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DETERMINANTS OF HOUSEHOLD'S CHOICE OF COOKING ENERGY IN UGANDA

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ABSTRACT

High dependency on biomass has been associated with energy poverty in Uganda with successful intervention to modern energy expected to results to economic transformation. This paper examines utilization of various forms of cooking energy sources among households using data from the 2005/6 Uganda National Household Survey (UNHS). Results indicate that utilization of modern energy sources was only by 4 percent of households. A multinomial probit model (MNP) was used to estimate coefficient of determinants of energy choices. Determinants of household energy choices were observed as consumption expenditure welfare, residing in urban or rural areas, household size, achievement of education levels beyond primary level and regional location of a household. The study recommended deliberate efforts by government to intervene in addressing low adoption of modern energy especially now that the country has oil and gas reserves. The government should implement policies to encourage private sector involvement in provision of modern energy alternatives, provision of micro-credit for buying equipments and availing modern energy in smaller quantities.

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1.0 INTRODUCTION

Energy poverty is one of the factors contributing to slowing down economic and social-transformation in Uganda (GoU, 2010). Energy poverty is defined as the absence of sufficient choice in accessing adequate, affordable, reliable, quality, safe, and environmentally benign energy services to support economic and human development (MEMD, 2002a). The energy exploitation and consumption patterns reflect that the country is still in infancy stages of energy application in production processes. The exploitation patterns are such that biomass accounts for 92 percent of total energy consumed while fossil fuels accounts for 7 percent and electricity only 1 percent. Most of biomass energy is from wood, which is consumed in the form of charcoal and firewood (NEMA, 2009).

Biomass exploitation is unsustainable due to heavy reliance of natural forests, limitation to its application and serious environmental effects (GoU, 2010). The rural – urban per capita consumption has been estimated at 680 kg per year and 240 kg per year for firewood and 4 kg and 120 kg for charcoal respectively (MEMD, 2007). Promotion of efficient use of energy and mitigation of the adverse environmental and health effects associated with the use of biomass fuels is an important policy issue for the country. Alternatives to biomass energy sources include electricity, liquidified petroleum gas (PLG) and kerosene, all of which are considered cleaner sources (Modi *et. al*. 2006).

Utilization of biomass has been observed to result to negative environmental, social (health) and economic impacts among the poor in the developing countries (von Schirnding et al. 2002). One of the most profound environmental issues affecting Uganda is high rate of deforestation (NEMA, 2009). Yet, forests play important roles including climate moderation, carbon sequestration, influencing the rainfall patterns, flooding control, absorption of pollutants, biodiversity conservation and other ecosystem services such as provision of food, medicine and spiritual purposes (NFA, 2004). Utilization of agricultural waste as fuel aggravates the soil fertility depletion which is associated with high cost especially for replacement of organic matter (Sanginga and Woomer, 2009). Loss of biodiversity affects the aesthetic, existence and bequest value that are important for tourism industry (NEMA, 2009). Low or non-use of clean energy may result to negative environmental effects that have negative impacts on key productive sectors including forestry, agriculture, tourism and water (GoU, 2010).

Globally about 1.3 million deaths per year are attributed to indoor pollution from biomass energy utilization (OECD/IEA, 2006). The deaths are more than those of malaria estimated at 1.2 million per annum. In Uganda pollution related diseases including upper and lower respiratory account for the second highest incidence of reported health issues after malaria (Nabulo and Cole, 2011). Other health issues that have been linked to indoor pollution exposure in developing countries include cancer, tuberculosis, perinatal mortality, low birth weights and eye irritation and cataract (von Schirnding et al. 2002).

A number of interventions have been undertaken for the energy sector in the last few years. In 2002, a National Energy Policy was produced with a goal "to meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner" (MEMD, 2002a). The policy was a response to the government's desire of a long-term planning approach to the energy sector due to its importance to the economy. One of the objectives of the policy was to manage energy-related environmental impacts and was to be achieved through promotion of alternative sources of energy and technologies which are environmentally friendly.

In 2007, the Renewable Energy Policy for Uganda was produced with a main goal of increasing the use of modern renewable energy, from the 4 percent to 61 percent of the total energy consumption by the year 2017 (MEMD, 2007). The policy wished to respond to some challenges associated with renewable energy technologies in meeting energy needs of the country. One of the challenges was the country's desire to fulfill the commitment on greenhouse gas emissions reductions, under the Kyoto Protocol and contribution to the global fight against climate change. Efficiency in biomass energy utilization was recommended in the renewable energy policy, but so far no efforts have been documented on the issue or intervention to reduce utilization of fuelwood. Although the country through the Forestry Policy and National Forest Plan strives to increase fuel source through farm forestry, the success of the activity are yet to be observed (NEMA, 2009). Already, supply of the biomass fuels has been limited leading to increased prices (UBoS, 2009) and the scarcity having impacts on the quality (nutritional value) of food prepared among the poor (NEMA, 2008).

Albeit the efforts by the government to encourage use of alternative energy source through policies, high levels of reliance on biomass energy for cooking has persisted (UBoS, 2010). No wonder, the country has remained among the energy poorest in Africa and has the second least improvement on multidimensional energy poverty index in the continent (Nussbaumer *et. al.* 2012). Natural resources management institutions have put in some effort in addressing the energy challenge by raising concern on the higher levels of forest depletions (NEMA, 2009; NEMA, 2008; NFA 2005). The recommendation of the natural resources management institutions has been to plant more trees to replace the forest cover lost through biomass harvesting for energy.

The efforts of replacing forest cover have not been successful due to long durations it takes for trees to mature and the higher rate of deforestation to cater for energy, timber and expansion of agricultural land (NFA, 2005). Figure A.1 (appendix) shows the country wood fuel utilization, country potential and net increase in biomass (MEMD, 2002b). Both the available stock and available yearly yields have been on decline trends. The available stock has declined from 275 million tonnes in 1995 to less than a million tonnes. Available yearly yields have declined from 33 million tonnes per year to about 15 million tonnes per annum. Consumption of woodfuel has been on increase from 19 million tonnes to 26 million tonnes per year.

