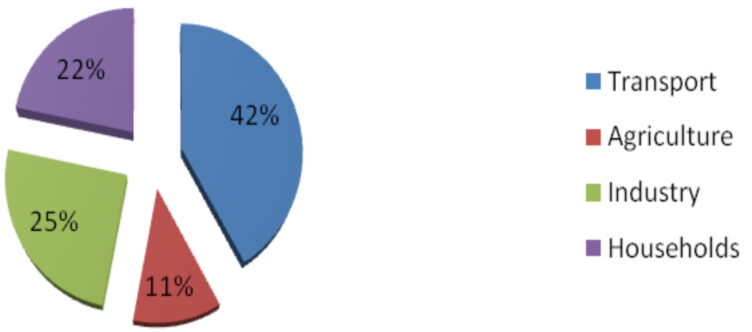

Figure 2: Petroleum consumption by sectors

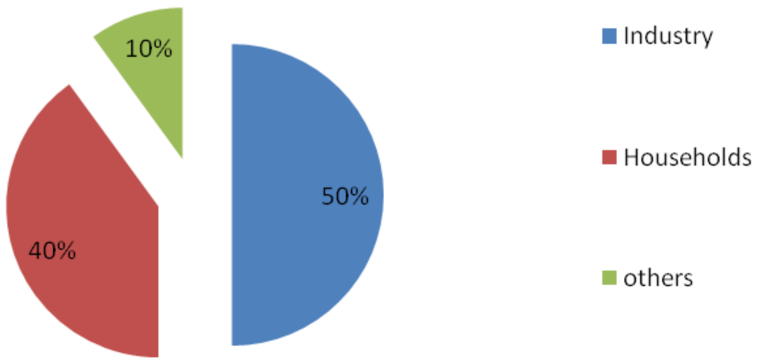

Figure 3: Electricity consumption by sectors

Source: Uisso (2005)

The demand of electicity is expected to increase from the value of 925MW to atleast 3800MW by 2025 (Msaki, 2006). The demand increase is due to rapidly population growth and increased in economic activities.. Moreover, due to improved living standards and income increase in urban population the demand of petroleum products especially Liqudified petroleum gas as a source of cooking is expected to increase significant.

2.2 Energy Consumption by Sectors in Tanzania

The household sector in Tanzania consumes the highest proportion of total energy in comparison with other sectors – industry, transport, agriculture and commerce. Kaale

(2005) asserted that the household sector accounts for as higher as 91% of total energy consumption in the country. Although reliable data on household energy consumption are not available (Kaale, 2005), it is estimated that biomass fuel accounts for 90% of household total energy consumption; petroleum accounts for 7%, and electricity accounts for 1.4% of total household energy consumption, renewable(solar wind, etc) and others accounts for about 1.6% (Sawe, 2008).

Table 1: Sector-based energy consumption in Tanzania for 1999 and 2004

No	Sector	Total energy (1999)	Total energy (2004)
1	Household	78	80
2	Industry	11	9
3	Transport	2	6
4	Agriculture	3	4
5	Commerce & public service	0.5	1
6	Non-energy and other consumption	4.5	-
	Total	**100**	**100**

Source: Adapted from URT (2004)

2.3 An Overview of Household Energy Fuel Use

Energy use is important for the welfare of households in developing countries. For most people in developing countries, energy comes from wood, dung, candles, and occasionally kerosene which are used for either cooking, heating or/and lighting. For most of these countries, more than 90% of the total household fuel is biomass. It is estimated that approximately 2.5 billion people in developing countries rely on biomass fuel to meet their cooking needs. Moreover, due to population growth and lack of new policies the number is expected to increase to 2.6 billion by 2015 and 2.7 billion by 2030, which is about one-third of world's population (IEA 2006).

But as the economy grows and population increase over time as well as environmental and health concerns, households tend to use combination of fuel which include high and low cost fuel such as charcoal and Liquid Petroleum Gas (LPG) which are more efficient and cleaner. In Tanzania, the percentage of rural and urban households using alternative source of energy rather than biomass is less than 10%. But due to improved standard of living, many people at the household level are trying to move upward the ladder to safer, cleaner and more efficient fuel such as electricity and LPG (Damian, 2009).

2.3.1 Determinants of Household Fuel Choice

Most empirical studies done on income effects on fuel choice have found contradicting results. In Ethiopia, the income effect dominates so that households consume more of all energy sources as budgets grow (Kebede *et al.,* 2002). Barnes and Qian (1992) using actual survey of urban household energy consumption in developing countries found that as income increases woodfuel do not disappear completely as households continue to increase use of woodfuels. The reason behind this relationship is that many high income households still use woodfuel. In a study done by Heltberg (2005) in Guatemala using household survey data set and employing the logit and multinomial logit regressions, found a positive relationship between household size and firewood use. A number of explanations have been given to this finding. First, a larger household size may mean larger labour output, which is needed in firewood collection. Secondly, it is assumed to be cheaper to cook for many people using firewood than its alternatives. Larger households are more likely to have extra labour (for example children's labour) that can be used to freely collect firewood from public fields. It is assumed that free collection of firewood lowers the price of firewood relative to alternatives which cannot be obtained freely. Mekonnen and Kohlin (2008) found, similar results in Ethiopia where Households with more members were more likely to use charcoal and firewood and less likely to use kerosene.

Pundu and Fraser (2003) analysed data from rural Kisumu, Kenya using multinomial logit model. The study found that the level of education improves knowledge of fuel attributes, tastes and preferences for better fuels. According to Pundu and Fraser, a highly educated woman is likely to lack time to collect firewood and may prefer to use firewood alternatives. Wuyuan et al. (2010) explains that when the resident's education level is higher, they use less biomass or more commercial fuel because their opportunity cost of biomass collection is increasing. Pundu and Fraser (2003) notes that women's age influences fuel choice through loyalty to firewood so that the older the woman (other things being equal), the more likely the household will continue using firewood. This have been found to be true by Mekonnen and Kohlin (2008)., where they demonstrated that older household heads are more likely to choose solid fuels(which include woodfuels, agriculture residues and animal residues) only as their main fuel, perhaps from habit, whereas non-solid fuels (which include biogas, electricity, and LPG) are relatively more adopted by the younger household heads. Schlag and Zuzarte (2008) found that high fuel prices made household more likely to use traditional fuels than modern fuels. Similar results by Mekonnen and Kohlin (2008) show that households are more likely to choose solid fuels (charcoal and firewood) than modern fuel (kerosene).

Albebaw (2007) found that a negative relationship exists between fuelwood consumption and distance. The reason behind this finding is that households may consider distance as an additional cost to the market fuel price. In this regard, the farther distance implies that households have to bear more cost in terms of transportation and this makes household be reluctant to choose such fuels for use. Pundu and Fraser (2003) postulate that selection of fuel is influenced by type of dwelling unit. If the dwelling unit is modern type house, the household is more likely to use firewood alternatives because these fuels are cleaner.

2.4 Household Energy Consumption Patterns

There exists scanty information on household energy consumption patterns in Tanzania (Kaale, 2005). In Tanzania more than 85% of urban dwellers use charcoal and more than 98% of rural population depend on firewood. One in five low-income households relies on wood for lighting, 90-100% of low-income households use kerosene for lighting, and 10% of low income households use candles for lighting (mainly because of its related high costs). Furthermore, 60% of low-income households use batteries for communication and entertainment. Cooking fuels in Tanzania are relatively diverse: firewood, charcoal, kerosene, LPG, electricity, crop residues, cow dung and wood processing residue. Wood based biomass fuels are the most important cooking fuels. Costs for cooking using electricity are very high (tariffs and prices for necessary equipment). The use of LPG by low-income households is small for a number of reasons: not readily available in both urban and rural areas, it is more expensive, and it requires relatively expensive accessories and appliances. Coal is mostly unavailable and is considered a health hazard. Dung is mainly used in areas with scarce wood resources. Crop residues are mainly available during the harvesting seasons, with considerable regional variation.

2.4.1 Effects of Urbanization on Households’ Energy Consumption

The key determinants of energy demand in the household sector include: prices of fuels and appliances, disposable income of households, availability of fuels and appliances, and cultural preferences (Wilhite, 1996).

With increasing disposable income and changes in lifestyles in the urban areas, households tend to move from the cheapest and least convenient fuels (firewood) to more convenient and normally more expensive ones (charcoal, kerosene) and eventually to the most convenient and usually most expensive types of energy (LPG, natural gas, electricity). There is also correlation between the choice of cooking fuels and the value of women's time. Women who enter the formal workforce demand more convenience in their use of household fuels. This leads to a preference for LPG compared to more traditional fuels. There is a strong positive relationship between growth in per capita income and growth in household demand for commercial fuels. For most developing countries, demand for commercial fuels has risen more rapidly than per capita incomes since 1970. This reflects the increasing desire for comfort and discretionary energy consumption (Dzioubinski and Chipman, 1999).

Urbanization is an important determinant of both the quantity and the type of fuel used in developing countries. In general, urbanization leads to higher levels of household energy consumption, although it is difficult to separate the effects of urbanization from the increases in income levels that generally accompany urbanization. There is also a shift from traditional to commercial fuels.

Several factors that contribute to this trend include a decline in access to biomass fuels, inconvenience of transportation and storage, and improvement in availability of commercial fuels in urban areas. Nonetheless, use of traditional fuels in many cities of the developing world remains high among low income groups (Dzioubinski and Chipman, 1999).

2.5 Consumer Choice Theories

2.5.1 General idea

As a consumer is subject to a consumption choice from different goods they normally try and choose the goods that will give them maximum satisfaction based on their available budget. The theory of consumer choice is a way of analyzing how consumer reaches equilibrium between preference and expenditure by maximizing utility as subject to consumer budget constraints (Mankiw, 2011). Thus consumer choice is based on two main factors preference and budget of the consumer.

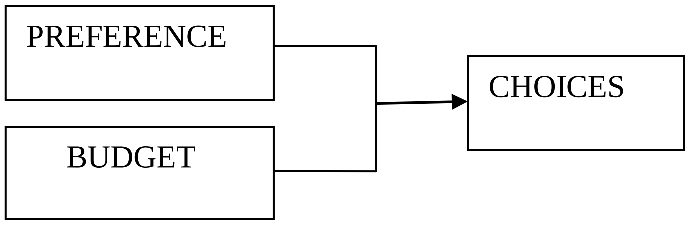

Figure 4: General factors affecting consumers' choice

The decision for an individual to choose a certain bundle of goods depends on how the consumer can translate the desires (preferences) into choices based on income for them to purchase the goods. In this theory, it assumes that the consumer has full knowledge of all available goods and their prices and his income. In addition, they must be able to compare the different level of satisfaction of goods, which he may buy from his income in order to attain maximum level of satisfaction. In this regard, a household will try to make themselves as well off as they possibly can in the circumstance in which they find themselves (Mankiw, 2011).

However, consumers are sometimes faced with bundles of goods that have the same utility. When a consumer is faced with such circumstance we refer that the consumer is indifferent. Preference that satisfies the condition above can be presented by

Indifference curves.

