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Urban Adaptation to Energy Insecurity in Uganda

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Abstract

The level of development of a society can be measured not only in terms of quantity of goods and services but also from the energy consumed. The importance of energy security derives from the critical role that it plays in all aspects of livelihoods of any society. The Government of Uganda is committed to well-planned urbanization and effective management of urban growth. This brings issues of low income settlements to the forefront of the national development agenda under one umbrella, but the provision of energy services to meet demand in low income settlements remains a critical challenge. Low income settlements in the four urban areas in Uganda were identified and a survey of energy demand patterns was conducted. This paper adopts ordered logistic regression modelling integrated with factor analysis (principal components analysis) to explore: 1) the relative importance of variable factors in determining household energy utilization, and 2) how they shape adaptation to energy insecurity within and across low-income settlements in selected urban centres in Uganda. Results indicate that, although charcoal use is uniform across all households, a large percentage of the slum population is heavily dependent for its energy services on multiple energy sources. Furthermore, households are burdened with relatively high retail prices for energy, electricity instabilities and wood shortages and wasteful/inefficient energy use. The logistic model indicates that household size, the share of adults in the household and gender in combination explain the utilization of firewood and electricity. Furthermore, adaptation strategies to energy insecurity coalesce around self-generation and use of improved energy technologies, adjustments in cooking practices and energy substitutions, and adjustments in sleeping schedules. Urban areas in Uganda are the residences of the future and efforts aimed at building energy security are very important.

Keywords

Energy Security, Energy Mix, Low Income Settlements, Uganda

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1. Introduction

Energy is crucial to a functioning society (Walekhwa, Mugisha, & Lars, 2009). It is critical to enhancing production, competitiveness and incomes (World Bank, 2007a) through its support to productive activities and facilitation of investments in industry, commerce and agriculture (World Bank, 2007a; OAG, 2011). Its availability has direct poverty impacts and is an important determinant of the quality of life in human settlements (Buchholz & Da Silva, 2010; World Bank, 2003). Access to modern forms of energy is essential to overcome poverty, promote economic growth and employment opportunities, support the provision of social services, and, in general, promote sustainable human development (Karekezi, McDade, & Kimani, 2012). The importance of energy in Uganda is further illustrated in the National Development Plan 2010/11-2014/15 where it is identified as one of the eight primary growth sectors in the country.

Uganda's internal energy potential is high but comprises of largely underdeveloped hydro, mini-hydro, solar, biomass, geothermal and peat resources although the energy sector comprises of both locally produced and imported traditional and conventional sources of energy (Sserunjogi, 2014). The proportion of households who depend on the particular fuel category differs across the across the country. Biomass dominated by fuel wood and charcoal accounts for more than 93 percent of Uganda's primary energy supplies, while imported fossil fuels and hydropower electricity supply only six and one percent, respectively (Banaabe, 2012; Zanchi, Frieden, Pucker, Bird, Buchholz, & Windhorst, 2012). Despite the discovery of oil, all petroleum products are still imported, while electricity is locally generated except for very limited off-set/inter-connection imports from Kenya and Rwanda (UBOS, 2010).

Energy security is a major stumbling block for economic development and improved standards in Uganda (Lee, 2013). The linkages between energy and the MDGs have been discussed elsewhere (World Bank, 1983) but reports in Uganda indicate that the per capita energy consumption is 69.5 kWh, which is a fraction of the African average of 578 kWh and world average of 2572 kWh (MEMD, 2012). According to the World Bank Global Tracking Framework[1] report, Uganda is grouped among those countries with the highest deficit in access to electricity (Banerjee, Bhatia, Elizondo, Jaques, Sarkar, Portale, Bushueva, Angelou, & Inon 2013).

Uganda has over the years experienced rapid growth, and, like most developing countries, the demand for energy is consequently increasing, superseding the supply of energy. For example, consumption of petroleum in the country increased by 38% between1995 and 1999. The total energy consumption in 2005 was estimated at almost 9 million tonnes of oil equivalent (TOE). The energy consumption per capita was 330 kilogram of oil equivalent (Kg-OE), and commercial energy consumption per capita was 23.5 Kg-OE (NEMA, 2010).

The concept of energy security takes on several interpretations and dimensions and this is illustrated by Brown, Rewey, & Gagliano (2003); Checchi, Behrens, & Egenhofer (2009); Cherp & Jewell (2011); Hildyard, Lohmann, & Sexton (2012) and Winzer (2011). It is a plastic phrase used by a range of different interest groups to signify many often contradictory goals (Hildyard et al., 2012) with greater emphasis placed on the relationship between national energy security and long-term availability of resources to provide power to a country than on community levels (Jarvie & Nicholson, 2013). The testing bed for this concept in this paper is the household. Energy security has been defined as "the absence of sufficient choice in accessing adequate, affordable, reliable, quality, safe, and environmentally friendly energy services to support economic and human development" (Reddy, 2000). In this paper, energy security means the continuity of energy supplies relative to demand and/or the uninterrupted availability of energy sources at an affordable price. Clearly, communities have to respond in some way and devise mechanisms to adjust to situations when their energy supplies are affected. This paper explores the way in which people adapt to energy insecurity, by calling on a wide range of physical attributes, capabilities and behaviours.

The paper is structured as follows: The next section starts with a short review of different case studies that address energy utilization in Uganda. This is followed in the third section by an explanation of the data and methods used in the study, followed by results and discussion in Section 4. The concluding section of the paper presents the emerging policy implications.

[1]The detailed World Bank Global Tracking Framework report identified India as the most deprived country in terms of access to energy with as many as 306.2 million of its people are still without energy. The remaining 19 nations lacking access to energy, with the number of deprived people are as follows: Nigeria (82.4 million), Bangladesh (66.4 million), Ethiopia (63.9 million), Congo (55.9 million), Tanzania (38.2 million), Kenya (31.2 million), Sudan (30.9 million), Uganda (28.5 million), Myanmar (24.6 million), Mozambique (19.9 million), Afghanistan (18.5 million), North Korea (18 million), Madagascar (17.8 million), the Philippines (15.6 million), Pakistan (15 million), Burkina Faso (14.3 million), Niger (14.1 million), Indonesia (14 million) and Malawi (13.6 million) (Banerjee, et al., 2013).

2. Review of Previous Studies on Energy Utilization and Adaptation in Uganda

Evidence suggests that there is scant coverage of urban energy demand issues, especially related to low-income settlements in Uganda. Multiple sources of energy are used across the country and the National Biomass Energy Demand Strategy 2001-2010 noted that 82 percent of Ugandan households (22 percent urban households and 91 percent of rural households) use firewood for cooking and another 15 percent use charcoal (67 percent urban households and 7 percent of rural households). Combined, this amounts to 97 percent of Ugandans using wood, residues or charcoal (89 percent urban households and 98 percent of rural households) (GOU, 2001; MEMD, 2001). The results of the 2002 Uganda Population and Housing Census, MLHUD (2008) and Okure (2008) showed that 50 percent of households in the urban areas used paraffin as their main source of energy for lighting while electricity was used by 25 percent households in urban areas.