Natural resources have been depleted to the point that they are no longer able to provide employment, water, fuel, medicine, spiritual and cultural services and support other productive sectors leading to higher levels of poverty (NEMA, 2008). A case is reported in Nakasongola where community livelihoods used to rely on rangelands through firewood and charcoal burning and selling. Currently the same community is experiencing challenges accessing biomass energy sources leading to a shift to paraffin for cooking, buying of firewood from other places and some households although with food are unable to afford cooking energy leading to hunger. Such experiences as in Nakasongola are wide spread in more districts with the entire country predicted to encounter biomass fuel scarcity by 2014 (MEMD, 2002b).

Utilization of biomass energy has been observed to be inefficient at production, processing and use levels (Naughtons-Treves et al. 2007; MEMD, 2002b). For example, charcoal production technologies recovery rates in Uganda are low at between 10 and 15 percent (Kazoora, *et al.* 2010). Naughtons-Treves and others (2007) estimated that the manufacturer of 50 tonnes of charcoal from hardwood required the clearance of 1 square kilometer of forest cover.

Considering the existing biomass resources, population growth and demand for land for various uses, the best intervention for addressing energy challenge may be on demand side management with more emphasis being on household shifting to cleaner energy. Understanding the factors that influence high reliance of biomass energy as a household cooking energy source and determining opportunities for shifting demand from biomass to modern energy will compliment the government intervention on the energy sector especially the supply side management. It is important to understand the demand side issues especially consumption patterns and factors affecting energy choice at the household level.

1.1 Policy Question and Objectives

The policy question being addressed by this study is "what are the interventions necessary to ameliorate households' energy poverty in Uganda?" The objectives of the study include: to determine factors influencing household's choice of cooking energy source in Uganda, to determine existence of relationship between energy poverty and household's consumption expenditure welfare and to determine factors that will facilitate amelioration of energy poverty in the country. Results of the study will provide information that will effectively facilitate the implementation of the energy policy and provide a yardstick for evaluation of the promoted and implemented energy policies that address people's basic needs and the preservation of the environment.

2.0 LITERATURE REVIEW

Concerns have been raised about the high proportion of people in developing countries relying on biomass such as fuelwood, charcoal, agricultural waste and animal dung to meet their energy needs for cooking (OECD/IEA, 2006). Unsustainable harvest of resources and energy conversion technologies inefficiency were prioritized as issues requiring immediate intervention. The study called for new policies to ensure shifts to cleaner and efficient use of energy for cooking. It recommended two complimentary approaches to improve the situation: promoting more efficient and sustainable use of traditional biomass and encouraging people to switch to modern cooking fuels and technologies with appropriate mix depending on local circumstances. The same study observed that switching to oil-based fuel would not have significant impacts on world oil demand and even when fuel costs and emissions were considered, the household energy choices of developing countries would not be limited by economic, climate-change or energy-security concerns.

Utilization of an energy source by a household was considered a discrete choice from a number of other alternative supply choices arranged in order of technological sophistication whether in rural or urban areas (Campbell et al. 2003). As the demand for or supply of more sophisticated fuels increased, a greater number of users made transition from firewood and charcoal through kerosene to LPG and electricity. This transition concept also considered as "energy ladder" (van der Horst and Hovorka, 2008) is driven by economic change, change in taste and preference of energy choice, technological change on energy sources, energy carrier availability (Campbell et al., 2003) and/or shifts in supply of energy options (Zulu, 2010) and their prices (van der Horst and Hovorka, 2008). The sophistication of energy sourcing has impact on environment and household health.

When households climb the energy ladder, forest resources utilization reduces as less of firewood and charcoal are required. Indoor and outdoor pollution that leads to respiratory acquired diseases is reduced or eliminated with shift to more sophisticated sources (Mishra, 2003). The sophistication of energy sources has been considered as improvement of household's or/and country's welfare, akin to other socio-welfare indicators that have been used to measure the standard and quality of life (Berenger and Verdier-Chouchane, 2007).

The Millennium Development Goals (MDGs), a United Nations initiative outlining time-bound goals in areas of poverty, health, education and environment recognized the importance of energy welfare to achieving most of the goals. The importance of modern energy in contributing to welfare in terms of health, saving time and providing opportunities for other activities (especially for women and children), improved productivity and education achievement has motivated international donors support to energy development as part of achieving MDGs (United Nations, 2005). Energy poverty has been considered to undermine global development challenges including income poverty, inequality, climate change, food security, health and education (Nussbaumer et al., 2012). While the idea of poverty has been widely accepted among the international community, it has been very difficult to get an agreement on an adequate definition of energy poverty due to problems in dealing with methodological and conceptual issues in defining it (Barnes, et al., 2011).

A number of approaches have been used in defining or establishing levels of energy poverty. Pachauri and Spreng (2004) estimated energy poverty based on energy expenditure as a proportion of household total expenditure. Under this measure households spending more than 10 percent of their total expenditure on energy are considered as energy poor. Another measure that has been used in estimating energy poverty is by considering the energy type used and its value in the consumption expenditure of poor households (Foster *et. al.* 2000). Another measure of energy poverty considers the physical needs of daily requirements for cooking and lighting based on surveys around the world and sets the minimum energy need to be about 50 kgOE[1] per capita per year (Modi, *et al.* 2006). Barnes *et al.,* 2011 used energy demand, income and other factors to identify the energy poverty line in Bangladesh and reported high consistence between the income and energy poverty. It was observed that 46 percent of the income non-poor were also energy non-poor while 81 percent of energy poor were also income poor.

Nussbaumer *et al*, (2012) used a multidimensional energy poverty index (MEPI) to estimate the deprivation of access to modern energy services in Africa. MEPI captured both the incidence and intensity of energy poverty at various levels including regional and country levels. Socio-economic and market access factors influence the household choice and intensity of utilization of various energy types, which when analyzed provide insight on energy poverty. Narasimha, *et al* (2007), used micro level data covering 118,000 households to establish variation in energy use by Indian households. They reported that a household chooses the desired source of energy considering their socio-economic characteristics, availability and prices of the different energy sources. The socio-economic characteristics that affect choice of primary source of energy include household size, income, religion, education and age of the family head and location of household whether in urban or in rural area and region. Economic, technical, social and traditional constraints affected complete switching to cleaner fuels in rural India (Joon *et. al.* 2009). Social factors that affected use/ choice of fuel used included housing characteristics, cooking behavior and food types. Demand for biomass fuel was predicted to persist if only pure transition approach based on the sophistication of energy source were not undertaken.