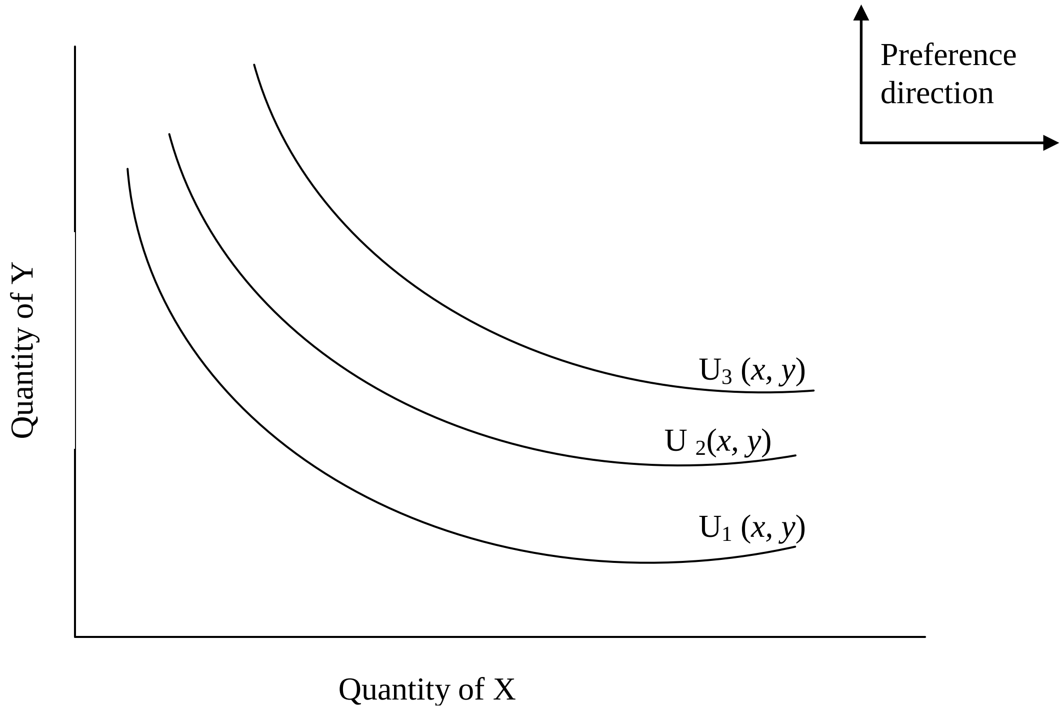

Figure 5: Indifference curve

Source: Adapted from Mankiw (2011)

The utility constant curve through *C* and *N* is referred to as an indifference curve. This is because the consumer is indifferent among all choice bundles yielding the same level of $U(x, y)$. For example, U_1 is achievable with either choice bundle *C* or *N*, and the consumer is therefore indifferent between them.

Several assumptions of the preference ranking ability of households set the characteristic shape of these indifference curves. First, we assume that households can determine pairwise rankings. In other words, if the underlying components of choice bundles are known, we assume households can determine which combination is preferred. Second, we assume that more is preferred to less for economic "goods," and less is preferred to more for economic "bads" (e.g., garbage, pollution, etc.). Third, we assume households are logically consistent and therefore that their preference ranking relations are transitive and additive. That is, if the consumer tells us she prefers choice bundle *J* to *C* and also that she prefers *K* to *J*, we assume that she also prefers *K* to *C*. However, *L* _ *C* may well be preferred over *K* because *L* _ *C* offers the consumption indicated by choice bundle *R*. Finally, we assume that marginal utility diminishes eventually as the consumption of good increases.

Therefore we can conclude that households may prefer a set of bundles but they will always consider their budget constraints of disposable income as it defines household's opportunity set and their preference as the aim to maximize utility. However in some cases there are some households that will consume a certain bundle just because of its characteristics even if the bundle contains less, we refer this preference as lexicographic preference. This has also been summarised from Hendler Lancaster's (1975) basic ideas as follows; "*goods themselves are not the immediate objects of preference/utility/welfare; goods have with them, characteristics which are directly relevant to the consumer; the consumer is assumed to have a preference-ordering over the set of possible characteristic vectors, with the aim being to obtain the most desirable bundle of characteristics; and consumer's demand for goods is derived from their demand for characteristics"*.

2.6 Consumption Theories

There are many theories that explain households' consumption choice and behavior. Different factors can be used to determine consumers' choice and preference on what they consume. However there are other theories that explain consumers' behaviour when it comes to consumption. Consumption theories can be grouped into the following groups.

2.6.1 Consumption as a Function of Disposable Income

The first category explains that consumption is determined by the households' current disposable income. Keynes (1936) argued that household consumption is directly related to its income (i.e. $C = a + bY$ where a autonomous consumption, C is the consumption, b the marginal propensity to consume). According to Keynes the amount of households' aggregate consumption depends on the household aggregate income. Keynes concluded that consumption is a linear function of disposable personal income and that average propensity to consume (APC) falls as income rises. However, Kuznets (1942), dismissed Keynes claim that the APC decreases with increase in disposable income.

2.6.2 Consumption as a function of permanent income

The second category refers consumption as a function of permanent income. The notably explanation was given out by Friedman's (1957) permanent income hypothesis in which he argued that consumption is positive related to permanent income. Friedman's PIH based on the intuition that individuals would wish to smooth consumption and not let it fluctuate with short run fluctuations in income. Furthermore, he argued that individuals base their consumption on a longer term view of an income measure, perhaps a notion of lifetime wealth or a notion of wealth over a reasonably long horizon. The basic hypothesis posited is that individuals consume a fraction of this *permanent income* in each period and thus the average propensity to consume would equal the marginal propensity to consume.

2.6.3 Consumption as a function of current and expected income

The third category of consumption is that which explains that consumption depends on current and expected income. Duesenberry's (1949) *relative income hypothesis* can be used to explain this notion of consumption function. Dueseberry's relative income hypothesis explains that individual attitude for consumption and saving is guided more by his income in relation to others than his standard of living. He emphasized on social formation of consumption and social interdependencies based on relative income concerns. Furthermore, Duesenberry's theory maintains that consumption decisions are motivated by "relative" consumption concerns so called "keeping up with the Joneses" behaviors, he stated that the strength of any individual's desire to increase his consumption expenditure is a function of the ratio of his expenditure to some weighted average of the expenditures of others with whom he comes into contact. This shows that consumption comparison is linked to both current and future income levels. Also he argued that consumption patterns are subject to habit and are slow to fall in face of income reductions. He stated that the fundamental psychological postulate underlying the argument is that it is harder for a household to reduce its expenditure from a higher level than for a family to refrain from making high expenditures in the first place this is because household will not want to alter their standard of living.

2.7 Energy Ladder Hypothesis

Household choice of fuel depends on number of factors chiefly been income. It is noted that the movement towards the use of alternative source of fuel depends mainly on income. As stated earlier the ladder explains the movement of energy consumption from traditional source to more sophisticated source along an imaginative ladder with improvement in the economic status of the households (Income) (Masera *et al*., 2000) .

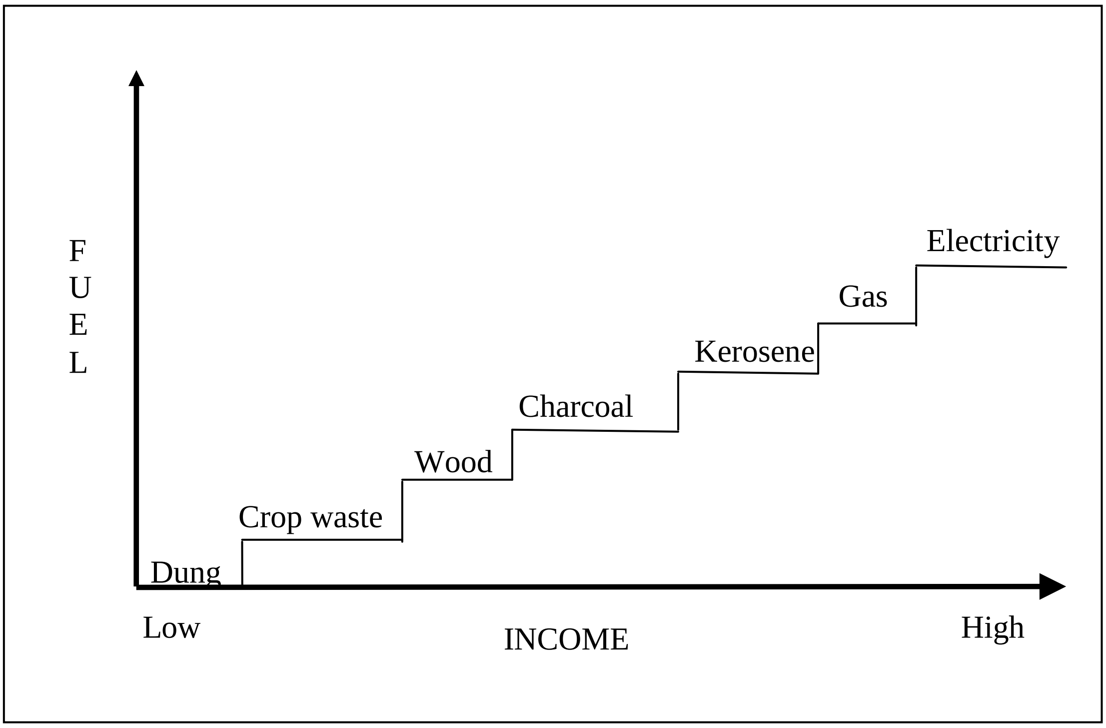

Figure 6: Energy ladder model

From figure 2 above the ladder shows that households will consume the same fuel but as income increase they tend to continue consuming more of the same fuel but they also shift to more sophisticated fuel which is more efficient which this is partly based on the economic theory of consumer behavior (Hosier and Kipondya, 1993). Furthermore, it explains that the ladder assumes that cleaner fuels are normal goods while traditional fuels are inferior. This is to say that if a household at certain point in time and at income I_1 consumes firewood, as the income increases to I_2 the household will shift from consuming firewood and start consuming charcoal which is the next fuel in the ladder but this is depends on budget of the household (budget constraints).

2.8 Fuel Switching

The term "fuel switching" as conceptualized by the energy ladder model lay down the idea of a step by step of fuel substitution from a less efficient fuel (traditional fuel) to a modern fuel because of income rises. Moreover, household fuel choice and demand have been often conceptualised in terms of the energy-ladder model, where more diversified choices and demands for fuel sources are predictable in terms of the nature of the appliances used and the purpose as income increases. The model purports to explain both fuel choice and switching in relation to income growth (Heltberg 2005). It is perceived that with low income, biomass tends to dominate. As income rises, and due to the pressure of deforestation and urbanization, households tend to adopt ’intermediate’ fuels such as kerosene, charcoal and coal.

In a third stage, households switch to cleaner and more efficient fuels such as LPG and electricity as their income is sufficient (Leach, 1992). However, the linear relationship between income and energy demand and preferences; as upholds in the ladder hypothesis, have been criticized as being simplistic because factors other than income could equally explain fuel choices and demand. For example, a pure demand effect, associated with increasing income, will result in substitution because of convenience and changing uses of time. Supply factors will also play a role as scarce or higher production cost fuels have higher prices and will be less available and/or affordable. In addition, households may not switch completely from one fuel to another as income rises but rather use combination of modern and traditional fuels and stack fuels for specific purposes, this leads to the concept of fuel stacking (Davis, 1998).