Existing literature on energy utilization in Uganda surrounds six key sub-themes: firewood extraction and consumption in rural areas (e.g. Adkins, Tyler, Wang, Siriri, & Modi (2010); Agea, Kirangwa, Waiswa, & Okia (2010); Clough (2012); Egeru, Katerega, & Majaliwa (2014); GVEP International (2012); Habermehl (2007); Knöpfle (2004); Miteva, Kramer, Brown, & Smith (2013); Morgan & Moss (1985); Mwaura (2012); Tabuti, Dhillion, & Lye (2003); WFP, WRC, & GTZ (2009)); charcoal production and supply (e.g. Forest Department, 1992; Khundi, Jagger, Shively, & Sserunkuma, 2011; Knopfle, 2004; Namaalwa, Hofstad, & Sankhayan, 2009; Schure, Dkamela, van de Goes, & McNally, 2014; Shively et al., 2010); business, financing mechanisms and wood fuel value chains (e.g. Ferguson, 2012; Nsasira, Basheka, & Oluka, 2013; Whitley & Tumushabe, 2014); electricity consumption (e.g. Muhoro, 2010; Neelsen & Jorg, 2011); biogas and related renewable energy technologies (e.g. Buchholz & Da Silva, 2010; Byakola, 2007; Menya, Alokore, & Ebangu, 2013; Naughton-Treves & Chapman, 2002; Ngaira & Omwayi, 2013; Walekhwa et al., 2009; Zanchi et al., 2012); and adoption and use of improved energy technologies (e.g. Levine, Beltramo, Blalock, & Cotterman, 2012; Wallmo & Jacobson, 1988) in general.

All the above studies provide a limited understanding of adaptation decisions of households to energy insecurity in low income settlements in urban areas. Given the potential societal impacts of energy insecurity, understanding household level responses represent an important research agenda with the potential to impact behaviour) or to develop appropriate energy policies (Damte, Koch, & Mekonnen, 2011). Scholars have reached a general consensus that communities engage in a number of activities to cope with energy insecurity, but the exact adaptation mechanisms in an urban setting are unclear and depend on many factors.

Energy adaptation has been classified into direct and indirect household responses (Damte et al. 2011). Cooke, Kohlin, & Hyde (2008) provides a summary of studies that have examined common concerns about energy scarcity for the period 1985 to 2006, and in all these studies too, limited attention was given to energy scarcity issues in urban areas. Kumar & Hotchkiss (1988) in a rural Nepal study noted that households cope with fuel wood scarcity by increasing the time spent on its collection. Similarly, Cooke (1998) concludes that when households are faced with shortages, as measured by shadow prices, they spend increasing amounts of time collecting these environmental goods, without affecting agricultural productivity, such that the reallocated time must come from other activities. Cooke et al. (2008) further note that in times of fuelwood scarcity, households change their cooking habits due to a reallocation of labour away from food preparation, and change the amount and kind of fuel used. Brouwer, Hoorweg, & van Liere (1997) found that households economize on wood use and increase the number of collectors while Veld, Narain, Gupta, Chopra, & Singh (2006) noted that households are less likely to collect from common areas at all, and are more likely to use privately produced fuel.

On the other hand, Brouwer, Wijnhoven, Burema, & Hoorweg (1996) and Egeru et al. (2014) noted that with fuel wood scarcity, have resorted to cooking meals once a day, omitting morning breakfast and between-meal snacks and avoiding energy-demanding dishes of, for example, beans being replaced with vegetable dishes that required less energy to cook. In extreme fuelwood scarcity to prepare the two meals (lunch & dinner), households maintained two meals in their diet because they both were considered important.

Substitution of fuels has been studied by many scholars. GIZ (2011) noted that households use kerosene during electricity load-shedding hours, while others households rely on candles, kerosene, torches, solar home systems, and inverter systems. While Brouwer et al. (1996); Brouwer et al. (1997); Cooke et al. (2008) and Egeru et al. (2014) note that households substitute cow dung, crop residue and poorer/lower quality tree/bushes for firewood for limited sources of firewood, Damte et al. (2011) in their analysis in Ethiopia uncover no evidence of substitution between fuel wood and dung and crop residues. On the other hand, Palmer & Macgregor (2009) find that there is limited evidence for substitution from fuel wood to other energy sources in Namibia. Using a non-linear dynamic programming model, Buyinza & Teera (2008), show that tree farming is one of the possible approaches to increase the supply of fuel wood, while woodstoves and kerosene substitution are policies that reduce the demand for fuel wood. Energy substitution is a complex process for one to draw quick conclusions from these studies since, for example, electricity power outages have been rampant in Uganda since the early 1990s but Kateregga (2009) observed that few consumers were willing to pay significant amounts of money to get rid of inconveniences caused by power outages. However, many biases and limitations plague these studies since they addresses adaptation from a rural perspective and a limited set of adaptation measures is considered.

There are also a myriad of slum profiling activities that have been carried out by Act Together and Uganda Slum Dwellers Association (2010) and UN-Habitat (2007, 2012) across the country. The major omission of these studies is the lack of an appropriate and clear examination of urban adaptation to energy insecurity in low income settlements in Uganda. Understanding urban energy adaptation will enable energy policy and planning to be undertaken to improve energy security across the country.

3. Data and Methods

3.1. The Setting: Low Income Settlements in Uganda

There is no specific database from which to extract the urban development patterns for Uganda and several data sets point to different urbanisation patterns for the country. About 15 percent of Uganda's population is categorized as urban and is projected to double by 2035 (MLHUD, 2013; UBOS, 2013). This pattern of growth is associated with an increasing number of informal settlements across the country. Estimates by the MLHUD (2008) and Uganda Human Settlements Network give a total of 2.45 million to 3.2 million slum residents in Uganda.

This paper is based on a survey conducted between December 2013 and March 2014 in slums, referred to in the paper as low income settlements in the urban areas of Kampala, Jinja, Arua and Mbarara (**Figure 1**). It is such developments in these urban centres that have, in part, contributed to the development of the new urban policy for the country. The slum profile (an inventory of slum characteristics) of each urban area is given in **Table 1**. It is these slums that have been the target of several funding agencies promoting energy improvements among the urban poor across the country. It is also recognized that these urban centres hold the largest number