The policy scenarios with either improved financing opportunities, fuel subsidies or a combination of both in India, suggested that a major obstacle for the adoption of modern fuels, especially LPG, is the high investment cost and the discount rates that the consumers use in their energy related decisions. According to the results, subsidy alone may be inefficient for promoting modern fuels, as the steep upfront investment costs are not always covered through the subsidy. Improved financial opportunities for the appliance investment alone would already increase penetration of modern fuels remarkably within the population. Combined with small LPG subsidy, the whole population might be prompted to switch to LPG (Ekholm, *et al.* 2010).

An increase in the proportion of households using wood fuel sources was reported in Kano State in Nigeria between 2002 and 2006 against a background of supply challenges for biomass sources of energy in the town's vicinity due to deforestation (Maconachic, *et al*. 2009). Although availability of wood was reported to have reduced between 2002 and 2006, its utilization rose by about 40 percent by 2006. Factors that affected the choice of energy sources included, cultural factors, cost of energy source, household size, convenience in use, health concern, environmental consideration, food taste attributable with specific energy use, energy source availability and recruitment of large number of people into energy business due to shifting returns from other enterprises.

1 kgOE stands for kilogramme oil equivalent. A measure of total energy consumption (1000 kgOE=42 Giga joule)

In Ouagadougou, Burkina Faso firewood was the cooking energy source of choice by 70 percent of households (Ouedraogo, 2005). Other preferred choices by households were LPG, charcoal, kerosene, electricity and other fuels which were reported by 13, 6, 4, 1 and 7 percent respectively of the households surveyed. Determinants of a household's cooking fuel choice for either natural gas, charcoal, firewood, kerosene and other fuels were income, frequency of different food delicacy cooking, household size, achievements of primary education, age of household and religion of household head, existence of cooking facilities (external or internal) and availability of electricity for lighting. The coefficients of the marginal effects of multinomial logit models for all these factors were significant at either 1, 5 or at 10 percent significance level as determinants of household cooking energy preference. Other factors with significant coefficients of the marginal effect included sex of household head, higher education level achievement and ownership of the dwelling.

3.0 DATA AND METHODS

3.1 The Data

Data used in this paper are derived from the Uganda National Household Survey 2005/6 (UNHS 2005/6) collected by Uganda Bureau of Statistics (UBoS). In particular, the data was derived from the socio-economic and community modules. The survey covered 7,421 households with 42,111 individuals and was conducted between May 2005 and April 2006. The survey was based on a two stage stratified random sampling design. In the first stage, Enumeration Areas (EAs) were selected from the four geographical regions with probability proportional to size. The sample of EAs was selected using the Uganda Population and Housing Census Frame for 2002. In the second stage, 10 households were randomly selected from each of the EA using simple random sampling. The household questionnaire gathered information on socio-economic issues affecting households and communities. Information on the type of fuel used for cooking in 2005 and retrospectively in 2001 was collected among others. The community module captured information on community infrastructure among others.

The data used includes the social economic characteristics of households, types of energy used for cooking and expenditure on energy sources used for cooking. The types of cooking energy included in the survey were firewood, charcoal kerosene, electricity, biogas and liquefied petroleum gas (LPG). Information reported on use of various energy sources in 2001 was only used descriptively due to its limitation for detailed analysis. The analytical part of the study utilized respondent information on energy use during the survey in 2005/2006. The energy sources were categorized into three including firewood, charcoal and modern energy.

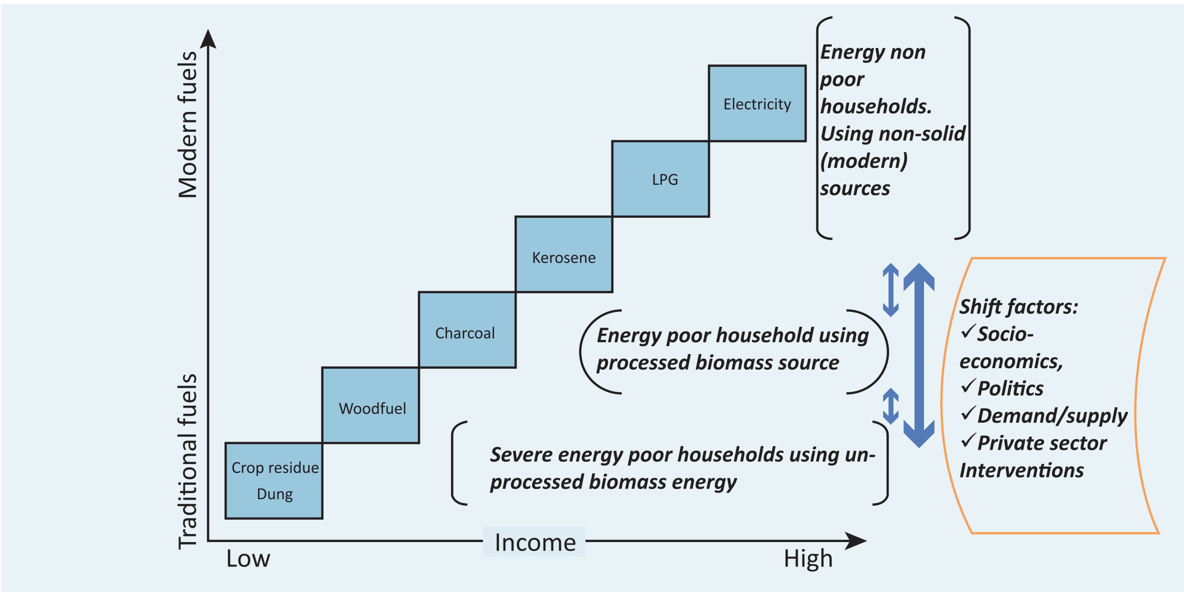
3.2 Conceptual framework

As shown in Figure 1, use of various energy sources for cooking by households reflect a ladder. Shift from one level to the other is influenced by socio-economic characteristics of the household, supply factors and government interventions that influence price of energy options. The use of non-processed biomass sources of energy or firewood (i.e. crop residue and wood fuel) illustrates energy poverty among households and is associated with the lowest scale of the ladder. This type of energy source is associated with higher levels of indoor pollution, time allocations especially by women and children for its collection, unreliability of supply and local environment degradation. The use of firewood is therefore a detrimental factor in welfare improvement and constraint to the achievement of all the eight Millennium Development Goals (MDGs).