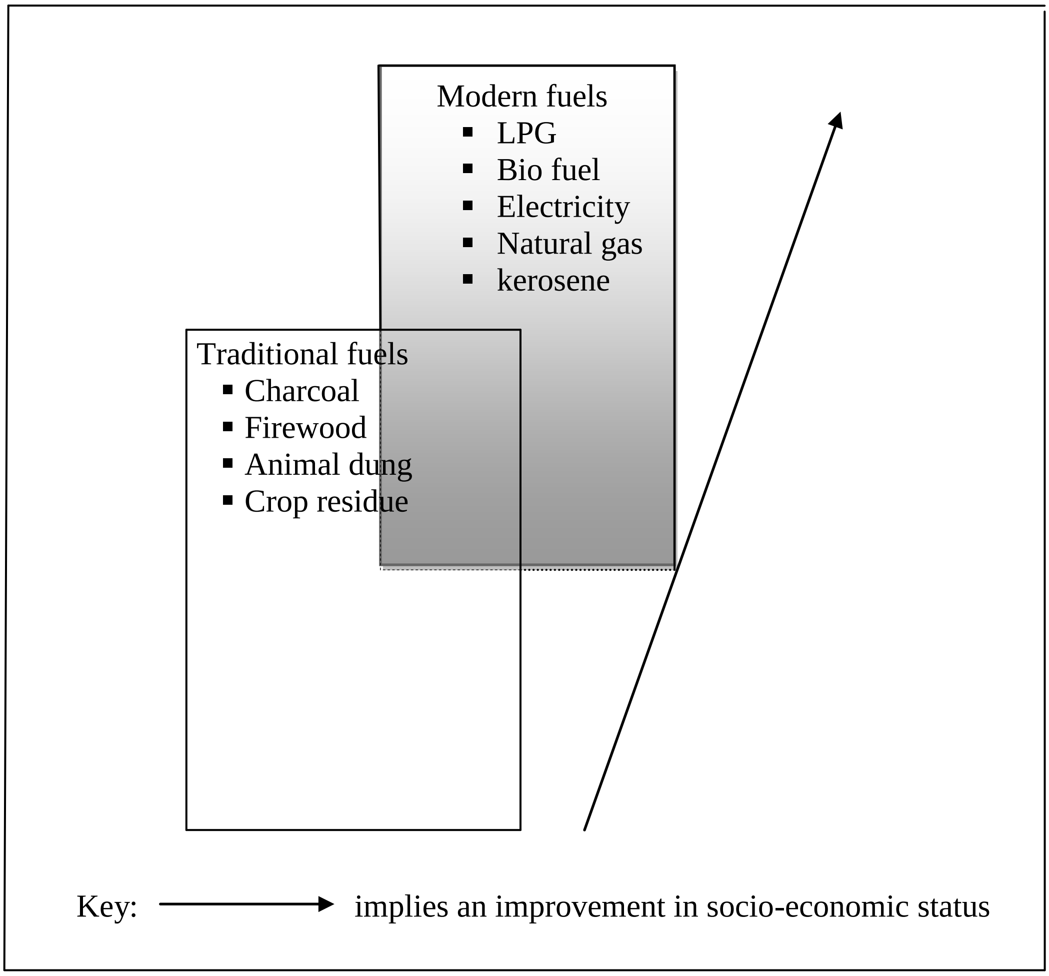

Figure 7: **Energy stack model**
Source: Adapted from Schlag and Zuzarte (2008)

The literature on fuel choice had shown that many factors other than income could influence the household fuel adoption decision. Chief among these are the household size, gender composition, location, cooking habitat, gender of the household head, age, education, availability of fuel alternatives and accessibility including cooking utensils as well as the degree of the development of fuel markets and wage labour market (Moses, 2006).

2.9 Environmental Perspective of Fuel Choice

As many people in developing countries keep on relying on biomass as source of fuel and as source of income for consuming and producing, this could have profound and long lasting negative effect to the forests. Heavy reliance by households on biomass fuels such as woody biomass and dung contribute on deforestation, forest degradation and land degradation. In Tanzania, the rate of deforestation is alarming; it is estimated at a rate of 412,000 hectares per annum and will jeopardize the future availability of biomass resource (Damian, 2009).

2.10 Associated Heath Risk of Fuel Choice

Use of biomass fuels for cooking is a major cause of health problems in developing countries due to indoor air pollution and has been estimated by the World Health Organization (WHO) to contribute to the global burden of disease and to be the fourth largest health risk causing 2.5 million premature deaths a year (WHO, 2002). This was further shown in a study by Hood et.al. (2004) on 30 households from Kassala Ethiopia which aimed to monitor indoor air pollution level during 24 hours. Their results reveal high level of carbon monoxide. Hence, they concluded that, high dependence on biomass fuels not only contribute to environmental degradation, but equally causes health problems to women and children less than five years.

2.11 Review of Analytical Tools Used in the Study

2.11.1 Modeling

Modeling is a process used in analytics to create statistical model of future behaviour. it is the process by which a model is *created* or *chosen* to try to best show the clear picture of an outcome. According to Mosley (2005), modeling is a form of "*data mining*". Data mining is *sorting through data to identify patterns and relationships.* Data mining includes the following parameters:

- association- looks for pattern where one event is connected to another later event
- sequence or path analysis- looks for patterns where one event leads to another later event
- classification- looks for new pattern. (may result in a change in change in the way data is organized)
- clustering- finding and visually documenting groups of facts not previously known
- forecasting- discovering data in the data that can lead to reasonable prediction about the future.

Modeling takes these relationships and uses them to make inference about the future (ibid). This model is made up of a number of *predictors,* which are variable factors that are likely to influence future behavior or results.

2.11.1.1 Ananlytical techniques for modeling

There are several types of analytical models that can fit the data including linear models, logistic regression, neutral network, regression spline, decision tree, Markov models, classification and regression trees (Mosley, 2005).

2.11.2 Binary logistic regression

Modeling the relationship between explanatory and response variables is a fundamental activity encountered in statistics. Simple linear regression is often used to investigate the relationship between a single explanatory (predictor) variable and a single response variable. When there are several explanatory variables, multiple regressions is used. However, often the response is not a numerical value. Instead, the response is simply a designation of one of two possible outcomes (a binary response) e.g. charcoal or LPG, success or failure. Although responses may be accumulated to provide the number of successes and the number of failures, the binary nature of the response still remains. Data involving the relationship between explanatory variables and binary responses abound in just about every discipline from engineering to, the natural sciences, to medicine, to education, etc. the functional formula for binary logitistic regression can be written as follow:

Logit (Y) = ln [p/ (1-p)] = $\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots$ ……………………… (1)

It assumes *Y* as a binary response variable

Where P is the probability of the event of interest, α is the *Y* intercepts, β_n are regression coefficients, and $X_{1,}$ X2, X3 and X_4 are a set of predictors. α and βs are typically estimated by the maximum likelihood (ML) method, which is preferred over the weighted least squares approach by several authors, such as Peng *et al*. 2002 and Schlesselman (1982).

The ML method is designed to maximize the likelihood of reproducing the data given the parameter estimates. Data are entered into the analysis as 0 or 1 coding for the dichotomous outcome, continuous values for continuous predictors, and dummy codings (example 0 or 1) for categorical predictors.

CHAPTER THREE

3.0 METHODOLOGY

This chapter outlines the materials and methods that were used to collect and analyse data in this study in which it includes the description of the study area, sampling procedure and sample size, data collection, data processing and analysis.

3.1 Study Site Description

This study was conducted in Arusha City Council located in Arusha. The City current population projection is estimated at 359,044 people with 100,000 people coming in and out the city for business purposes (Arusha profile, 2009). The city has three divisions namely, Themi, Elerai and Suye. These are further divided into seventeen wards; Kati, Sekei, Themi, Kaloleni, Levolosi, Ngarenaro, Unga Limited, Daraja Mbili, Baraa, Sokoni I, Elerai, Kimandolu, Oloirien, Sombetini, Terrat, Engutoto and Lemara. Data was collected from households' in three wards namely Kati, Sekei and Themi which are located in Themi division in Arusha City.

3.1.1 Geographical description of Arusha city council

Arusha city council is located on the southern slope of Mt. Meru. It covers an area of 208 square kilometers out of 34.526 square kilometers of the total area of Arusha Region. It lies between 1130 and 1450 meters above sea level. It is also extend between latitudes 2° and 6° south and longitude 34.50° and 38° East.

3.2 Research Design

This study employed cross-sectional research design method where data was collected once in the selected population. The study adopted this method due to its strength over other designs in providing the overall picture of the relationships among variable of interest. Also the cross-section study design provides useful data for simple statistic description and interpretations (Babbie, 1995) and its requires little resources (Bailey, 1995).

3.2.1 Sampling techniques and sample size determination

Different sample techniques were used for sampling and determination of the sample size, this involved several steps as follows; the first step involved the selection of the division among the three divisions, in which Themi division was selected using purposive sampling at it represents real urban setting. The second step involved the selection of wards, in which three wards were selected using simple random sampling (Sekei, Themi and Kati) out of seventeen wards. The third step involved selection of streets from each ward, whereby in Kati all streets were selected (Bondeni and Pangani) as well as Themi (Themi mashariki, Old police, corridor Area and AICC Flats) were also selected. In Sekei four streets (Sanawari, AICC, Mahakamani and Naura) were selected out of six streets and this was done as a result of simple random sampling. The final step involved the selection of 200 households using simple random sampling, where the sample units were drawn using a sample frames from the residence list. The sampling size determination is presented in Table 2

Table 2: Sample size of the respondents in the study area

City	Division	Ward	HH population size per ward (N)	No. of Households sampled (n)
Arusha	Themi	Sekei	1661	84
		Kati	671	34
		Themi	1603	82
Total			**3935**	**200**

The sample size in the study area was determined using the following formula as stated by Boyd et al; $C = \frac{n}{N} \times 100$ …………………………………………… (2)

Where *C* represented a figure greater or equal to 5% of the ward household population, *N* was the total households in the three wards (3935 households) and *n* was the number of sampled households (Boyd *et al.*, 1981). The 5% was sufficient sample size and each sampled ward met the criteria stated by Boyd et al that the 5% will be sufficient provide that the sample size will not be less than 30 units.

3.3 Data Collection Methods

The study used several methods in the attempt to bring forth the information from the sample population and other sources relevant to the study. Among the methods were interviews using questionnaires administered to the respondents, interview schedule for two key informants and market survey for charcoal and LPG dealers by using observation and interview via check list.

3.3.1 Primary data

A semi-structure questionnaire (see appendix 1) was design and administered to households' for collecting primary data. Furthermore, a checklist (see appendix 2) was designed to collect primary data from cooking fuel dealers (charcoal, kerosene and LPG). also a interview schedule was design to collect in-depth information from key informants which included, the question that were included in the questionnaire aimed to solicit information related to household consumption behaviour on cooking fuel, households socio-economic characteristics and their influence in fuel choice, cost of cooking fuels, households knowledge of cooking fuel and households cooking fuel preference.

3.3.2 Questionnaire testing

The questionnaires were both pre-tested and pilot tested before the study was carried out. The questionnaire was pre-tested in order to check its validity and reliability. Pre-testing was done to see if it works and whether changes were necessary before the actual study. It allowed room to correct mistakes and add relevant information. The advantage of pre-testing the questionnaire included improve the wording of the questionnaire, correct and improve translation of technical terms, check the accuracy and adequacy of the questionnaire, eliminated unnecessary questions and added necessary ones and estimate the time needed to conduct the interview. Also the questionnaire was pilot tested before the questionnaire was administered in real situation. A random sample of 20 households' from Sekei, Themi and Kati wards was selected. Pilot testing provided an opportunity to detect and remedy the problem of questions that could not be understood, ambiguous questions, double barreled questions and questions that could make the respondents uncomfortable.