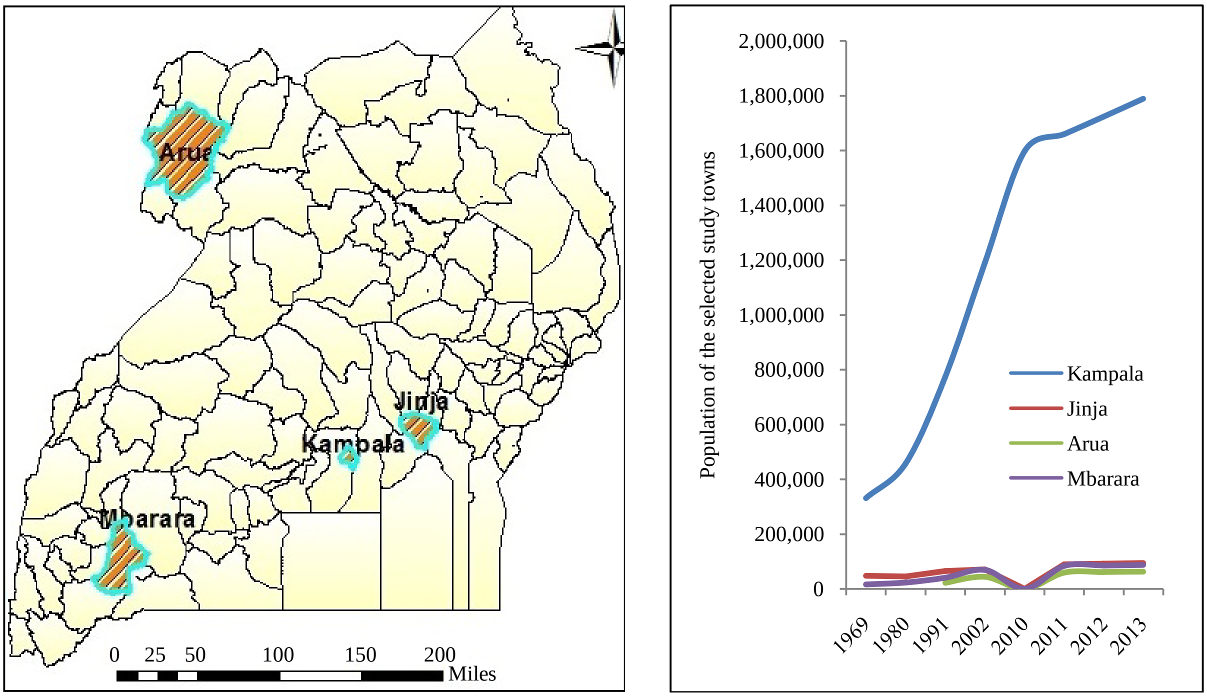

Figure 1. The study towns in Uganda (left) and growth of population in the four study towns (data from UBOS, 2015).

Table 1. Selected urban areas.

	Description of the study towns	Informal settlements profile	Mid-year population (est.) UBOS (2015)	Est. slum population 2012
Arua	Arua town is located in northwest Uganda about 19 kilometres east of the border shared with the Democratic Republic of Congo (Act Together, 2010).	Informal settlements occupy 452 acres of land and the majority of the settlers are tenants.	64,200	56,247 (Act Together, 2010)
Jinja	Jinja lies in south eastern Uganda, approximately 54 miles (87 km), by road, east of Kampala, the capital. The city is located on the shores of Lake Victoria, near the source of the Nile River (National Slum Federation of Uganda, 2010).	There are 8 settlements that can easily be categorized as informal settlements. These include: Loco, Ripon Market, Masese 1, Mpumudde Market Zone A, Soweto, Walukuba-Zabe, Walukuba-Babu Patel and Kimaka	73,900	20,800 (National Slum Federation of Uganda, 2010)
Kampala	Kampala is both the administrative and commercial capital city of Uganda situated on about 24 low hills that are surrounded by wetland valleys (UN-Habitat, 2007).	There are 62 slum settlements in the city (KCCA, 2012 and UN-Habitat, 2007) with an estimated population standing at 55% - 65% of the total city population (KCCA, 2012) and housing 560,000 families (Dobson, Lutwama, & Mugisha, 2014)	1,542,300	49% - 64% of the total population (560,000 families) (KCCA, 2015)
Mbarara	The municipality found in western Uganda had a total population of 69,363 and 94,393 by 2002 and 2009 respectively.	Informal settlements are expanding fast in Mbarara Municipality due to shortage of affordable housing in the face of the ever increasing population (UN-Habitat, 2012).	198,900	Over 50% of the total population (UN-Habitat, 2012)

of households residing in informal settlements across the country. The results of this paper also fit closely into the UN-Habitat Medium Term Strategic and Institutional Plan (2008-2013), which calls for taking a step further to create the necessary conditions to stabilize the growth of slums and set the agenda for the subsequent reduction in and reversal of the number of slum dwellers.

3.2. Data Collection and Analysis

Data collection was anchored at household level and a questionnaire was the main data collection instrument. Questionnaires were administered to a randomly selected set of 574 households in selected low-income settlements in the four urban areas depending on their willingness to participate in the survey. Specific attention was paid to residential energy utilization, indicators of energy utilization and adaptation to energy insecurity. The estimated slum population in the four selected urban areas is 1,104,322 and given that the average household size in urban areas in Uganda is 3.9 people, according to the Uganda Bureau of Statistics, the assumed number of households in the selected low income settlements was 283,460. It was from this population that the sample size was determined using guidelines given by Ric Coe (1996) and Equation (1) given by Krejcie and Morgan (1970).

$$S = \frac{X^2 NP[1-P]}{d^2[N-1] + X^2 P[1-P]} \quad (1)$$

where:

S = Required sample size.

X^2 = The table value of chi-square for 1 degree of freedom at the desired confidence level (0.10 = 2.71; 0.05 = 3.841; 0.01 = 6.64; and 0.001 = 10.83).

N = The population size.

P = The population proportion (assumed to be 0.50 since this would provide the maximum sample size).

d = The degree of accuracy expressed as a proportion (0.05).

Descriptive statistics were generated to describe respondents' characteristics and energy utilization patterns in the low income settlements. Ordered logistic regression was applied to explore the determinants of energy utilisation and how these shape adaptation among households. To use logistic regression, the response must only have two outcomes, i.e. yes/no, 0/1. The aim of this method is to fit a regression equation to the data (assuming two explanatory variables) where α is the intercept, β_1 and β_2 are the parameters for the explanatory variables x_i, p is the proportion for the event of interest and *In* denotes the natural logarithm function. The term on the left hand side of the equation is known as the logit link function of p. According to the Cook, Dixon, Duckworth, Kaiser, Koehler, Meeker, & Stephenson (2000) is of the form:

$$In\left\{\frac{p(x)}{1-p(x)}\right\}=\alpha+\beta_1 x_1+\beta_2 x_2 \quad (2)$$

The explanatory variables can be quantitative (discrete or continuous) or qualitative (factors).The data was further studied with factor analysis in mind to assess relative adaptation of residents to energy insecurity in the low income settlements. The underlying assumption of factor analysis given by Hair, Anderson, Tatham, & Black (1998) & Kaiser (1960) were confirmed before it was utilised. The ultimate aim was to identify the observed underlying structure in the data matrix of variables against which residents adapt to energy insecurity. All the basic assumptions, routines and procedures given by Pallant (2011) were followed in the Statistical Package for Social Scientists (SPSS V.19) to run the logistic regression and factor analysis.

4. Results and Discussion

4.1. Determinants of Energy Utilization in Selected Low Income Settlements

Energy demand patterns of urban households, especially the poor, largely revolve around household energy end-uses such as cooking and lighting as well as energy services for home-based commercial and productive activities. It was found that charcoal (34.9%) was the dominant energy source for cooking followed by kerosene (25.0%) and fuel wood (20.6%) (**Figure 2**). These results are consistent with MEMD & UBOS (2014); Menya et al. (2013); Ngaira & Omwayi (2012) and WFP et al. (2009) observations that charcoal is the most popular and predominant source of energy used in urban settings; where, for example, between 200,000 and 230,000 tonnes was reported for the Kampala City (Knöpfle, 2004).