Although the use of charcoal has been considered among some literature as similar to firewood due to it being biomass sourced and the fact that it is solid (Rehfuess, *et al.* 2006), this study considered it as a transitional step in achieving desired energy welfare. Charcoal is processed thereby improving its portability, reducing its pollution potent and does not constraint the achievement of all the MDGs. All other energy sources which are non-solid and are not biomass derived have been considered as the desired type and hence are associated with better household welfare. This category of energy source that include fossil fuel derived kerosene and liquidified petroleum gas (LPG) and electricity utilization have minimal constraint in achievement of all MDGs (Barnes, et al. 2011).

The movement of households to different levels of the energy ladder reflects a shift from one energy poverty level to another. A number of factors influencing such shifts include changes in socio-economic characteristics, changes in community characteristics as influenced by private sector actors or government and or changes affecting energy types' prices as a result of interactions between demand and supply. Government interventions could influence shifts from one energy level to the other especially with policies that affect access and prices of energy sources. This study is interested in establishing socio-economic factors determining household choices for cooking energy.

Figure 1. Conceptual framework of poverty –energy ladder nexus



Source: Adapted from van der Horst and Hovorka, 2008

3.3 Analytical Model

To assess the most likely explanation(s) for household utilization of a particular type of cooking energy among the various categories, this paper uses the multinomial probit model (Maddala, 1983). The model was selected due to its practicability on prediction of probability for multiple choices and the fact that it has been widely used (Jumbe and Angelsen, 2011; Jepsen, 2008). The multinomial probit model (MNP) was chosen from other probabilistic-choice models as the data used on energy choice was unordered (McFadden, 1980; Jepsen, 2008). MNP was adopted in favour of multinomial logit model (MNL) in the consideration of assumption related to the residual. MNL assumes residuals as identically and independently distributed, while MNP consider residual as independent and normally distributed (Maddala, 1983). Besides MNP takes cognizant that other alternative choices also influence the outcome unlike MNL which doesn't (Lerman and Manki, 1982).

Although MNP has been identified as constraint in computations involving evaluating multiple integrals, in this study limitation did not apply as only three alternative outcomes were being considered (Maddala, 1983). If more than three alternatives of outcome were being considered, then, we could have simulated using the Monte Carlo simulation techniques (Maddala, 1983). To address the challenge of heteroskedasticity which is common with cross-sectional data, weights were incorporated in the analysis.

The theoretical framework for analyzing household's decisions on the choice of energy source type can be cast in a random utility model (McFadden, 1980). The MNP model could be simply represented as

$$y^*_{ij} = x_i'\beta_j + \varepsilon_j$$

In this equation y^*_{ij} is the unobservable utility of alternative i as perceived by individual j. x' is a (1 x M) vector of explanatory variables characterizing both the alternative i and the individual j. β is a (M x 1) vector of fixed parameters and ε_{ij} is a normally distributed random error term of mean zero assumed to be correlated with errors associated with the other alternatives j, j =1, … j, j ≠ i. Where it is assumed that the ε_i's follows a multivariate normal distribution with covariance matrix ∑ where ∑ is not restricted to be a diagonal matrix. Category j is chosen if Y^*_{ij} is highest for j, i.e.

$$y_i = j \text{ if } y^*_{ij} = \begin{cases} j \text{ if } y^*_{ij} = \max\ (\ y^*_{i1}, y^*_{i2} \dots\dots\dots\dots y^*_{iM}, \\ 0 \text{ otherwise} \end{cases}$$

The probability to choose category j can then be written as

$$p(y_i = j|x_i) = p\ (y^*_{ij} > y^*_{i1}, \dots, y^*_{ij} > y^*_{i(j-1)}, y^*_{i(j+1)}, \dots\dots y^*_{ij} > y^*_{iM})$$

$$= p\ ((\varepsilon_{ij} - \varepsilon_{i1}) > x_i'(\beta_1 - \beta_j), \dots (\varepsilon_{ij} - \varepsilon_{i(j-1)}) > x_i'(\beta_{(j-1)} - \beta_j),$$

$$= p\ ((\varepsilon_{ij} - \varepsilon_{i(j+1)}) > x_i'(\beta_{(j+1)} - \beta_j), \dots (\varepsilon_{ij} - \varepsilon_{iM}) > x_i'(\beta_M - \beta_j),$$

Looking at this probability it is clear that only the differences between the y^*_{ij}'s are identified and hence a reference category has to be assigned. As a consequence the covariance matrix also reduced in its dimension from (M x M) to (M-1) x (M -1). If definition for $\varepsilon_{il} = (\varepsilon_{ij} - \varepsilon_{il})\ and\ \xi_{il} = x_i'\ (\beta_{(j-1)} - \beta_j)$ for l =1… (j+1), …. , M then the probability $p(y_i = j|x_i)$ is given by a high dimensional integral at each iteration (Weeks, 1997). We shy away from highlighting the dimensional matrix (Bolduc, 1999; Weeks, 1997) in this paper considering the type of readers we are targeting. To estimate the probability p (y_i=1), we make one or more draws from the density f $((y_i^* = |x_i, \beta)$ and calculate the fraction of draws that fall into the required interval, namely, $y_i^* \geq 0$.

In this case we estimate the equation given by

$$y*_{ij} = x_i'\beta_j + \varepsilon_j$$

Where $y*_{ij}$ is the probability of cooking energy source alternative (i.e. energy source selected either from firewood, charcoal or modern). x_i' is a vector of explanatory variable composed of vector of household head characteristics, household characteristics and community characteristics, β is a vector of the parameters, while ε_{ij} is the error term. i represents individual households while $_j$ could take the value of 1, 2, or 3 depending on choice of energy. Explanatory variables used in the MNP are shown in Table 1. In this analysis modern energy comprised the non-solid energy sources used for cooking including electricity, kerosene, LPG, solar and biogas.