3.3.3 Secondary data

Secondary data was collected in order to supplement primary data. The data included prices of cooking fuels, economic situation in the study area, and source of cooking fuel(s). The data were obtained from local fuel shops, journals, other published scientific research reports, official websites as well as newspapers.

3.4 Analytical Tools

The data obtained was analysed with the aid of the statistical package for social science (SPSS) computer programme and Microsoft Excel. Descriptive statistics were used to analyse socio-economic characteristics of interest and to assess the influence of socio-economic status of a household towards cooking fuel choice and consumption behavior.

Binary logistics was use to check the socio-economic factors that influence the choice of households cooking fuel consumption on the main cooking fuels in the study area (charcoal and LPG). Also a LPG predictive model was designed to predict the household consumption of LPG as a cooking fuel.

3.4.1 Binary logistic regression model

A logistic regression was used to determine the factors that influence households' consumption on cooking fuels. This study used a binary regression model to determine those factors since the dominated used cooking fuels in the study were charcoal and LPG. this model was used as it was designated to one or two possible outcomes (a binary response). The binary regression model is expressed as follows:

$$\text{Logit (Y)} = \ln [p/ (1\text{-}p)] = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Whereby; Y as a binary response variable

Where P is the probability of the event of interest, α is the Y intercepts, β_n are regression coefficients, and $X_{1,}$ X2, X3 and X_4 are a set of predictors. α and βs are typically estimated by the maximum likelihood (ML) method.

Hypothesis

H_0: $\beta_1 = \beta_2 = \ldots.\ \beta_p = 0$ (household socio-economic factors have no effects on cooking fuel choice)

H_a: At least one of the $\beta_i \neq 0$ (household socio-economic and demographic factors have effects on cooking fuel choice)

Table 3: Variables used in Binary regression model

Variable	description
Y	Household cooking fuel choice
X_1	Age of the respondent
X_2	Household size
X_3	Residence ownership
X_4	Education level of the respondent
X_5	Occupation of the respondent
X_6	Household monthly income
X_7	Marital status of the respondent

3.4.2 Modeling for LPG consumption

as it was briefly discussed in the literature that modeling is the analysis of a set of data to make inference or identify meaningful relationship, and the use of this relationships to better describe future events (Davenport et al and 2006, Guszcza 2008). Furthermore there are several types of analytical techniques used in modeling as it has been discussed in different studies on descriptive analysis. In this study the technique used was linear regression model that was used to construct the LPG consumption descriptive model.

3.4.3 Specification of the functional form

The functional form used in developing the LPG consumption descriptive model was *log-linear regression.* The choice of this form was backed by information from the data collected in the field and literature review which indicate that log-linear regression, when compared with other models fit the LPG consumption better. The mathematical formula for log-linear regression models used is:

$$\text{In } Y = C + \Sigma\, \beta_i \text{ In } X_i + \alpha_j X_j + \varepsilon \quad \ldots\ldots (4)$$

Where: Y is the annual amount of cooking fuel consumed by a household; C is the constant term, β_i and α_j are the coefficients; X_i and X_j are socio-economic variables considered to influence quantity of household fuel consumption; and ε is a random error term.

3.4.4 Variables used in modeling

From different literature review on factors that influence households' fuel consumption and from personal experience acquired from the field guided the selection of variables that were to be included in the present LPG consumption predictive model. Table 4 shows variables which were considered useful for the model.

Table 4: **Variables used in the model**

variable	Description
Y	In [household LPG consumption]
X_1	Household monthly income
X_2	Education level of the respondent
X_3	Occupation of the respondent
X_4	In [price of charcoal]
X_5	In [price of LPG]
$X6$	Household size
$X7$	Age of the respondent
$X8$	Dwelling category
$X9$	Gender of the respondent

3.4.5 Why LPG

Modeling of the descriptive model was based on LPG consumption as it is the focus of this study. The study aims at promoting the use of modern cooking fuel, in particular LPG. In different literature on household energy, it has been advocated that LPG can be a perfect substitute of traditional fuels like charcoal and firewood. Also in recent years the availability of LPG has increased significantly and companies that distributes this product has forecasted a significant increase in demand.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Overview

This chapter highlights the socio-economic and demographic characteristics of the households' in the study area. The discussion in this chapter covers the economics of households cooking consumption and describes the socio-economic and demographic characteristics of the households such as age, sex, level of education, marital status, income and household size. This chapter also discusses households' consumption pattern of cooking fuels, households' cooking fuel preference and households' cooking fuel consumption intensity. Furthermore, this chapter highlights the relationship between households' cooking fuel choice and their socio-economic characteristics in the study area.

4.2 Respondents' Characteristics and Relationship to Households' Cooking Fuel(s)

4.2.1 Socio- economic characteristics

This first part will highlight the socio- economic characteristics of the respondents which include the sex of the respondents, age of the respondents, marital status and household size, respondent education level, respondent main occupation dwelling unit and ownership and households' income. This part is set to help provide a summary of the socio- economic characteristic that influences the households' consumption of cooking fuel(s).

4.2.1.1 Sex of the respondents

Findings presented in Figure 8 shows that 26% (52 respondents) were male while 74% (148 respondents) were female. This shows that most of the respondents that participated in the study were female as the study also intended. Despite the intention of having more female participants in the study, the sampling of the respondents was done randomly (see chapter 3) making the chance of having both a female and male respondent equal. But having more female respondents provides more accurate information on most issues pertaining cooking fuels. This has also been the case in a study done in Kisumu Kenya were it was believed that fuel procurement and cooking are largely responsibilities of women (Moses, 2003).

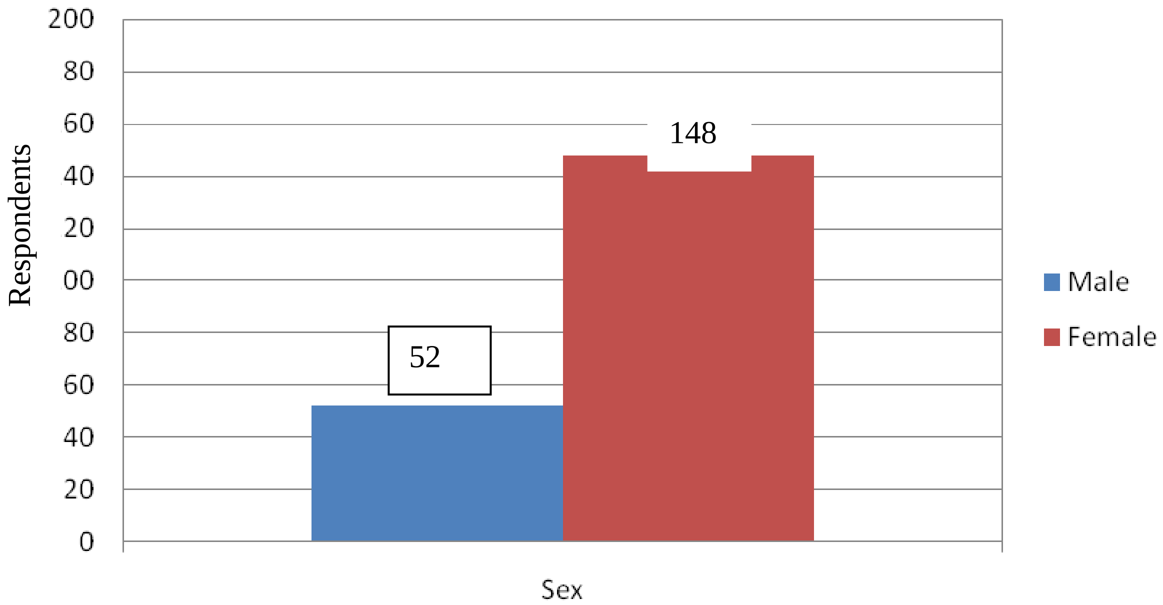

Figure 8: Sex of the respondents

4.2.1.2 Age of the respondents

The age of the respondents in the study as represented in Table 5 shows that 8% and about 24.5% were respondents aged 26-30 and 31-35 respectively. Also the proportion of respondents aged 36-40 and 41-45 were 15% and 25% respectively. The Table 6 also shows that there were about 19.5% of the respondents with the age of 46-50. Moreover, the table indicates the respondents with the age 51-55 and 56-60 were about 2.5% each. And those with the age above 60 were 3% of the total respondents.

Table 5: Age of the respondents

Age	Primary cooking fuel (n = 200)					
	Charcoal	**LPG**	**LPG+Charcoal**	**Kerosene**	**Firewood**	**Total respondents in a respective age group**
26-30	1	10	0	5	0	16
31-35	17	31	0	1	0	49
36-40	5	23	2	0	0	30
41-45	25	24	1	0	0	50
46-50	21	17	0	0	1	39
51-55	1	4	0	0	0	5
56-60	1	0	1	3	0	5
61+	0	6	0	0	0	6
Total	**71**	**115**	**4**	**9**	**1**	**200**

The findings presented in Table 5 suggests that age has some influence on choice of household cooking fuel(s) as it indicates that people with young age have high affinity towards the use of modern fuels as about 73.7% of those with the age between 26- 40 prefer to use LPG and kerosene as their primary cooking fuel which are both modern fuels. Furthermore, the findings also suggest that households with respondents with the age of 41- 50 are more likely to consume both traditional and modern fuels about 50% for each group of fuel. Last the findings suggest that as people grow older they prefer more modern fuels than traditional fuels. The reasons for this distribution are shown in Table 6 below.

Table 6: Reasons for the use of traditional/modern fuels

Age group	Traditional fuels	Modern fuels
26-40	→ *High price of modern fuels*	→ *More easier and convenient to use* → *Less time need for cooking* → *Less time available for cooking*
41-50	→ *Loyalty to traditional fuels* → *Hard dying habit* → *High price of modern fuels*	→ *More easier and convenient to use* → *Less time need for cooking*
50 and above	→ *Loyalty to traditional fuels* → *Hard dying habit*	→ *Less labour available* → *More easier and convenient to use*

So these reasons explain why different age groups have different preference of cooking fuels in the study which can be supported by the study done by Pundu and Fraser (2003) which demonstrated that older household heads are more likely to choose solid fuels. Also from a study done by Schlag and Zuzarte (2008) found that the high price of cooking fuels can result to a household to choose to use traditional fuels than modern fuels. In addition to that, another study done by Mekonnen and Kohlin (2008) revealed that modern fuels are relatively more adopted by younger household heads. So now we can conclude that age of the household head has some influence on the use/ adoption of households' cooking fuel(s).

4.2.1.3 Respondent's marital status and household size

For a better and clear psychological and sociological explanation of family size and the role of men and women in the well-being of their families, marital status provides valuable information (McLoyd et al., 2000; Walton and Takeuchi, 2010). The findings in Table 7 shows that among the respondents 8% were single, about 90.5% were married, 1% were divorced and about 0.5% were widowed. Also the findings of the study show that a respondents living alone were 4.5%. Households with 2 and 3 members were about 3.5% and 5% respectively while those households with 4 were about 13.5%. Households with 5 and 6 members were about 46.5% and 22.5% respectively. Also the households with 7 and 8 were about 3.5% and those households with more than 8 members were 1%. In general, the findings suggested that the study area has an average size of 5 members in a household. This was determined by using mode as a measure of central tendency.