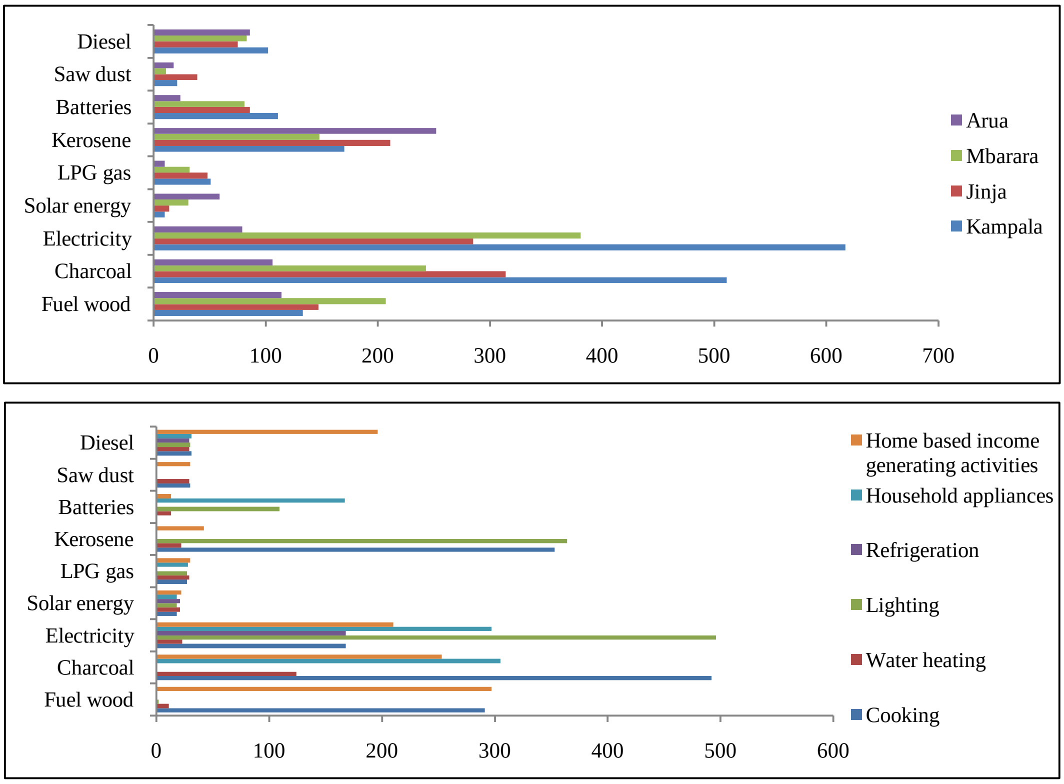

Figure 2. Patterns of energy utilization in low income settlements.

Wood biomass will likely remain the dominant household energy source for cooking and heating for several decades in Uganda due to low accessibility to alternative energy sources (Gore, 2008). This is an old observation given by Morgan & Moss (1985) who noted that wood and charcoal are often regarded as cheap alternatives to electricity, for domestic cooking and small industrial purposes, even in high temperature processes. Preference for wood and charcoal may be derived from tradition, the taste of food cooked in this way, reliability of supply and ease of transport and storage. Use of wood requires just three stones or extremely cheap locally made stoves. Often wood is much better suited to large-scale cooking, as for large families, organisations, or for special occasions. Also, traditional round-bottomed cooking pots can be used with wood fires, while modern stoves require the additional expense of flat-bottomed, usually metal, saucepans. At a broad level, the results speak to Coelho & Goldemberg (2013) who observed that poor urban households were found to be using different fuels and their energy demand for cooking and heating is usually met from a mix of sources, including modern and relatively clean sources, such as LPG and kerosene to traditional biomass.

By their spatial location in well-defined urban centres in the country, one would have assumed that the electricity infrastructure in the studied areas would be elaborate and available, but the selected settlements have insufficient electricity infrastructure and so residents use alternative sources of energy such as charcoal, firewood, paraffin/candle. This is not any different from the results of the 2002 Population and Housing Census and the UNHS 2005/06 which indicated that 1 out of every 2 households in urban areas in Uganda used paraffin as their main source of energy for lighting. The percentage of households using electricity for cooking in the studied areas is still relatively low at 4.3%. This again is consistent with Knöpfle (2004) observations that charcoal is per energetic content (MJ) on the average even less expensive than firewood, which is often considered as the source of energy for the poor. In the kitchens of Kampala there are still mostly inefficient iron stoves used and even if people can afford a more efficient energy source for cooking—like LPG or electricity—they still use charcoal. The importance of charcoal among households can be gauged by its nickname, “black gold”, as it is referred to by some traders in Kampala City (UNDP, 2013). Furthermore electricity needs a high initial investment for buying an electric cooker/oven, and has the disadvantage of insecure power supply in many areas. Therefore electricity, in spite of still being the focus of national energy policies in most of the countries, is generally used for lighting, household appliances and home-based income generating activities.

When all the logistic regression routines in SPSS suggested by Cook et al. (2000) were followed, all the predictor variables given in **Table 2** were entered in Equation (1) to explain utilization of only three selected energy types: firewood, charcoal and electricity. Of the sixteen factors, only three were statistically significant. Results in **Table 3** indicate that there is a significant power for variables household size ($p = 0.045$), and share of adults in the household ($p = 0.003$) in explaining fire wood consumption in the low income settlements. The model explained 4.3% (Nagelkerke R^2) of the variance in fuelwood utilization and correctly classified 62.3% of the cases. The same process was applied for charcoal utilization and none of the factors entered into the model were significant. For electricity utilization, the model indicates that there is a significant power for variables gender ($p = 0.045$), and share of adults in the household ($p = 0.069$). The model explained 24.4% (Nagelkerke R^2) of the variance in electricity utilization and correctly classified 77% of the cases. These results corroborate Egeru (2014) who noted that household size increased firewood demand due to the increased demands for cooking in a household with a large number of people.

4.2. Household Adaptation to Energy Insecurity in Selected Low Income Settlements

Figure 3 illustrates the energy problems experienced in the low income settlements. What is most apparent in the figure in that energy insecurity in the low income settlements coalesce around four major components: high retail prices/tariffs for energy, electricity shortages, wood shortages and waste/inefficient use. The majority of Ugandans who depend on charcoal and firewood for cooking have to brace themselves for higher prices of charcoal. It is possible that the price of charcoal is a reflection of excessive demand for charcoal, especially in urban areas, while other alternatives like hydro-electricity power are too costly and unreliable for the average Ugandan to afford. Despite government’s commitment to bolster supply of electricity across the country, the availability of reliable and cheap electricity remains a major challenge for low income settlements. The access to electricity in the selected settlements is constrained by high power tariffs and inadequate transmissions and distribution network. It has been reported elsewhere that Ugandans pay the highest power bills in East Africa. Even at a time when government was offering a substantial amount of money in subsidies to the power sector, a unit

Table 2. Description of variables used in the model.