3.4 Model specification testing issues

The proliferation of random effects is one of the most troublesome characteristic of the multinomial probit model. The computational challenges associated with dimensional integral have been lifted by development of the simulation-based inference particularly the Monte Carlo integration, yet due to the number of outcomes evaluated, MNP was effective for this study. The specification of an error structure associated with the underlying data generating process is a key component of any (stochastic) economic model (Weeks, 1997). In the case of the MNP model, the importance of this is magnified given that the impact of misspecification of the error structure filters through to the parameters of the deterministic component of choice. Although the specification of the stochastic component does influence mean equation parameters, necessitating specification testing in multinomial models, no testing have been recommended for MNP due to its inherent complexity (Hausman and McFadden, 1984). Unavailability of specification testing notwithstanding, researcher has adopted the MNP due to its strength than the MNL which also require a Hausman specification test. The test statistics is based upon the difference between the two sets of parameter estimates and relies on both being consistent under the null. This is a particularly logical test of the MNL model since the predominant characteristic of the model, the independence of irrelevant alternatives (IIA), states that the ratio of two probabilities depends only upon the attributes (and possibly characteristics) of the two alternatives considered (Weeks, 1997).

Although the MNP model is characterized by the intractability of probability expressions for greater than four alternatives, the log-likelihood function has a relatively simple structure. As a consequence, once an estimator has been found for the pseudo true value, the Cox test statistic has a closed form representation. Also it has been recommended of a possibility to utilize classical methodology to compare the MNL and MNP. Since the few proposed testing involve arbitrary decisions by the analysts, their use and improvement are limited (Natarajan *et. al.*, 2000; Bolduc, 1999; Weeks, 1997).

3.5 Descriptions of variables used in the analysis:

Household head characteristic: - Household head characteristics considered in this study include:- education level of household head, marital status and sex interaction, and age of household head. Achievement of advanced level of education was predicted to lead to adoption of a higher energy source on the energy ladder. Education levels achieved were disaggregated into categories including no formal education; some primary; completed primary; some secondary; completed secondary and any other post-secondary education.

Age of the household head was expected to have inverse relationship with adoption of an alternative higher energy source on the energy ladder. Age captures an individual's life cycle and its association with influencing adoption of technologies. Age of household was categorized into those aged below 25 years, those aged 26 and above but less than 60 years and those aged 60 years and above.

Marital status and sex interaction was considered as an important factor that will influence choice of energy source in a household. Categories for marital status and sex interaction were unmarried/divorced/widowed female head, married female, unmarried/divorced/widowed male head and married male. Inclusion of a variable representing missing data on education levels of household head was influenced by the fact that leaving that information out could have biased the analysis. The variable was included after imputing median value of education level of household heads.

Household characteristics: - Household characteristic considered were household size, share of adults in the household and household welfare proxied by consumption expenditure. Choice of an energy alternative higher in the ladder was predicted for households with improved welfare (high income or expenditure) and those with larger proportion of family members being adults. Since investment on cleaner energy is considered expensive household with improved welfare were assumed have higher probability of affording modern energy. Households with many members were assumed to be unlikely to adopt cleaner energy due to more energy requirements and associated costs to fulfill household demand.

Community characteristics:- Community characteristics considered as important in influencing choice of energy for cooking by a household were whether the household is located in rural or urban area, specific region, distance to feeder roads.. Access to different energy sources have a location dimension with modern energy sources e.g. electricity is well distributed in urban areas. Regional dummies (Central, Eastern, Northern and Western) and distances to feeder roads (infrastructure) were also considered as explanatory variables. Also included in the explanatory variables, was the variable representing missing data on distance to feeder roads. The variable was included after imputing median value of the distance to feeder roads.

Dependent variables: the multinomial probit model used to estimate determinants of energy choice in household allowed the concurrent use of three dependent variables. The variables used were firewood, charcoal and modern energy.

Table 1. Description of explanatory variables used in the model

Characteristics	Explanatory variables	Proportion (%)	SD
Household head characteristics			
Education level of household head	No formal education	18.1	
	Some primary	41.5	
	Completed primary	14.9	
	Some secondary	13.6	
	Completed secondary	5.1	
	Post-secondary plus	6.9	
Education level of household head (missing data)	Imputed median value of education level of household head	0.006	
Marital status and sex interaction	1=unmarried/divorced/widowed female head, 0=Others	18.3	
	1=Married female, 0=Others	8.9	
	1=unmarried/divorced/widowed male head, 0=Others	8.7	
	1=Married male, 0=Others	64.1	
Age of household head	Household age<=25 years	12.3	
	Household age=(26-59) years	71.8	
	Household age>=60 years	15.9	
Household characteristics		*Mean*	
Household size	Household size	5.2	2.9
Share of adults in the house hold	Share of adults in the household	0.6	0.6
Welfare	Log of Consumption expenditure per adult equivalent per month (Ush), real terms	10.7	0.7
Community characteristics		*Proportion (%)*	
Residence in urban	1= urban, 0=others	22.9	
Region	1=central, 0=others	28.3	
	1=eastern, 0=others	25.9	
	1=Northern, 0=others	21.9	
	1=Western, 0=others	23.8	
		Mean	
Distance to feeder roads	Log of distance to the feeder roads	0.7	1.1
Distance to feeder roads(missing data)	Imputed median value of distance to feeder roads	0.04	0.2

4.0 RESULTS

41. Descriptive results

Table 2 shows the proportion of households using various sources of energy for cooking in Uganda in 2005 and 2001. In 2005, firewood use at the national level was 76 percent of households. Charcoal use at national level was low with about a fifth of all households. Use of modern energy was observed to be very low nationally with only 4 percent of household reporting its use in 2005. Use of charcoal was dominant in urban areas

Table 2: Trends of households' cooking energy source preference in 2005 and 2001 (column percentages)

	Urban		Rural		National		Regional, 2005			
Energy Source	2001	2005	2001	2005	2001	2005	Central	East	North	West
Firewood	38.9	29.9	92.1	90.2	80.4	76.4	63.6	78.3	83.3	83.3
Charcoal	55.9	60.8	6.8	7.7	17.6	19.8	30.1	18.6	18.3	13.0
Modern	5.1	9.3	1.2	2.2	2.0	3.8	6.3	3.1	1.42	3.7
Total	**6,761**	**7,389**	**6,761**	**7,389**	**6,761**	**7,389**	**2,088**	**1,920**	**1,623**	**1,758**

Source: Authors calculation based on UNHS, 2005/6

(61 percent) while firewood was widely relied on in rural areas where 90 percent of respondents reported it as the main energy source for cooking. Use of modern energy sources was by 2 and 9 percent in rural and urban areas respectively.