Table 7: Respondent's marital status and household size

Marital status	**Frequency (%)**	**Primary cooking fuel (n = 200)**					
		Charcoal	**LPG**	**LPG+ Charcoal**	**Kerosene**	**Firewood**	**Total**
Single	16(8)	0	15	0	1	0	16
Married	181(90.5)	69	100	4	8	0	15
Divorsed	2(1)	2	0	0	0	0	2
widowed	1(0.5)	0	0	0	0	1	1
Total	**200(100)**	**71**	**115**	**4**	**9**	**1**	**200**
Household size							
1	9(4.5)	0	9	0	0	0	9
2	7(3.5)	0	7	0	0	0	7
3	10(5)	2	7	0	1	0	10
4	27(13.5)	5	17	0	5	0	27
5	93(46.5)	44	45	4	0	0	93
6	45(22.5)	20	22	0	3	0	45
7	1(0.5)	0	1	0	0	0	1
8	6(3)	0	5	0	0	1	8
>8	2(1)	0	2	0	0	0	0
Total	**200(100)**	**71**	**115**	**4**	**9**	**1**	**200**

Note: *Numbers in brackets indicates values in percentages*

Descriptive analysis on marital status and household from the findings in Table 7 suggests that people that are living alone and with less than 4 people in the household prefer to use modern fuel like LPG and Kerosene. Furthermore the findings suggest that married couple have a 50% preference towards traditional and modern fuels consumption. Most of the divorced and widowed have high affinity for traditional fuels as their households income drops, however this is for those female head households.

4.2.1.4 Respondents' educational level

Education of the respondent is believed to improve knowledge of fuel attributes, taste and preference for better fuels as well as income which can be used to purchase the fuels which are comparatively expensive (Pundo and Fraser, 2006). The findings in Table 8 show that 3% (2males and 4 females) had primary education, about 23.5% (5 males and 42 females) had secondary education, 49% (27 males and 71 females) had college education and about 24.5% (18 males and 31 females) had university education.

Table 8: Respondents education level and choice of primary cooking fuel

Education level	**Frequency (%)**	**Primary cooking fuel (n=200)**					
		Charcoal	**LPG**	**LPG+ Charcoal**	**Kerosene**	**Firewood**	**Total**
Primary education	6(3)	2	0	0	3	1	6
Secondary education	47(23.5)	29	18	0	0	0	47
College education	98(49)	37	52	3	6	0	98
University education	49(24.5)	3	45	1	0	0	49
Total	**200(100)**	**71**	**115**	**4**	**9**	**1**	**200**

Note: *Numbers in brackets indicates percentages*

Descriptive statistics on education of the respondents suggests that education of the respondent has some influence on choice and/or use of cooking fuel. the findings as presented in Table 8 suggests that respondents who have primary and secondary education have more affinity towards traditional fuels (for about 60%) than modern fuels(for about 40%), while those with higher education from colleges and university have higher affinity towards modern fuels (for about 73%) than traditional fuels (for about 27%).

This finding can be supported with a study done by Pundu and Fraser (2003) where they suggested that education improves knowledge of fuel attribute, tastes and preference for better fuels. Therefore the study may suggest that highly educated women are likely to lack time and see it inconvenient to prepare food by using traditional fuels and they may prefer to use the alternatives.

4.2.1.5 Respondents' main occupation

The occupation of the respondent is more likely to show how much the purchasing power a household has, as it is believed to improve the income of the household. Respondents with better jobs are more likely to have higher purchasing power for fuels and demand for better fuels as it elevates the social status of the household (Pundo and Fraser, 2006).

Table 9: Respondent occupation and choice of primary cooking fuel

Education level	**Frequency (%)**	**Primary cooking fuel (n=200)**					
		Charcoal	**LPG**	**LPG+ charcoal**	**Kerosene**	**firewood**	**Total**
Main occupation							
Government employee	123(61.5)	45	68	1	9	0	
Office work	38(19)	14	21	3	0	0	
Business man	13(6.5)	1	12	0	0	0	
Diplomats	2(1)	0	2	0	0	0	
Casual employment	22(11)	11	12	0	0	1	
Total	**200(100)**	**71**	**115**	**4**	**9**	**1**	**200**

Note: *Numbers in brackets indicates percentages*

The findings in Table 9 show that about 61.5% and 19% were government employees and office workers respectively. Also the findings show that about 6.5% were business men. Furthermore, the findings show that 1% were diplomats and 12% of the respondents were engaged in casual employment.

Descriptive analysis also revealed that there is some relationship between respondents main occupation and choice and/or use of cooking fuels. The findings as presented in Table 8 suggests that the is almost an equal preference of respondents that work for the government and those that work in private offices as well as those that have casual jobs towards traditional and modern fuels, while those works as diplomats and business man have a higher preference on using modern fuels (for about 92%) than traditional fuels (for about 8%). However, it is believed that women who have entered the formal workforce demand more convenience in their use of household fuel, this leads to preference in more better, cleaner and less time consuming fuels in meal preparation such as LPG (Dzioubinski and Chipman, 1999).

4.2.1.6 Dwelling category and ownership

The findings presented in Table 10 shows that all of the respondents in the study stay in concrete houses (modern houses) mad by bricks. However, the ownership of the houses differs, whereby about 40.5% owned their houses, 28% lived for free and about 31.5% were renting their houses.

Table 10: **Dwelling category and house ownership**

Dwelling category	Frequency (%)	Primary cooking fuel (n=200)					
		Charcoal	**LPG**	**LPG+ Charcoal**	**Kerosene**	**Firewood**	**Total**
Traditional	0(0)	-	-	-	-	-	-
Modern	200(100)	71	115	4	9	1	200
Total	**200(100)**	**71**	**115**	**4**	**9**	**1**	**200**
Ownership status							
Self owned	81(40.5)	46	30	1	3	1	81
Rented	63(31.5)	16	41	0	6	0	63
Living for free	56(28)	9	44	3	0	0	56
Total	**200(100)**	**71**	**115**	**4**	**9**	**1**	**200**

Note: *Numbers in brackets indicates percentages*

Descriptive statistics suggests that there is also some influence of house ownership towards the choice of household cooking fuel use. The findings in Table 10 suggest that there is approximately 57% and 43% preference towards traditional and modern fuels respectively by those who own their own houses. Also the findings suggests respondents that lives for free may prefer to use more of modern fuels (for about 84%) than traditional fuels (for about 16%), while those that rent their houses use modern fuels more (approximately 75%) than traditional fuel (approximately 25%).

The findings shown in Table 10 provides a different insight on the relationship between house ownership and choice of cooking fuel, from the initial thinking it was thought that people who own their own houses may prefer using modern fuels than traditional fuel as they have more income to spare from renting a house. But this has been the different case for this study, where by respondents that own their own houses seem to prefer traditional fuels to modern fuels. This prompt a question on why do people that rent houses prefer to use modern fuels than traditional fuels. The respondents that rent houses stated reason for this which included; lack of storage space, less time to procure traditional fuels, poor quality of traditional fuel and few members in the household. This means that the opposite of this reason may be the true for respondents that own their own houses. The findings show consistence to the initial thinking for people who lives for free as they may prefer modern fuels to traditional fuels.

4.2.1.7 Households' monthly income

Various literatures on household energy have conceptualized income as the main determinant factor of households' cooking fuel choice and consumption. Furthermore, the energy ladder model has conceptualized that as income increase people switch from one less efficient fuel to a better fuel upward the ladder. Therefore, if a household for example uses charcoal for cooking at a certain income, if there is an increase of income this household will switch from using charcoal and consume the next cooking fuel such as kerosene, LPG and/or electricity.

The findings in this study shows that most of the household in the study area can afford to buy all types of fuels except those with income below Tshs. 500 000. The findings in Table 11 suggest that Households with income of more than Tshs. 500 000 can afford the use of using modern fuel(s). Moreover, the findings suggest that households with income above Tshs. 500 000 use charcoal as their principal cooking fuel except those who have income more than Tshs. 2 500 000, these households use LPG instead of charcoal. This shows that households with income below Tshs. 2 500 000 are more likely to use a combination of fuels than those with income above. Also the findings in Table 11 suggests that households with income below Tshs.1 000 000 use kerosene but not at a significant amount (about 4.5%) and firewood is only used with those with income below Tshs. 500 000. These findings suggest that households do prefer using more better fuel(s) as income increase but it does not support the ladder model since households in the study area do consume a combination of traditional and modern fuels as the same time in this study the main combination was LPG and charcoal. In addition to that, it is suggested that if the household's income increase above Tshs. 2 500 000 the households could completely switch from using traditional fuel to modern fuel. Even so, use of traditional fuels in many urban areas remains high among low income groups.

Table 11: Household income and primary cooking fuel(s) Tsh. 1x 100,000/= (n=200)

HH Income	Charcoal	LPG	LPG and charcoal	Kerosene	Firewood	Frequency (%)
1-5	3	1	0	5	1	10(5)
5-10	17	14	0	4	0	35(17.5)
10-15	10	15	1	0	0	26(13.5)
15-20	28	45	3	0	0	76(38)
20-25	13	12	0	0	0	25(12.5)
25+	0	28	0	0	0	28(14)
Total	**71(35.5)**	**115(57.5)**	**4(2)**	**9(4.5)**	**1(0.5)**	**200(100)**

Note: *Numbers in brackets indicates percentages*

4.3 Household Cooking Fuel Consumption

After highlighting the socio-economic characteristics of the respondents in the study area as represented and explained in details in Part 1. This part presents in details the different aspects of household cooking fuel consumption and the effect that the socio-economic characteristics have on the consumption of cooking fuels. Therefore this contains the core issues of this study.

4.3.1 Household cooking fuel consumption patterns

The cooking fuel types found in the study area were firewood, charcoal, kerosene, LPG and Electricity. The findings presented in Table 12 shows eight combination of cooking fuels used by the households as follows; those using firewood, charcoal and kerosene were about 0.5%, LPG only were 12%, charcoal and kerosene were about 26.5%, while those using charcoal and LPG were 38%, LPG and Electricity were 10%, charcoal, kerosene and Electricity were 3.5%, charcoal, LPG and Electricity were about 4.5% and the last combination was charcoal, kerosene and LPG were 10%. This then supports the theory of energy stack model that households' due tend to consume a combination of fuels as from a menu rather than switching form one inferior fuel to a superior fuel but rather consume both set of fuels (Davis,1998).

The respondents in the study area stated that the more often used cooking fuel in the study area was LPG were about 57.5% used LPG for cooking followed by charcoal were about 35.5% used charcoal for cooking. The respondents that used more of LPG and charcoal at the same time were about 2% while those using kerosene and firewood were about 4.5% and 0.5% respectively. This shows that there is a significant decrease in the use of biomass fuels which is supported by a study done by Heltberg (2003) that indicated the use of biomass fuels is declining with income particularly in urban areas.

Table 12: Household cooking fuel consumption patterns (n=200)

SN	**Fuel combination**	**F**	**C**	**K**	**L+C**	**L**	**Frequency(%)**
1	F+C+K	1	-	-	-	-	1(0.5)
2	L	-	-	-	-	24	24(12)
3	C+K	-	49 (92)	4(8)	-	-	53(26.5)
4	L+C	-	17(22)	-	3(4)	56(74)	76(38)
5	L+E	-	-	-	-	20(100)	20(10)
6	C+K+E	-	4(57)	3(43)	-	-	7(3.5)
7	C+L+E	-	-	-	1(11)	8(89)	9(4.5)
8	C+K+L	-	1(10)	2(20)	-	7(70)	10(5)
	Total	1(0.5)	71(35.5)	9(4.5)	4(2)	115(57.5)	200(100)

Key: F-*firewood*, C- *charcoal*, K- *kerosene*, L-*liquidified Petroleum Gas*

Note: *Numbers in brackets indicates percentages*

4.3.2 Cooking fuel availability in the study area

The cooking fuels available in the study area as shown above and as perceived by the respondents that are used includes firewood, charcoal, kerosene, LPG and Electricity. As assumed earlier, firewood was overruled from the consumption since only one person use firewood as a primary cooking fuel. This can be due to availability of more commercial fuels and market for better markets for energy using equipments and appliance in the urban area. This is also enhanced by more diversity of fuels to choose from and greater accessibility to modern commercial fuels (Farsi et al 2005). The findings in Table 13 indicates that 61% of the respondents stated that charcoal is always available while 24% stated that charcoal is seasonal available and 15% stated that they do not use charcoal et al.