Variable/definition	Description	Expected sign	N	Mean/proportion (%)	Std. error of mean	Std. deviation	Range
Average monthly income	1 = <200, 2 = 201 - 400, 3 = 401 - 600, 4 = 601 - 800, 5 = >801	+	568	333,802	0.03	0.67	3
Size of household	1 = <3, 2 = 3 - 6, 3 = >6	+	566	4.32	0.02	0.56	3
Share of adults in household	1 = 1 - 2, 2 = 3 - 4, 3 = 5 - 6, 4 = 7 - 8	+	550	2.42	0.03	0.67	3
Age	1 = <14, 2 = 15 - 29, 3 = 30 - 44, 4 = 45 - 59, 5 = 60 - 74, 6 = >75	+	567	25.54	0.03	0.67	3
Time spent at home (in a 12 hour day)	1 = 1 - 4, 2 = 5 - 8, 3 = 9 - 12	+	568	7.10	0.028	0.667	2
Average expenditure on fuel in Ug. Shs.	1 = 1 - 20,000, 2 = 20,001 - 40,000, 3 = 40,001 - 60,000, 4 = 60,001 - 80,000	+	571	40805	0.041	0.972	3
Variable/definition	**Description**	**Expected sign**	**N**	**Description**	**%**	**Description**	**%**
Home ownership (dwelling)	1 = Owner and 2 = Otherwise	±	568	Owner	60.8%	Otherwise	39.2%
Main household residence	1 = Urban, 2 = Rural	±	550	Urban	74.8%	Rural	25.2%
Most preferred household cooking practices	1 = Traditional, 2 = Modern	+	550	Traditional	52.7%	Modern	47.3%
Availability of fuels	1 = Readily available, 2 = Very scanty	+	550	Readily available	63.9%	Scanty	35.1%
Gender of respondent	1 = Male, 2 = Female	±	562	Male	46%	Female	54%
Type of dwelling	1 = Single room, 2 = Single bedroom apartment (apt), 3 = 2-bedroom apt, 4 = 3-bedroom apt, 5 = 4-bedroom apt	+	568	Single room	15.2%	Two bedroom	31.2%
				One bedroom	52.3%	Three bedroom	1.3%
Education of head of household	1 = Lower primary, 2 = Completed primary, 3 = Lower secondary, 4 = Completed secondary, 5 = Other post-secondary education, 6 = degree	±	568	Lower primary	15.2%	Lower secondary	31.2%
				Completed primary	52.3%	Completed secondary	1.3%
Occupation of head of household	1 = Civil servant, 2 = Private sector employed, 3 = Self-employed, 4 = Student, 5 = Unemployed/Home-keeper/wife	+	568	Civil Servant	0.5%	Self employed	34.5%
				Private Sector Employed	29.3%	Student	7.7%
				Unemployed	27%		
Marital status	1 = Single, 2 = Married, 3 = Cohabiting, 4 = Separated, 5 = Widowed	+	568	Married	15.2%	Cohabiting	31.2%
				Single	52.3%	Separated	1.3%
Town	1 = Kampala, 2 = Jinja, 3 = Arua, 4 = Mbarara		574	Kampala	59.8%	Arua	16.9%
				Jinja	11.5%	Mbarara	11.8%
Dependent variable	Energy Choice/Utilization (Firewood, Charcoal, Electricity)						

Table 3. Results of the ordered logistic model of determinants of the utilization of firewood and electricity.

		B	S.E.	Wald	Sig.	Exp(B)
Firewood	Household size					
	Expenditure on energy	0.132	0.095	1.909	0.167	1.141
	Occupation	−0.015	0.081	0.034	0.854	0.985
	Share of adults in household	0.432	0.146	8.720	0.003**	1.540
	Constant	−0.358	0.612	0.341	0.559	0.699
Electricity	Gender (1)	−0.488	0.243	4.036	0.045**	0.614
	Share of adults in household	0.584	0.321	3.307	0.069***	1.793
	Availability of fuels	−0.696	0.455	2.342	0.126	0.499
	Constant	−1.760	0.383	21.142	0.000	0.172

**Significant at 5% level; ***Significant at 10% level.

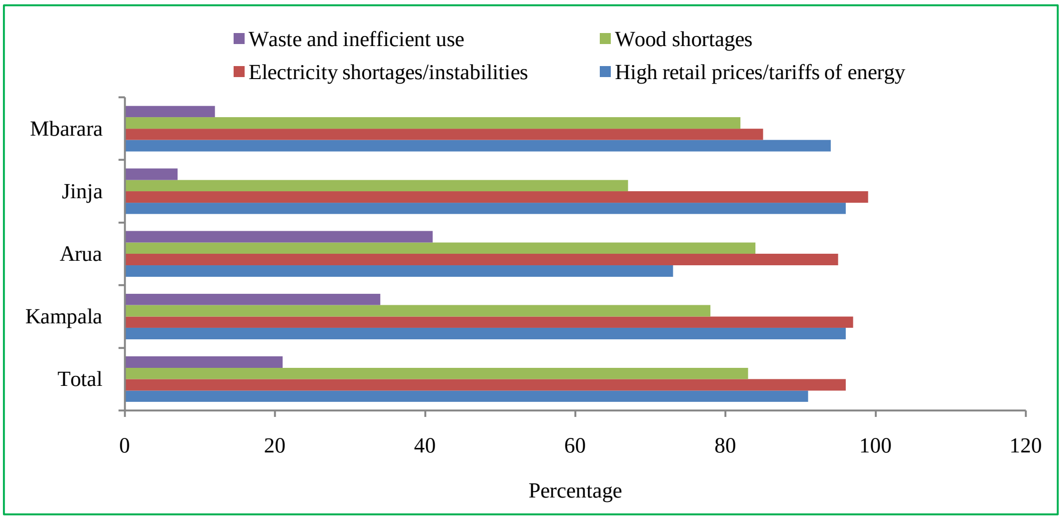

Figure 3. Major energy related problems in the selected low income settlements.

of electricity for domestic consumption was the equivalent of $0.154 per unit in Uganda but $0.098 per unit in Kenya and $0.082 per unit in Tanzania (Wesonga, 2014).

Notwithstanding the country's commendable progress on reforms and private investment, Uganda has suffered chronic power shortages which have resulted into uneven distributions, chronic rationing, frequent load shedding during the day and night and yet demand continues to grow at an annual rate of about 7 percent. The instability of electricity supply is further exemplified in frequent "load shedding", with up to 12 hour daily cycles in Kampala (Lee, 2013). Some of the electricity disruptions may seem simple and localised but taking longer to address them is a big problem. Uganda has a regular supply of electricity of approximately 305 MW, still 75 MW short of the 380 MW peak demand (Mawejje, Munyamnonera, & Bategeka, 2012). From time to time, customers especially in low income settlements have to bear with fluctuations in electricity supply and power surges from complete blackouts, rolling blackouts, to brownouts (voltage drops), which are strong elements of Uganda's energy supply. Although a number of dams have come to the grid, with an addition of several megawatts, the ever growing demand for electricity together with inadequacies in the whole electricity transmission and distribution chain mean that the full benefits of these investments will not be fully realised in low income settlements.

Households do not remain passive under conditions of energy insecurity but adapt themselves in various ways, depending on the socio-economic position of individual households. Households undertake a wide range of actions and conscious effort to stay afloat and maintain their livelihoods. To describe the adaptive mechanisms used by households in low income settlements, the data collected was studied with a factor analysis together with a principal Axis Factor (PAF) with a Varimax (orthogonal) rotation of 18 questions on adaptation to energy insecurity was conducted. The ultimate aim was to screen variables, identify underlying aspects common to many variables and cluster them into homogenous sets. An examination of the Kaiser-Meyer Olkin measure of sampling adequacy suggested that the sample was suitable for factor analysis (KMO = 0.947) for the four urban centres. KMO values of 0.947 derived in this study suggest that sufficient correlations among the variables existed to warrant factor analysis.