In urban areas, the proportion of households who were using firewood progressively decreased from 39 percent in 2001 to about 30 percent in 2005. The proportion of urban households who were using modern cooking energy increased from 5 to 9 percent. There was an increase in the proportion of households who were using charcoal from 56 to 61 percent among urban dwellers between 2001 and 2005. The proportion of rural households who used various types of energy changed marginally between 2001 and 2005. Reliance on firewood as a preferred choice of cooking energy source reduced from 92 to 90 percent. In rural areas, the proportion of those who used charcoal and modern energy in 2005 increased by about one percent from the 2001 levels. Nationally, status of various energy sources used changed slightly between 2001 and 2005. Proportion of households who were using firewood decreased from 80 to 76 percent. Proportion of households utilizing charcoal increased from 18 to 20 percent while use of modern energy rose from 2 to 4 percent between 2001 and 2005.

Energy source utilized for cooking among households changed marginally between 2001 and 2005 indicating a little improvement of type of household's cooking energy adopted among Ugandans. This study's observation is consistent with that of Nussbaumer and others (2012) which reported only slight improvement in multidimensional energy poverty indices (MEPI) in Uganda over time. Although Uganda was observed as being among the energy poorest country in Africa together with Malawi, Rwanda, Niger and Ethiopia, the country performed the worst in improving its population's energy poverty welfare.

Though firewood was the most popular cooking energy source across the regions, the highest percentage of households who reported use of firewood as the main energy source were in northern and western regions (83 percent). Only Central region reported a percentage use of firewood lower than the national average. The percentage of households using charcoal in the Central was 30 percent, more than twice the percentage in the Western at 13 percent. As expected, modern energy utilization was highest at 6 percent in the more urbanized Central region which has greater access to modern sources of energy.

Figure 2 depicts the relationship between household welfare (proxied by consumption expenditure) and their expenditure on various categories of cooking energies. The graph for household expenditure on charcoal indicates that at lower levels of household welfare improvement (increased consumption expenditure to about UGX 300,000 per month), households increased its use up to about UGX 25,000 per month. As welfare improved expenditure on charcoal reduced while expenditure on modern energy increased. At higher levels of welfare, households do not expand firewood use. Expenditure on firewood remained low at less than UGX 15,000 per month. From the graph it is clear that there is a direct exponential relationship between monthly expenditure on modern energy and consumption expenditure per adult equivalent. Observations from this graph lead to a conclusion that the incidence and intensity of improved energy utilization among households is influenced by household welfare proxied by consumption expenditure.

Figure 3 shows share of total expenditure attributed to various types of energy sources for different income quintiles. Across all quintiles, expenditure on charcoal accounted for the largest share of spending on energy. The expenditure on firewood and modern energy accounted for the second and third largest share respectively across all the quintiles. While the ratio of expenditure associated with energy to the total household expenditure decreased as one ascended to the richer quintiles, the patterns of spending on various energy types remained identical. The ratio of expenditure attributed to modern energy decreased as one ascended the welfare ladder from quint1, the poorest fifth of the households to quint5 (the richest 20 percent of the households). The ratio of spending on various energy types to the household's total expenditure ranged from 3 to 11 percent.