From the findings Kerosene is always available while about 69.5% of the respondents stated that LPG is always available while about 30.5% do not/ have not used LPG. This shows that the adoption of modern fuels is more significant in the study area and this can be due to the shifting demand of cooking fuels from less sufficient and less clean fuels to better fuels. The findings support the idea that due to economy development, urbanization and population increase more cleaner energy is consumed and demanded (Heltberg, 2005).

Furthermore, from the market and the respondents' perspective only charcoal, kerosene and LPG are the mainly available cooking fuels. However charcoal availability is restricted to only the charcoal market and very few charcoal vendors. The findings indicate that charcoal is more available in the charcoal market located in Kambi ya Fisi . According to Mr. Mwaijibe the city council natural resource officer, charcoal production is banned in Arusha and that the available charcoal comes from Singida, Tanga and Manyara.

Meanwhile kerosene is available in all petrol stations surveyed in the study area and its availability is reliable and most time available for consumers, but the number of domestic consumers has significantly decline due to its high price. On the other hand, LPG availability has significantly increased in recent years. In 2005, there was only one outlet of LPG in the City by then a municipal council as reported by a study done by Meikel (2005). The findings indicates that there are more than 25 business areas that provide LPG as surveyed in the study area as shown in Table 13 and most notably outlets being Oryx and Manjis petrol station who are also the major outlets as stated by the respondents, other places includes supermarkets, retail shops, dedicated LPG shops and other shops. In addition, there are five companies that supply LPG which includes Oryx Gas, Manjis Gas, Lake Gas, Orange Gas, and Mihan Gas. However, the major suppliers are Oryx and Majis Gas and this is because they have been in the business for a longer time compare to the other three.

Table 13: **Charcoal and LPG availability**

Availability	**Charcoal**	**LPG**
Always	122 (61)	139(69.5)
Seasonal	48(48)	-
Do not know/ do not use	30(15)	61(30.5)
LPG suppliers		
Manjis		
Oryx		
Lake gas		
Mihan gas		
Orange gas		
Outlets	**Surveyed outlets**	
Petrol stations	5	
Supermarkets	5	
Retail shops	5	
Dedicated LPG shops	5	
Other shops	5	

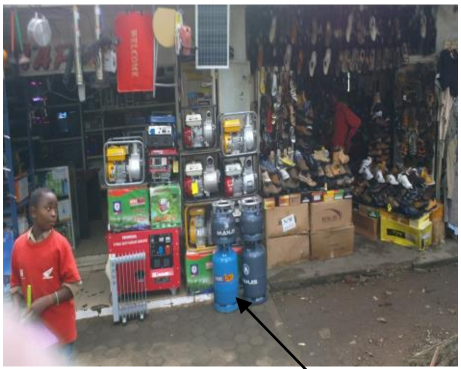

Plate 1:**Gas tanks at a petrol station**
(Photo: Semmy Thadeo)

Plate 2: **Gas tanks at an electonics shop**
(Photo: Semmy Thadeo)

Plate 3: **Gas tanks at a cloth shop**

(Photo: Semmy Thadeo)

From the findings and field experience suggest that households have different cooking fuels alternative as a coping strategy when there is shortage of their primary cooking fuel. Main strategies include temporarily switching to another fuel, temporarily switching to the next available cooking fuel present at that time stop cooking and eat already cooked food. Respondents described different set of alternatives when they are faced with fuel shortage as indicated in Table 14.

The result further revealed that shortage of charcoal can lead to the use of kerosene. The findings in Table 14 suggests that for households that use charcoal as their primary cooking fuel 55% use kerosene as their alternative fuel while 45% have no alternative. Also the findings suggests that out of 115 households that use LPG as their primary cooking fuel, 34% use charcoal as their fuel alternative, 7% use electricity, 3.5% use kerosene, 3.5% consume already cooked food, 17% have two tanks and 35% have no alternative. In case of households that use kerosene, 33% use charcoal and 67% have no alternative. From the findings and field experience it can be concluded that most of the households have no immediately alternative fuel when faced with fuel shortage. However, in case of fuel shortage the households coping strategy will be consuming the next immediately available cooking fuel that they can afford.

Table 14: **Households alternative cooking fuel(s)**

Principal cooking fuel	**Alternative cooking fuel**					
	Charcoal	**Kerosene**	**Electricity**	**LPG (two tanks)**	**Already Cooked food**	**No alternative**
Firewood	-	1(100)	-	-	-	-
Charcoal	-	39(55)	-	-	-	32(45)
Kerosene	3(33)	-	-	-	-	6(67)
LPG and charcoal	-	-	1(25)	-	-	3(75)
LPG	39(34)	4(3.5)	8(7)	19(17)	4(3.5)	41(35)

Note: *Numbers in brackets indicates percentages*

4.3.3 Fuel switching patterns of households

This section brings out the fuel transition pattern of households in the study area. As indicated in Table 15 the pattern of fuel switching shows a declining trend in the consumption of traditional fuels and kerosene while the consumption of LPG has been increasing. This indicates that the households are climbing the energy ladder longitudinally. Although the households show that they are climbing the ladder, it has also been revealed that there is a multiple use of cooking fuels.

Table 15: Income effects on household fuel switching

Category	Household income (Tshs)	Traditional fuels	Modern fuels	Total
1	100 000-500 000	4	6	10
2	500 001-1 000 000	17	18	35
3	1 000 001-1 500 000	10	16	26
4	1,500,001-2 000 000	28	48	76
5	2 000 001-2 500 000	13	12	25
6	2 500 001+	0	28	28
		72	128	200

The findings presented in Table 15 suggest that as income increase people switch from a inferior fuel to a superior fuel or traditional to modern fuels. It is evident only in point in time as we can see that as income increase the number of users of modern fuels increases. And the findings suggests as income increase it will reach a point that households will complete switch from traditional fuel to modern fuel as it is shows in Table 15 whereby all 28 households with a monthly income of category 6 consume modern fuels only. However, fuels switch is not always influenced by income increase as the findings in Table 15 also suggests that people also use a combination of fuels despite income increase as we can see that in two income categories (category 3 and 5) as there is slightly difference between traditional fuels users and modern fuel users. Thus from field experience and literature we can categories fuels switching in three stages which are no switch, partial switch and complete switch.

4.3.4 Household choice of cooking fuel consumption

In order to understand households' cooking fuel preference, a test was done for two hypotheses in connection with households' fuel consumption patterns. The first hypothesis is concerned with the influence of households' cooking attributes on choice of cooking fuel. Since charcoal and LPG in the study area, they were used in testing the hypothesis. For this hypothesis a binary logistic regression analysis was used;

Logit (Y) = ln [p/ (1-p)] = $\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \ldots$ ……………………… (5)

It assumes *Y* as a binary response variable

Where P is the probability of the event of interest, α is the *Y* intercepts, β_n are regression coefficients, and X_1, X2, X3 and X_4 are a set of predictors. α and βs are typically estimated by the maximum likelihood (ML) method, which is preferred over the weighted least squares approach by several authors, such as Peng *et al*. 2002 and Schlesselman (1982).

The ML method is designed to maximize the likelihood of reproducing the data given the parameter estimates. Data are entered into the analysis as 0 or 1 coding for the dichotomous outcome, continuous values for continuous predictors, and dummy codings (example 0 or 1) for categorical predictors.

The null hypothesis underlying the overall model states that all βs equal zero. A rejection of this null hypothesis implies that at least one β does not equal zero in the population, which means that the binary logistic regression equation predicts the probability of the outcome better than the mean of the dependent variable *Y*. The interpretation of results is rendered using the odds ratio for both categorical and continuous predictors.

Hypothesis

H_0: $\beta_1 = \beta_2 = \ldots.\ \beta_p = 0$ (household socio-economic factors have no effects on cooking fuel choice)

H_a: At least one of the $\beta_i \neq 0$ (household socio-economic and demographic factors have effects on cooking fuel choice)

The cooking fuels in the study area include firewood, kerosene, charcoal, LPG and electricity. As explained earlier the major cooking fuels in the study area are charcoal and LPG. Therefore, the modeling was made focused and conducted on these two fuels with the variables used in the model are presented in Table 16.

Table 16: Variables used in regression model

Variable	**Description**
Y	Household cooking fuel choice (0=charcoal, 1=LPG)
X_1	Age of the household age
X_2	Residence ownership (0= rented, 1=owned residence, 2=living for free)
X_3	Education level (0=primary education, 1=advanced education)
X_4	Household income (1:Tshs 500 001- 1 000 000 2:Tshs 1 000 001-1 500 000, 3: Tshs 1 500 001-2 000 000, 4: Tshs 2 000 001-2 500 000, 5: > Tshs 2 500 000
X_5	Occupation of the respondent (0=temporary employment, 1= permanent employment)
X_6	Household size
X_7	Marital status (0= unmarried, 1= married)

Table 17: Binary logistic regression analysis for household cooking fuel choice

	Choice of charcoal as cooking fuel							
Predictors	β	SE β	Wald's χ^2	df	P	Exp(β)	95% C.I of Exp (β) lower	Upper
Constant	-3.200	1.758	3.312	1	0.069^{NS}	0.041		
X_1	-0.107	0.116	0.846	1	0.035*	1.113	0.886	1.398
X_2	-0.225	0.204	1.218	1	0.027*	0.798	0.535	1.191
X_3	0.170	0.255	0.446	1	0.005**	1.186	0.720	1.953
X_4	0.31	0.123	0.066	1	0.798^{NS}	1.032	0.811	1.312
X_5	0.189	0.120	2.463	1	0.011*	1.207	0.954	1.528
X_6	-1.089	0.151	1.562	1	0.021*	0.828	0.616	1.113
X_7	-1.299	0.672	3.737	1	0.005**	3.665	0.982	13.679
Tests			χ^2	df	p			
Model evaluation (overall):								
Likelihood ratio test			247.947	7	0.202			
Goodness-of-fit test								
H-L statistic			10.393	8	0.239			

* Statistically significant at $\alpha = 0.05$
** Statistically significant at $\alpha = 0.01$
^{NS} Not statistically significant

Binary logistic regression analysis was carried out to find out factors affecting choice of cooking fuels (LPG and charcoal) in the study area as shown in Table 17. It was found that the statistically significant factors are: *Education level (p < 0.01)*: the higher the education level of the household head the more is the preference of LPG to charcoal, *marital status (p <0.01)*: unmarried people have more preference to LPG to charcoal than married people, *occupation of the respondent (p <0.05)*: people with permanent employment prefer to use LPG to charcoal than those who have temporary employment, *Household size (p <0.05)*: households with a small number of people prefers LPG to charcoal and those with a large number of household members, *Residence ownership (p <0.05)*: respondents with owned residence prefer charcoal to LPG while those who rented and live for free prefer LPG to charcoal, *age of the respondent (p <0.05)*: households with younger households heads and older age prefer to use LPG to charcoal while those in between prefer to either charcoal or LPG.