In this paper, three factors had eigen-values over 1 and were chosen for the final analysis for all the four towns. The cumulative variance explained by the factors was 75% for all the towns. A Principal Components Analysis (PCA) with a Varimax (orthogonal) rotation of 14 initial questions from the questionnaire was used to extract factors. When loadings less than 0.5 were excluded for all towns, the analysis yielded a three-factor solution that household members felt are adaptation measures that they use to adjust to energy insecurity. These would be qualified as three domains; where household members take personal responsibility and self-discipline themselves to adjust. The results of an orthogonal rotation of the solutions are shown in **Table 4**.

The ability of households to optimize creates significant heterogeneity in type of activities that they engage in. **Table 4** shows thirteen items that clustered on factor 1. All the factors are clustered around adjustments in cooking practices and energy substitution. As energy source becomes scarce, unreliable and expensive, households have adapted their food preparatory practices and cooking styles by omitting or substituting some essential energy-demanding foods in order to save cooking energy. There are several foods whose preparation has changed given the availability and cost of energy but the most classic example in the low income settlements are dry beans and bananas. Typical cooking practices today involve pre-soaking hard grains and dry beans in water

Table 4. Rotated component matrix[a].

	Component			Construct	Communalities/ extraction
	1	2	3		
Use of generators	0.392	0.775	0.071	Self-generation and improved energy technologies	0.760
Use solar panels	0.101	0.863	0.042		0.756
Use improved stoves	0.404	0.547	−0.125		0.478
Abandon boiling of water	0.903	0.232	−0.032	Adjustments in cooking and energy practices	0.870
Prepare one meal or large quantities of food	0.845	0.216	−0.029		0.762
Concentrate of fast foods cooking	0.749	0.165	−0.026		0.589
Drop foods that require long hours of preparation	0.865	0.203	−0.038		0.791
Extinguish fire/stove immediately after cooking	0.713	0.288	−0.035		0.593
Engage in non-home food consumption	0.870	0.304	0.117		0.862
Use energy saving bulbs and/or switch off lights that are not in use/reduce the number of bulbs in the house	0.536	0.488	−0.059		0.529
Use of multiple/several energy technologies—kerosene, candles etc.	0.848	0.220	−0.028		0.768
Walk long distances to fetch fuel wood	0.896	0.295	−0.028		0.890
Use crop residues/firewood	0.867	0.195	−0.023		0.790
Illegal theft and tapping electricity	0.603	0.528	0.089		0.651
Forego hot water baths	0.728	0.277	−0.039		0.609
Iron clothes to serve for long periods of time	0.870	0.304	0.117		0.862
Drop use of banana leaves	−0.011	0.012	0.995	Drop use of banana leaves and adjust sleeping patterns	0.991
Sleep early	−0.010	0.012	0.995		0.991

several hours before cooking to soften them; thereby requiring less time and energy during preparation. To respond to high fuel prices and scarcities, the practice of simmering *matooke* and *ugali/kawunga* (steamed bananas and posho) gently has reduced gradually and there is preference of boiled bananas fingers (*katogo*) to the traditionally steamed and mashed banana type.

Although charcoal was a constant in most households in the low income settlements it was observed that when charcoal availability reduces and its prices increase, there was a movement down the energy ladder to cheaper energy sources such as firewood and crop residues. Even for those households that depend on electricity for lighting, there is a tendency to switch to cheaper energy once they experience price increases and load shedding. There is a shift from the use of electricity to the use of kerosene lamps and candles (known locally as *tadooba*), and further down to wick and wax candles during the electricity load shedding phases. Firewood sources are not within easy reach either and especially for low income settlements in Arua town have increased tremendously over the years. This can be compared with MWE (2007) which noted that on average the distance travelled to collect firewood had increased from 0.06 km in 1992 to more than 1 km in 2007. Recent estimates by Egeru et al. (2014), NPA (2010) and Agea et al. (2010) indicated that the distance travelled had increased to 2 ± 7 km and 8 - 12 km and respectively. The increasing distance to traditional sources of energy places extra demands on women and children in the low income settlements. These results corroborate well with GIZ (2011) which found energy substitution behaviour involving the use of kerosene, candles, and solar power among households in Nepal.

Other adaptation measures adopted within this cluster include the widespread adoption of energy conservation measure such as energy saving bulbs, switch off unnecessary unusable lights in rooms and security lights if and where available, abandonment of traditional cooking practices and widespread adoption of preparation of foods that require less energy. Other households have reduced the consumption of energy in a variety of ways including; 1) reducing the number of cooked meals substantially; 2) increasingly paying attention non-home based food consumption and increasing attention being paid to the purchase of cooked food; 3) limiting the frequency of use of household appliances such as flat irons, electric kettles, radios and televisions where these are available; 4) preparing one meal in a day or large quantities to preserve energy for the next day; 5) abandoning boiling water for domestic purposes; and 6) shifting to less energy demanding foods. In extreme cases, especially with high electricity tariffs, residents have gone ahead to illegally connect, tamper with electricity supply metres and steal electricity, a practice that has been reinforced by the high number of unlicensed wiremen with the direct connivance of UMEME personnel (ERA, 2011). Theft is also significant in slums and areas with informal settlements, whose inhabitants often do not meet the legal requirements to become regular customers of the electricity company (World Bank, 2010). To delve into the magnitude of this problem including who is involved, what incentives exist for people to obtain illegal connections and the losses associated with illegal connections were not the main concerns of this paper but Mwaura (2012), ERA (2011) and several media reports of deaths from electrocutions indicate that the practice is rampant, especially in low income settlements. In general this is also consistent with Cooke et al. (2008) that households alter their behaviour in the presence of sufficient scarcity in ways that are least costly to them.

Three items clustered onto factor 2; referred to here as self-generation and fuel substitution including the use of generators. It was difficult to ascertain how widespread the practice of self-generation was among households in low income settlements, but generators were apparent among small-scale enterprises in the settlements especially retail shops and entertainment hotspots. Today, probably as many Ugandans are 'electrified' through the use of lead-acid batteries, small diesel and petrol generators, and photovoltaic systems as are connected to the national grid. However, current prices of generator sets may be higher that most households would be in a position to afford. The use of solar panels was most prevalent in Arua town and this could be explained by the lack of an electricity grid network in the region. Data from the World Bank (2007b) indicates that running a generator is between 2 and 6 times more expensive than obtaining electricity from the public grid (World Bank, 2007b) and the use of generators in slum settlements should be regarded as a short term measure.

Finally, one item loaded onto factor 3. This is related to households making certain that they adjust their sleeping patterns (habits and lifestyles) in order to cope to several instabilities in electricity supply. Two responses were reported here; while the stress and routine changes disrupted routines and sleep schedules/cycles for some people especially for families with working couples and those with children, for others, power outages provided a much needed push to go to bed just a little bit earlier. Detailed studies are required here but as Schocker (2012) noted; people are hostages to the daylight schedule and when the power goes out, there is a disruption in zeitgebers "time givers," or those items like light exposure, exercise, bathing, social interaction and eating that the body uses to figure out where it is in a 24-hour period.