Figure 2. Household income and cooking energy expenditure relationship in 2005

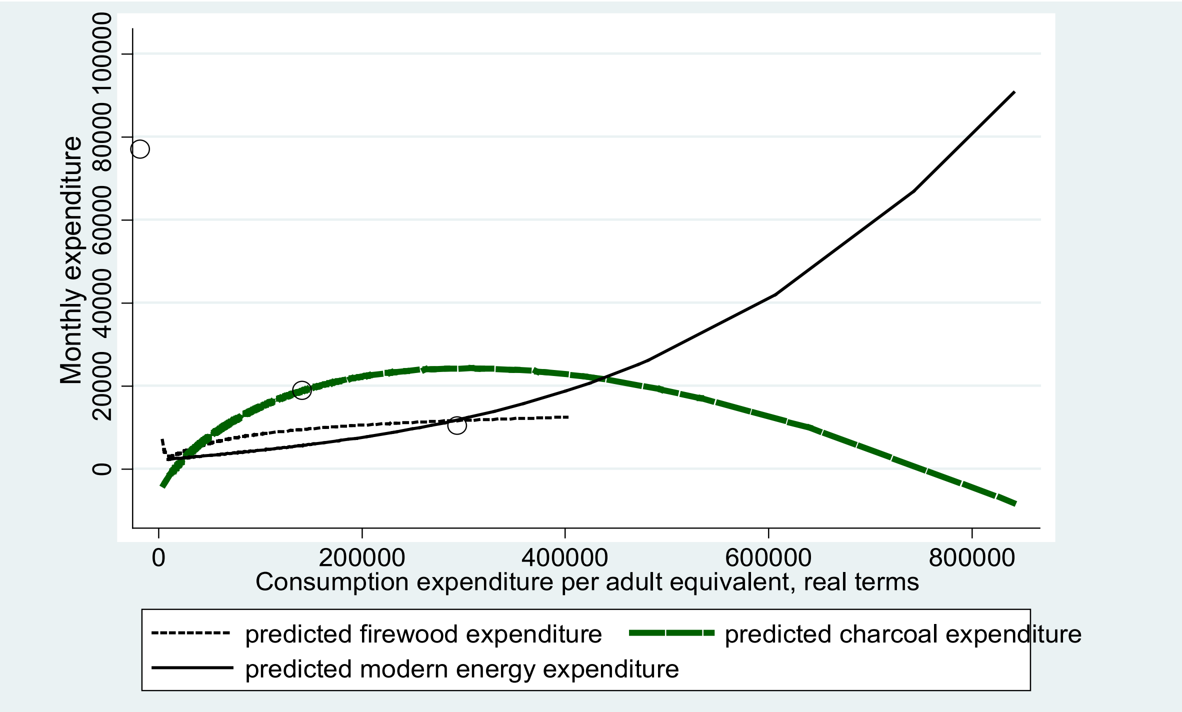
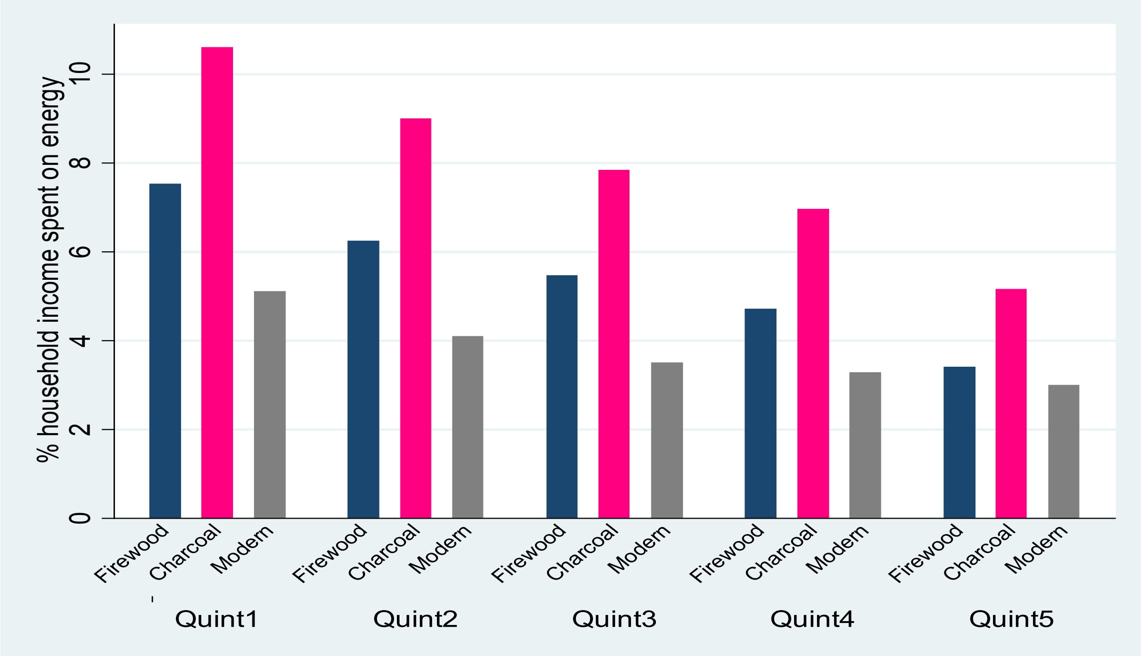


Figure 3. Proportion of income spent on energy by income quintiles in 2005



Source: Authors calculations based on UNHS 2005/06

4.2 Analytical Results

Table 2 shows marginal effects coefficients and predicted probability of a multinomial probit estimates. Predicted probability values confirmed that most households had very high probability (89.7 percent) of adopting firewood for cooking. Households with a probability of choosing charcoal as energy source accounted for 9.7 percent of Uganda's households, while those that could have a probability of choosing modern energy made up less than 1 percent of the population.

The marginal effects of household energy use for cooking indicate that households in rural areas had 51 percent chances of choosing firewood than their urban counterparts. The probability of household in urban area adopting modern energy was about 3 percent. The probability of household in urban area choosing charcoal was about 49 percent. Achievement of formal education by household head to beyond completion of primary education was observed to have increased the probabilities of households choosing cleaner energy source.

Achievement of some secondary education reduced the likelihood of households adopting firewood as the cooking energy source. Completion of secondary and post–secondary plus education achievements reduced probabilities of choosing firewood by 13 and 14 percent respectively. Being unmarried/divorced/widowed male head, share of adults in a household, improved welfare and a household being in the urban increased the likelihood of households adopting modern energy.

Married females, household heads aged above 25 years, large households and household being in Northern region were observed as being significant in reducing likelihood of household choosing modern energy as the cooking energy source. Some factors that influenced household persistence use of firewood included;- the head of

Table 3. Marginal effects coefficients and predicted probability of a multinomial probit estimates (Base fuel choice= Modern)

	Firewood Pr(choice=0.883		Charcoal Pr(choice=0.109		Modern Pr(choice=0.008	
	Dp/dx	SE	dP/dx	S.E	dP/dx	SE
unmarried/divorced/widowed female head	0.003	0.015	-0.001	0.014	-0.002	0.003
Married female	0.019	0.014	-0.013	0.014	-0.006***	0.003
unmarried/divorced/widowed male head	0.026	0.016	-0.065***	0.012	0.039***	0.013
Household age=(26-59) years	0.046***	0.014	-0.038***	0.013	-0.008**	0.003
Household age>=60 years	0.119***	0.012	-0.111	0.011	-0.008***	0.003
Some primary	-0.006	0.017	0.005	0.015	0.001	0.004
Completed primary	-0.018	0.020	0.017	0.019	0.002	0.005
Some secondary	-0.071***	0.024	0.068***	0.023	0.002	0.005
Completed secondary	-0.125***	0.040	0.123***	0.038	0.002	0.007
Post-secondary plus	-0.135***	0.040	0.128***	0.039	0.008	0.007
Data on education level missing	-0.095	0.108	0.103	0.108	-0.008***	0.002
Log of welfare (consumption expenditure)	-0.107***	0.010	0.096***	0.009	0.011***	0.003
Share of adults in the household	-0.044	0.029	0.012	0.028	0.033***	0.011
Household size	0.015***	0.003	-0.014***	0.003	-0.002***	0.001
urban	-0.513***	0.033	0.485***	0.031	0.027***	0.007
Eastern	0.071***	0.017	-0.069***	0.016	-0.002	0.003
Northern	0.073***	0.018	-0.068***	0.017	-0.005*	0.003
Western	0.122***	0.017	-0.118***	0.015	-0.004	0.003
Log of distance to the feeder roads	0.002	0.009	-0.001	0.008	-0.001	0.001
Data on distance to feeder roads missing	0.029	0.021	-0.033*	0.019	0.004	0.007

*Significant at the 10% level; ** significant at the 5% level and *** Significant at the 1% level. Sample size (n) = 7304 household being in age category above 59 years, between 26 to 59 years and household size. An increase by one individual in a household had a 2 percent probability of plunging a household into severe poverty. Households found in Eastern, Northern and Western had 6, 7 and 11 percentage chances of experiencing severe energy poverty than their counterparts in Central region. The shifts from Central to other regions had significant influence on the choice of alternative energy sources at ($P< 0.01$).