4.4 Household Cooking Fuel Consumption Intensity

4.4.1 Household cooking fuel consumption intensity in the study area

The findings as presented in Table 18 shows that household consume about 15KGs of LPG in two months or a month for a household whose consumption is cautious and normal respectively. This is for those households that consume LPG as their primary cooking fuel. Also the findings suggest that household tend to consume an average of 2 bags for a bag of 60-70 KGS in a month for normal use and this is for charcoal of good quality. Although, the consumption of the above mentioned cooking fuels depends on the number of members in the household. However, the conclusion for the above consumption intensity was made based on the average number of members in a household in the study area as mentioned in section above

Table 18: household's use of cooking fuel(s) per month

Cooking fuel	Quantity		Market prices		
	Cautious use	Normal use	Sadolin	Tin	Bag
Charcoal	1.5 bag	2bags	1,200- 1,400	6,000-7,000	28,000-30,000
			6kgs	15kgs	
LPG	7.5Kg	15kgs	21,000-22,000	51,000-54,000	

Note: A bag of charcoal is at an average of 70KGs in a normal quality and the use of the above fuels is based on an average of 5 members in the households.

4.4.2 Market price of cooking fuels as a predictor of cooking fuel consumption intensity

The findings in the study as presented in Table 18 shows that the price of charcoal is as follows; for a sadolin the price is at Tshs. 1,200- 1,400, for a tin the price is at Tshs. 6,000-7,000 and for a bag the price is at Tshs. 28,000- 32,000. Also the findings presented in Table shows that the price of LPG starts from Tshs. 51,000-54,000 for a tank of 15KGs and Tshs. 24,000-26,000 for a tank of 6KGs. The Price of kerosene was at Tshs. 2085. From these findings and the above findings, it shows that households using charcoal for cooking spend more money than households that use LPG. The study has also revealed that the cost of buying and transporting charcoal is higher that of charcoal (for about 7.6%) leaving out the associated health risks and time for setting off charcoal and cooking time. From the findings and field experience people not aware of these cost and they are rather ready to consume a bag of charcoal for up to Tshs.30, 000 at a single consumption which will not last for a whole month instead of a LPG tank for Tshs.54, 000 that can be used for the whole month at normal use. This shows that people in the study area that consume charcoal have less economically caution on their buying behavior and also not aware of the incurred cost in their choice of cooking fuel(s). However, from the author point of view most of people in the study area exhibit the same trait even for those that consume modern fuels like LPG and electricity. Most people consume fuel(s) based on their living standard or cultural values rather than considering the benefit and cost associated with their choice. Furthermore, findings suggests that households who consume charcoal as their principal cooking fuel prefer to use LPG and very few will like to use electricity as indicated in Table 19 but fail to consume them due to price constraints of the respective fuel(s) in the market. In the other hand, households that consume LPG prefer to use LPG, Electricity, solar and kerosene as indicated in Table 20.

Table 19: Cooking fuels often consumed and the price constrained of preferred cooking fuel in the market

Fuel often consumed	**Price constrained of preferred cooking fuel in the market**					
	LPG	**Electricity**	**None**	**Solar**	**Kerosene**	**Total**
Charcoal	60	3	6	0	2	71
LPG	17	30	67	1	0	115
LPG+ charcoal	0	1	3	0	0	4
Kerosene	3	3	0	0	3	9
Firewood	1	0	0	0	0	1
	81	**37**	**76**	**1**	**5**	**200**

4.4.3 Household income as predictor of cooking fuel consumption intensity

The descriptive statistics in Table 11 suggest households with a monthly income of less than Tshs.500, 000 (about 0.5%) cannot afford using modern cooking fuels. Also households with income above Tshs.500,000 can afford most type of fuels and the majority of them using Charcoal (about 35.5%) and LPG (about 57.5%). The findings in the Figure further suggest that households with income of Tshs.100,000- 500,000 are more likely to consume kerosene as their primary cooking fuel, where as those with income of Tshs.500,000-1,000,000 are more likely to consume charcoal. Also the findings in Table 10 suggest that households with monthly income of above Tshs.1,000,000 are more likely to consume LPG as their primary cooking fuel. from the findings we can help to conclude that people are more likely to switch from traditional fuel to more modern fuels as income increase, this can be supported by Chaudhuri and Pfaff (2003), who hypothesized that the higher the income lowers the probability of using traditional fuels. So as income increase a household will consume more of modern fuels than traditional fuel, but note that in some point they will still use combination of both fuels. This shows that even if the households' income increase people will always use a combination of fuels and households in the study area show no sign of completely switch from one fuel to another although they will indeed shift from using traditional fuel to modern fuel(s). from the above findings it gives me the confidence to contribute that the energy ladder model should be explained based on three categories of fuel switching which will included *no switching, partial switch and complete switch* (i.e. no switch−households which use traditional fuels only, partial switch−households which use both traditional and modern fuels, complete switch−households that use modern fuels only).

4.5 Descriptive Model of LPG Consumption

Since most of the households in the study area prefers the use of LPG as the source of cooking fuel. This study also found it interesting to develop a model that will be able to describe the consumption of LPG. The model was developed based on the following socio-economic variables as adopted from Lusambo (2009) were: Age of respondent, education level of respondent, Dwelling category, Household size, Gender of respondent, household monthly income, price of LPG, price of other modern fuels. These factors (independent variables) were considered as they influence fuel consumption (dependent variable).

4.5.1 Functional form of the model

The functional form used to develop LPG predictive model was log-linear regression. The choice for this form was supported by literature review and it is fit for LPG consumption data as well as other fuel consumption such as firewood and charcoal. The mathematical formula of a log-linear regression model used was:

$$\text{In } Y = C + \Sigma \beta_i \text{ In } X_i + \alpha_j X_j + \varepsilon \qquad (6)$$

Where: Y is the annual amount of cooking fuel consumed by a household; C is the constant term, β_i and α_j are the coefficients; X_i and X_j are socio-economic variables considered to influence quantity of household fuel consumption; and ε is a random error term.

4.5.2 Choice of variables

There are many socio-economic factors that are believed to influence the fuel consumption as they have been mentioned earlier in chapter 3. However the selection of variables used in the predictive model was governed by thoroughly literature review on studies done on household fuel consumption and from field experience. Table 20 shows the variables which were selected for constructing of the model. It should be noted that some variables that were included in the model was categorical. It was more easy and appropriate to mention the income category rather than the income of the households. Moreover, during data analysis occupation variables were treated as Temporary employment, Business and permanent employement. Also education variables were treated as primary education level(from primary to secondary school), secondary education level (from college that offers more qualification than the previous group but not a degree) and Advance education level (from a degree qualification onwards)

Table 20: Description of variables used in the log-linear model

Variable	Description
Y	Household LPG consumption
X_1	Household monthly income
X_2	Education level of the respondent (1: Primary education level,2=advance education level)
X_3	Occupation of the respondent (0=temporary employment, 1=Permanent employment)
X_4	Price of charcoal (Tshs/kg)
X_5	Price of LPG (Tshs/kg)

Table 21: Log-linear regression model parameter estimates for LPG consumption descriptive model

Parameter	B	Std error	t	Sig.	95% confidence interval	
					Lower bound	Upper bound
Intercept	6.681	0.014	41.118	0.0001	6.464	8.724
[Income]	0.194	0.014	1.575	0.031	-0.170	0.587
[Occupation=0]	-0.091	0.025	-2.114	0.024	-0.018	0.386
[Occupation=1]	0.051	0.032	6.782	0.037	-0.705	0.202
[Education=0]	-0.208	0.016	0.023	0.267	-0.463	0.490
[Education=1]	0.354	0.001	0.670	0.004	0.121	0.587
Ln Charcoal price	-0.148	0.488	-0.468	0.0001	-0.244	-0.053
Ln LPG price	-1.288	0.046	-6.417	0.623	-0.149	1.368

R2 = 0.780

R^2_{adj} = 0.769

Therefore, the proposed structural form of the descriptive model is:

$\text{In}Y = C + inc_i + occ_j + edu_k + \beta_1 \text{In}P_c + \beta_2 \text{In}P_l$ …………………………………… (7)

Where:

Pc = Price of charcoal (Tshs/kg)

P_l = Price of LPG

i: 1= low income; 2= medium income; 3= high income

j: 1= temporary employement, 2=business, 3= permanent employement

k: 1=primary education level; 2=secondary education level; 3=advance education level

From the information available in Table 21 we can now use it to form the predictive model as follows:

$$\text{In}Y = 0.668 + 0.194 + \begin{pmatrix} -0.091 \ \textit{if}\ j=1 \\ -0.051 \ \textit{if}\ j=2 \end{pmatrix} + \begin{pmatrix} -0.208 \ \textit{if}\ k=1 \\ 0.354 \ \textit{if}\ k=2 \end{pmatrix} -0.148\text{In}P_c - 1.288\text{In}P_l \ \ldots\ldots\ldots (8)$$

Therefore the descriptive model of LPG consumption as shown above can be useful in ensuring continues supply of LPG gas and also be used to describe the future demand of LPG. However the constructed model needs to be validated in order to make it more useful as predicting model.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

This chapter gives conclusion and recommendations based on the discussion of the findings as presented in chapter four. The main objective of the study was to examine the economics of urban households' cooking fuel consumption in Arusha city in Tanzania. The specific objectives were to: (i) investigate households' cooking consumption pattern (ii) analyse factors affecting the households' choice of cooking fuels (iii) examine households' cooking fuel consumption intensity (iv) develop LPG consumption descriptive model.

5.1 Conclusions

The results of the descriptive analysis show that, four fuels are used by the urban households' in Arusha city, these fuels includes; firewood, kerosene, charcoal and LPG. Also the study shows that there are eight fuel consumption pattern whereby six of them includes charcoal in the fuel bundle and five includes LPG and four includes kerosene. Electricity is only used as a alternative fuel when there is shortage of charcoal or LPG for these fuels users and the its use is not significant. The major cooking fuels in the study area as reveled by the findings in chapter four are charcoal and LPG which are likely to dominate fuel portfolio even in the long run.

Although the use rate of charcoal declines as income increases, it remains relatively important fuel for the majority low income class. According to the findings in the study LPG, by and large, dominates the urban cooking fuel portfolio followed by charcoal and kerosene. LPG is found to be urban fuel portfolio primary cooking fuel in the study area, followed by charcoal and kerosene. However, kerosene use is and might further decline due to its increase in price and availability of LPG as an alternative cooking fuel. In addition to that the decline is also a subject of LPG being the only next modern fuel available, reliable and affordable.

The socio-economic and demographic characteristics of the households are found to be important factors influencing the probabilities of fuels, choice, use and adoption. Broadly, the analysis confirms that, households are moving-up the energy ladder and their fuel choices are not only determined by their level of income, but, with addition of factors such as; higher education of household head, occupation of woman in the household, marital status, age of the household head, residence ownership, urbanization and insufficient availability and poor quality of traditional fuels in the market; tend to encourage adoption of modern fuels. However, fuel switching in this study area can be classified into three categories as households' in the study area do not completely switch from one inferior fuel to the next superior fuel instead they exhibit a fuel stacking characteristics (i.e. multiple fuel use). Thus, the study has classified fuel switching into the following categories; no switch, partial switch and complete switch.