4.3. Conclusions and Policy Implications

The critical household factors in low income settlements including household size, share of adults in the household and gender greatly influence household energy utilization. The energy lifestyle of people in low income settlements is built on scarcity, uncertainty, and inadequacy. There is a need to get energy supply and prices right for urban areas and low income settlements in particular. The continued increases in the costs of energy can potentially erode livelihoods for people in low income settlements. Charcoal use is a constant and dominates the energy source across all households studied and it is important to understand the urban charcoal market in greater detail; while reforming the electricity sector to take care of the urban poor. It is also important that a continuous supply and use of this resource needs to be understood clearly from its health, environmental and broader climate change implications. The continued rural extraction of wood for charcoal is responsible for encroachment into major fragile ecosystems and forested areas across the wider Ugandan landscape especially in the wood and charcoal producing zones.

The diversity of adaptation strategies is indicative of the ability and capacity of household members to cope with adversity. These strategies must be understood in depth in order to build resilient livelihoods in low income settlements. Low income settlements may not usually realise the extent to which they depend on various forms of energy to get through each day but there is a need for a strategy that provides uninterrupted supply of energy, promotes energy conservation, and minimises total energy costs that affect low income settlement across the country.

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References

Act Together Uganda (2010). Arua Municipality 2010 Slum Profile. Kampala Uganda.

Adkins, E., Tyler, E., Wang, J., Siriri, D., & Modi, V. (2010). Field Testing and Survey Evaluation of Household Biomass Cook-Stoves in Rural Sub-Saharan Africa. *Energy for Sustainable Development, 14,* 172-185. http://dx.doi.org/10.1016/j.esd.2010.07.003

Agea, J. G., Kirangwa, D., Waiswa, D., & Okia, C. A. (2010). Household Firewood Consumption and Its Dynamics in Kalisizo Sub-County, Central Uganda. *Ethnobotanical Leaflets, 14,* 841-855.

Banaabe, J. (2012). Energy Supply in Uganda? http://www.unep.org/transport/pcfv/PDF/icct_2012/ICCT_EnergySituation_JamesBanaabe_MEMD.pdf

Banerjee, S. G., Bhatia, M. A., Elizondo, G., Jaques, I., Sarkar, A., Portale, E., Bushueva, I., Angelou, N., & Inon, J. G. (2013). *Overview. Vol. 2 of Global Tracking Framework. Sustainable Energy for All.* Washington DC: World Bank.

Brouwer, I. D., Hoorweg, J. C., & van Liere, M. J. (1997). When Households Run out of Fuel: Responses of Rural Households to Decreasing Fuel Wood Availability, Ntcheu District, Malawi. *World Development, 25,* 255-266. http://dx.doi.org/10.1016/S0305-750X(96)00100-3

Brouwer, I. D., Wijnhoven, T. M. A., Burema, J., & Hoorweg, J. C. (1996). Household Fuel Use and Food Consumption: Relationship and Seasonal Effects in Central Malawi. *Ecology of Food and Nutrition, 35,* 179-193. http://dx.doi.org/10.1080/03670244.1996.9991488

Brown, M. H., Rewey, C., & Gagliano, T. (2003). Energy Security. National Conference of State Legislatures. Denver Colorado.

Buchholz, T., & Da Silva, I. P. (2010). Potential of Distributed Wood-Based Bio-Power Systems Serving Basic Electricity Needs in Rural Uganda. *Energy for Sustainable Development, 14,* 56-61. http://dx.doi.org/10.1016/j.esd.2010.01.002

Buyinza, M., & Teera, J. (2008). A System Approach to Fuel Wood Status in Uganda: A Demand Supply Nexus. *Research Journal of Applied Sciences, 3,* 264-275.

Byakola, T. (2007). Improving Energy Resilience in Uganda. Helio International.

http://www.helio-international.org/Uganda.En.pdf

Checchi, A., Behrens, A., & Egenhofer, C. (2009). *Long-Term Energy Security Risks for Europe: A Sector-Specific Approach*. CEPS Working Paper No. 309, Centre for European Policy Studies. http://dx.doi.org/10.2139/ssrn.1334620

Cherp, A., & Jewell, J. (2011). The Three Perspectives on Energy Security: Intellectual History, Disciplinary Roots and the Potential for Integration. *Current Opinion in Environmental Sustainability, 3,* 202-212. http://dx.doi.org/10.1016/j.cosust.2011.07.001

Clough, L. (2012). *The Improved Cook Stove Sector in East Africa: Experience from the Developing Energy Enterprise Programme (DEEP).* London: GVEP International.

Coelho, S. T., & Goldemberg, J. (2013). Energy Access: Lessons Learned in Brazil and Perspectives for Replication in Other Developing Countries. *Energy Policy, 61,* 1088-1096. http://dx.doi.org/10.1016/j.enpol.2013.05.062

Cook, D., Dixon, P., Duckworth, W. M., Kaiser, M. S., Koehler, K., Meeker, W. Q., & Stephenson, W. R. (2000). *Beyond Traditional Statistical Methods*. Ames, IA: Iowa State University.

Cooke, P. (1998). The Effect of Environmental Good Scarcity on Own-Farm Labour Allocation: The Case of Agricultural Households in Rural Nepal. *Environment and Development Economics, 3,* 443-469. http://dx.doi.org/10.1017/S1355770X98000230

Cooke, P., Kohlin, G., & Hyde, W. F. (2008). Fuelwood, Forests and Community Management—Evidence from Household Studies. *Environment and Development Economics, 13,* 103-135. http://dx.doi.org/10.1017/s1355770x0700397x

Damte, A., Koch, S. F., & Mekonnen, A. (2011). *Coping with Fuel Wood Scarcity: Household Responses in Rural Ethiopia*. Working Paper Series, Pretoria: Department of Economics, University of Pretoria.

Dobson, S., Lutwama, M., & Mugisa, F. (2014). *Negotiated Planning: Breaking the Implementation Impasse in Kampala*. Discussion Paper, Paper prepared for presentation at the Annual World Bank Conference on Land and Poverty, Washington DC: The World Bank.

Egeru, A. S. (2014). Rural Households' Fuelwood Demand Determinants in Dry Land Areas of Eastern Uganda. *Energy Sources, Part B: Economics, Planning, and Policy, 9,* 39-45. http://dx.doi.org/10.1080/15567241003716688

Egeru, A. S., Kateregа, E., & Majaliwa, M. J. G. (2014). Coping with Firewood Scarcity in Soroti District of Eastern Uganda. *Open Journal of Forestry, 4,* 70-74. http://dx.doi.org/10.4236/ojf.2014.41011

ERA (2011). *Annual Report 2010/2011*. Kampala: Electricity Regulatory Authority.

Ferguson, H. (2012). *Briquette Businesses in Uganda. The Potential for Briquette Enterprises to Address the Sustainability of the Ugandan Biomass Fuel Market.* London: Global Village Energy Partnership International.

Forest Department (1992). *National Biomass Study, Phase 1*. Technical Report, November 1989-December 1991, Kampala: Forest Department.