5.0 CONCLUSION AND POLICY IMPLICATIONS

5.1 Conclusions

The study has observed high dependency of firewood as cooking energy source among households in Uganda. Socio-economic factors affecting choice of energy source for cooking have been observed as consumption expenditure (welfare); whether a household is in urban or rural areas, age of household head, number and composition of members in households, geographical regions, marital status and sex and education levels of household head. There is direct relationship between households' consumption expenditure levels and energy poverty. Considering that a large proportion of households have likelihood of choosing either firewood (88.3 percent) or charcoal (10.9 percent), the ability of available biomass stock to sustainably cater for cooking energy is doubted. Although there was a slight decline in the proportion of households utilizing firewood and charcoal between 2001 and 2005, the condition seems to be persistent requiring deliberate targeted policies to ameliorate the problem.

Considering the persistently high demand for wood fuel and yet wood regeneration is very low, the forest resources are under high pressure with resultant high depletion rates. To ensure conservation of the forest resources for them to offer other ecosystem services, an intervention to reduce fuel wood dependency is urgently required. The successful intervention would address the costs aspect of wood fuels and also other consequences including; human health, climate variability and change, and environmental disasters from the high level of reliance on this fuel. While it is possible to shift household from a specific utilization of energy source to another, it is difficult to replace trees/forests as mitigation to climate change as fast as the country may desire. This therefore suggests the need for urgent and deliberate policy intervention to shift household cooking energy sources from wood fuel to other superior sources and hence reducing the levels of energy poverty.

With the country's recent discovery of oil and gas reserves and its commitments to pursuance of the social welfare improvement and economic transformation (GoU, 2010), targeting shift to modern energy sources is timely. The move will also ensure mitigation to the threat of climate change as forest resources will be saved and an avenue for more income through the Reducing Emissions from Deforestation and Forest degradation (REDDs) programmes (NEMA, 2010). Availability of the energy source targeted and improved welfare of the population will facilitate shift.

5.2 Policy Implications

There are several policy implications of these results.

i) *Policy interventions that would increase the demand for LPG cooking technologies*

Government interventions that may affect successful transition include those supporting the households to afford LPG or paraffin energy as well as the appropriate equipment to be used in cooking. It would be worthwhile for government to rethink policy that would increase the demand for LPG cooking technologies than just the reduction of tax on LPG. The high cost of LPG cooking equipment (canisters, hose, stove) may be more of detriment on LPG use than just the price of LPG.

The government should also consider through fiscal policies to encourage private sector to ensure that modern energy especially LPG equipment (cylinder) are available in small quantities that most households could afford to replenish regularly as the challenge of re-filling the conventional cylinder (which are large with the smallest being 6Kg) may hinder its use. Government and other development agencies should provide affordable micro-credit to households to support purchase of efficiency appliances and required equipment for use with modern energy sources.

ii). *Government to provide incentives for private sector participation in supply of modern energy*

Government should provide incentives and enabling environment for private sector participation in supply of modern energy. Improvement of infrastructure in the countryside will encourage private sector investment and hence removal barriers to accessing of cleaner fuels. Government and other sectors stakeholders should also encourage demand through promotion of cleaner energy.

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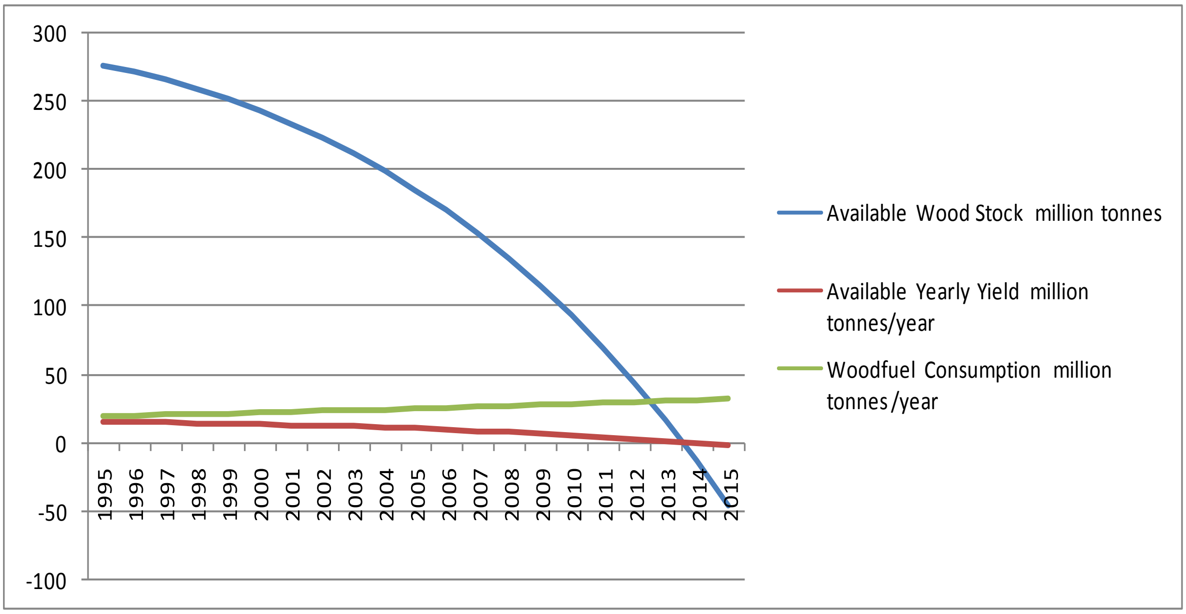
7.0 Appendix

Appendix 1

Figure A.1 shows the country wood fuel utilization, country potential and net increase in biomass.



Source: Ministry of Energy and Mineral Development, 2002b

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