Furthermore the study also reveals that households consume 15KGs of LPG for an average of two months for those households with cautions use and one and half months for those with normal use. Also the findings suggests that an average of two bags of charcoal can be used in a month for a charcoal bag of 70KGs and this is for normal use, but the consumption of charcoal depends on the quality of charcoal available and stoves used.

The study believes that adoption and consumption of LPG may increase if its price drops and price of traditional fuels rises. The study further reveals that most households are not economic cautions as most of them do not take into account the associated cost of using traditional fuel especially charcoal as they omit cost such transport cost and health associated risks.

The study also established a LPG descriptive model (equation 8) that will serve in providing an overview picture of LPG consumption by a household. The model was formed using predictors such as education level of the household head, household income, and occupation of the household head, price of charcoal and price of LPG. However, this model presented in equation 8 can serve a better purpose if it will help predict the future consumption of LPG. Therefore, there is room for this model to be validated in order for it to be able to predict the future consumption of LPG in a household.

5.2 Recommendations

The focus of this study is promoting the adoption of modern fuels, chiefly LPG. Based on the major findings, the following recommendations are made for policy actions in order to boost and foster this effort;

- The design of appropriate policy instruments and their implementation are critical for relieving energy crisis of urban households. With relevant insights for the United Nation millennium project, that recommends halving the number of households using traditional fuels for cooking by 2015, a policy intervention is deemed critical to help improve household welfare and assure sustainable availability of diverse modern energy sources for urban households, which will take into account its reliability and affordability.

- A complete energy transition from inferior fuel use to modern fuels use requires holistic social, economic, cultural, and even ideological changes of the whole society. Education provision on the cooking fuels and the associated cost and benefits should be provided in order to provide clear knowledge regarding each particular fuel. The education programs should be focused on carrying out capability building, where giving information on the negative impacts of using such fuel and the benefits derived when the public switch to modern fuels.

- Subsiding the household fuel sector should focus on end-user price on modern cooking fuels, cooking fuels appliances and LPG supply. Also in improving LPG distribution networks, through promotion of entrepreneurship in cylinders distribution, refilling and maintenance shops would promote and stabilize the supply of LPG. Such programs would also create positive externalities by engaging numerous small scale entrepreneurs in the household energy sector.

- Taking into account of the initial efforts of the city council to ban the production of charcoal in the region, more efforts should be done in the long run to reduce the accessibility of charcoal by putting restriction on the quantity of charcoal allowed to enter the city. This will help reduce the availability of charcoal for household and force them to adopt different alternative fuels as well as raise the demand of modern fuels. This will create a dependable energy distribution towards modern fuels.

If these efforts are achieved, the pressure of human activities on forests will decrease and help the fight towards deforestation. It will also help in environmental conservation and reduce the amount of air pollution and associated help risk from the use of traditional fuels. In summary it will help increase public development, improve productivity, reduce deforestation, help conservation efforts as well as improve human health.

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APPENDICES

Appendix 1: Questionnaires

Introduction

Hello, I am Thadeo Semmy Mokiti, a MSc. Environmental and Natural Resource Economics student at Sokoine University of Agriculture. I am conducting an academic research on the “Economics of Urban Household Cooking fuel Consumption in Arusha City, Tanzania” by using Arusha city as a sample to accomplish my work. The research is meant for academic purpose and will help me in my completion of my MSc. Environmental and Natural Resource Economics..

Kindly, respond to the questions below with as much transparency as possible. The information you provide will strictly be treated confidential. Participation in the study is completely voluntary. If you come to any question that you do not have an answer please let me know and go to the next question, or you can stop the interview at any time. However I hope you will participate in the study since your view is important.

Your cooperation is highly appreciated

Please choose the answer you fill is most appropriate for the multiple questions and fill your answer in the box provided and provide explanation to those questions that requires explanation according to your views.

A. GENERAL HOUSEHOLD INFORMATION

A.1 Division Themi,

A.2 Ward/………………………

A.3 Street /………………………..

A.4 Date of interview/……………………..,

A.5 Sex/……..

A.6 Your age/…….

A.7 Marital status (tick √ the appropriate answer please)

1) Single
2) Married
3) Divorced
4) Widow or widower

A.8 If married what is the age of your spouse? /……. yrs old

A.9 Highest Education level of Respondent and Spouse if married

Education status	Response	Respondent	Spouse
Have you attended school	Yes =1, No=2		
Level of education (if Yes)	Primary education=1 Secondary education=2 College=3 University (higher learning)=3 Other (mention)		

A.10 Occupation (multiple answer is allowed) and monthly income of Head of household and Spouse

Current occupation	Tick the appropriate answer	Monthly income
Government employee		
Office work		
Business Man		
Diplomat		
Other (please specify)		

A.11 What is the total number of household members living in this household?

	Age range	Number of persons
1	0-5 years old	
2	6-15 years old	
3	16- 20 years old	
4	21-24 years old	
5	25-60 years old	
6	60+ years	
Total		

A.12 What type of dwelling are you currently living in

1) Modern (brick house)
2) Traditional (straw or mud house)

☐

A.13 What is the ownership status of home that your household is currently living in?

1) Owned
2) rented
3) living for free (assistance)
4) other specify/…………………..

☐

A.14 Who makes your family final financial decisions?

1) Father
2) father and mother
3) all family members
4) others (mention)…………………………

☐

A.15 How does your household make its financial decisions

1) Household head only
2) Household head and spouse
3) all members of household
4) others (mention)……………………….

☐

B. HOUSEHOLD COOKING FUEL CONSUMPTION PATTERN

GENERAL COOKING FUEL CONSUMPTION

B.1 Which cooking fuel(s) do you consume?

1) ………………………………..
2) ………………………………..
3) ……………………………….
4) ……………………………….
5) ……………………………….
6) ……………………………….

B.2 Which cooking fuel(s) do you consume often?

1) ……………………………..
2) ……………………………...
3) ……………………………...
4) …………………………......
5) ……………………………...
6) …………………………......

B.3 How many times in a month do you consume the cooking fuel(s) mentioned in 18?

1) ……..
2) ……..
3) …...
4) ………………………………
5) ………………………………
6) ………………………………

B.4 What is your coping strategy when your favourite fuel is not available?

1) Yes
2) No

☐

B.5 Do you know that there are modern and traditional cooking fuels?

1) Yes
2) No

☐

B.6 Which cooking fuel(s) mentioned in B.1 do you regard as modern fuel(s)

1) …………………………….
2) …………………………….
3) …………………………….

4) ……………………............

5) ……………………………

6) ……………………………

B.7 Why do you regard the cooking fuel(s) mentioned in B.6 as modern fuel(s)? (give reason(s)……………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………

B.8 Which cooking fuel(s) mentioned in B.1 do you regard as traditional fuel(s)?

1) ………………………………

2) ………………………………

3) ……………………………….

4) ……………………………….....

5) ………………………………..

6) ………………………………..

B.9 Why do you regard the cooking fuel(s) mentioned in B.8 as traditional fuel(s)? (give reason(s)…………………………………………………………………

FIREWOOD CONSUMPTION

B.10 Does your household currently use firewood for cooking? ☐

1) Yes
2) No

B.11 How frequently do your household use firewood for cooking ☐

1) Use most of the times
2) Use for some of the time
3) Use for a specific type of food
4) Have not used

B.12 Where do you obtain your firewood supply? ☐

1) Purchased,
2) cut from forest for free,
3) other specify……………………………………..

B.13 How much firewood do you use for cooking in a month? Please state the answer of the amount used in Bags/…………………Bags

CHARCOAL CONSUMPTION

B.14 Does your household currently use charcoal for cooking?

1) Yes
2) No

B.15 How frequently do your household use charcoal for cooking

1) Use most of the times
2) Use for some of the time
3) Use for a specific type of food
4) Have not used

B.16 How much charcoal do you use for cooking in a month? Please state the answer of the amount used in Bags/…………………Bags

B.17 How much is charcoal available for you household?

1) Always
2) Season
3) Not available

KEROSENE CONSUMPTION

B.18 Does your household currently use kerosene for cooking?

1) Yes
2) No

B.19 How frequently do your household use firewood for cooking

1) Use most of the times
2) Use for some of the time
3) Use for a specific type of food
4) Have not used

B.20 How much kerosene do you use for cooking in a month? Please state the answer of the amount used in litres/…………………litres

LIQUIFIED PETROLEUM GAS (LPG)

B.21 Does your household currently use LPG for cooking? ☐

1) Yes
2) No

B.22 If NO, why?

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………

B.23 Which company gas tank do you use? Please mention……………………………….

B.24 How frequently do your household use LPG for cooking ☐

1) Use most of the times
2) Use for some of the time
3) Use for a specific type of food
4) Have not used

B.25 Where do you obtain your LPG supply? ☐

1) Filling statiion,
2) LPG shops,
3) other specify……………………………………..

B.26 How much LPG do you use for cooking in a month? Please state the answer of the amount used in KGs/…………………KGs

B.27 How often is LPG available in the market to your Household?

1) Always available
2) Season available
3) Not available

ELECTRICITY

B.28 Does your household currently use electricity for cooking? ☐

1) Yes
2) No

B.29 If NO, why?

....

....

....

B.30 How frequently do your household use electricity for cooking

1) Use most of the times
2) Use for some of the time
3) Use for a specific type of food
4) Have not used

☐

C. HOUSEHOLD COOKING FUEL CONSUMPTION INTENSITY, COST AND EXPENDITURE

C.1 How much quantity of cooking fuel(s) mentioned in B.3 do you consume in a month?

1) ……………………………
2) ……………………………
3) ……………………………
4) ……………………………
5) ……………………………
6) …………………………….

C.2 What is the market price of each cooking fuel mentioned in B.3?

1) …………………………….
2) …………………………….
3) …………………………….
4) …………………………….
5) …………………………….
6) …………………………….

C.3 Have you ever failed to purchase cooking fuel(s) because of its price?

1) Yes
2) No

☐

C.4 Which cooking fuel(s) in the market do you prefer the most?

C.5 Please provide the most optimum amount that you have spent in the last past month on the expenditure list below.

S/NO	EXPENDITURE ITEM	AMOUNT
1	Cell Phone	
2	Clothing	
3	Education	
4	Household utility such as water and maintenance	
5	Household energy such as heating, lighting and cooking (e.g. charcoal, electricity, liquefied petroleum gas, firewood, etc)	
6	Food	
7	Car/bus/taxi/transport	
8	Housing rent	
9	Support for other family members	
10	Health care	
11	Leisure	
12	Savings/investments	
13	Donation/ giving's for religious	
14	Other………………………………………	
	TOTAL	

Appendix 2: Market survey checklist

1. What product do you sell?

2. Who are your customers?

3. What is the age of your customers?

4. Do you have regular customers?

5. How do your customers acquire your product?

6. How much of your product do you sell per month?

7. What is the price of your product?

8. How much is your product demanded?

9. Are there any difficulties in selling your product?

10. Have you ever run out of stock?

11. Who are your competitors?

Appendix 3: Key informants interview schedules

Checklist (a)

1. How is the current supply of charcoal?

2. Where does it come from?

3. How is it distributed?

4. What is the average consumption in Arusha city?

5. What is the demand of charcoal in Arusha city?

6. How much does a household consume charcoal in a month/year?

Checklist (b)

1. What is the economic situation in Arusha city?

2. How is the purchasing power of household in Arusha city on cooking fuels?

3. What is the average spending of households in a month/year?

4. In your opinion is LPG and/or other modern fuels affordable?

5. If Yes, then why do people use traditional fuels instead of modern?

6. If No, what should be done?