GIZ (2011). *Grid Expansion in Countries with Power Shortages: Experiences from Energizing Development (En-Dev) Nepal*. GIZ-EnDev.

Gore, C. D. (2008). *Power and Process: The Politics of Electricity Sector Reform in Uganda*. PhD Thesis, Toronto: University of Toronto.

GOU (2001). *The National Biomass Energy Demand Strategy for Uganda 2001-2010*. Kampala: Ministry of Energy and Mineral Development, Government of Uganda (GOU).

GVEP International (2012). *Uganda Market Assessment. Sector Mapping*. London: Global Alliance for Clean Cookstoves.

Habermehl, H. (2007). *Economic Evaluation of the Improved Household Cooking Stove Dissemination Programme in Uganda. Dissemination of the Rocket Lorena Stove in the Districts of Bushenyi and Rakai and Dissemination of the Improved Charcoal Stove in Kampala in the Years 2005 and 2006*. Eschborn.

Hair Jr., J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate Data Analysis.* Upper Saddle River, NJ: Prentice Hall.

Hildyard, N., Lohmann, L., & Sexton, S. (2012). *Energy Security for What? For Whom*? Dorset: The Corner House.

Jarvie, J., & Nicholson, D. (2013). Building Climate Resilience through Community Based Energy Security. *Boiling Point, 61,* 17-19.

Kaiser, H. F. (1960). The Application of Electronic Computers to Factor Analysis. *Educational and Psychological Measurement, 20,* 141-151. http://dx.doi.org/10.1177/001316446002000116

Karekezi, S., McDade, B. B., & Kimani, J. (2012). Energy, Poverty and Development. In GEA, *Global Energy Assessment—Towards a Sustainable Future*. Cambridge University Press, Cambridge, UK and New York, USA and the International Institute for Applied systems Analysis, Laxenburg, Austria.

Kateregga, E. (2009). The Welfare Costs of Electricity Outages: A Contingent Valuation Analysis of Households in the Suburbs of Kampala, Jinja and Entebbe. *Journal of Development and Agricultural Economics. 1,* 001-011.

KCCA (2015). Solutions to Urban Slums: Building on Communities, Knowledge and Heritage. http://www.kcca.go.ug/uDocs/EDs%20presentation%20at%20the%2011th%20Africa%20Union%20of%20Architects%20Congress.pdf

Khundi, F., Jagger, P., Shively, G., & Sserunkuuma, D. (2011). Income, Poverty and Charcoal Production in Uganda. *Forest Policy and Economics, 13,* 199-205. http://dx.doi.org/10.1016/j.forpol.2010.11.002

Knöpfle, M. (2004). *A Study on Charcoal Supply in Kampala. Final Report*. Energy Advisory Project (EAP), Kampala: Ministry of Energy and Mineral Development (MEMD).

Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement, 30,* 607-610.

Kumar, S. K., & Hotchkiss, D. (1988). *Consequences of Deforestation for Women's Time Allocation, Agricultural Production and Nutrition in Hill Areas of Nepal*. Research Report No. 69, Washington DC: International Food Policy Research Institute (IFPRI).

Lee, L. Y. (2013). Household Energy Mix in Uganda. *Energy Economics, 39,* 252-261. http://dx.doi.org/10.1016/j.eneco.2013.05.010

Levine, D. I., Beltramo, T., Blalock, G., & Cotterman, C. (2012). *What Impedes Efficient Adoption of Products? Evidence from Randomized Variation in Sales Offers for Improved Cook Stoves in Uganda*. CEGA Working Paper Series, Paper No. 014, Berkeley, CA: Centre for Effective Global Action University of California.

Mawejje, J., Munyambonera, E., & Bategeka, L. (2012). *Uganda's Electricity Sector Reforms and Institutional Restructuring*. Research Series No 89, Kampala: Economic Policy Research Centre, Makerere University.

MEMD & UBOS (2014). *Uganda Rural-Urban Electrification Survey*. Kampala: Ministry of Energy and Mineral Development and Uganda Bureau of Statistics.

MEMD (2001). *Energy and Mineral Sector Performance Report 2008/09-2010/11*. Kampala: Ministry of Energy and Mineral Development.

MEMD (2001). *National Biomass Energy Demand Strategy 2001-2010*. Kampala: Ministry of Energy and Mineral Development.

MEMD (2012). *Energy and Mineral Sector Performance Report 2008/09-2010/11*. Kampala: Ministry of Energy and Mineral Development.

Menya, E., Alokore, Y., & Ebangu, B. O. (2013). Biogas as an Alternative to Fuelwood for a Household in Uleppi Sub-County in Uganda. *Agricultural Engineering International: The CIGR e-journal, 15,* 50-58.

Miteva, D. A., Kramer, R., Brown, Z., & Smith, M. (2013). A Spatial Model of Household Fuelwood Extraction in Northern Uganda. *Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting*, Washington DC, 4-6 August 2013.

MLHUD (2008). *A Situation Analysis of Slums in Uganda and National Slum Upgrading Strategy and Action Plan*. Kampala: Ministry of Lands, Housing and Urban Development.

MLHUD (2013). *Issue Paper for the Development of the National Urban Policy*. Kampala: Ministry of Lands, Housing and Urban Development.

Morgan, W. B., & Moss, P. A. (1985). Biomass Energy and Urbanisation: Commercial Factors in the Production and Use of Biomass Fuels in Tropical Africa. *Biomass, 6,* 285-299. http://dx.doi.org/10.1016/0144-4565(85)90054-X

Muhoro, P. N. (2010). *Off-Grid Electricity Access and Its Impact on Micro-Enterprises: Evidence from Rural Uganda*. PhD Thesis, Ann Abor, MI: University of Michigan.

Mwaura, F. M. (2012). Adopting Electricity Prepayment Billing System to Reduce Non-Technical Energy Losses in Uganda: Lesson from Rwanda. *Utilities Policy, 23,* 72-79. http://dx.doi.org/10.1016/j.jup.2012.05.004

Namaalwa, J., Hofstad, O., & Sankhayan, P. L. (2009). Achieving Sustainable Charcoal Supply from Woodlands to Urban Consumers in Kampala, Uganda. *International Forestry Review, 11,* 64-78. http://dx.doi.org/10.1505/ifor.11.1.64

Naughton-Treves, L., & Chapman, C. A. (2002). Fuelwood Resources and Forest Regeneration on Fallow Land in Uganda. *Journal of Sustainable Forestry, 14,* 19-32. http://dx.doi.org/10.1300/J091v14n04_03

Neelsen, S., & Jorg, P. (2011). Electricity Usage in Micro Enterprises—Evidence from Lake Victoria Uganda. *Energy for Sustainable Development, 15,* 21-31. http://dx.doi.org/10.1016/j.esd.2010.11.003

NEMA (2010). *The Potential of Bio-Fuel in Uganda. An Assessment of Land Resources for Bio-Fuel Feedstock Suitability*. Kampala: National Environment management Authority and National Agricultural Research Laboratories.

Ngaira, J. K. W., & Omwayi, K. (2012). Climate Change Mitigation: Challenges of Adopting the Green Energy Option in the Lake Victoria Basin. *International Journal of Physical Sciences, 7,* 5615-5623.

NPA (2010). *National Development Plan 2010/11-2014/2015*. Kampala: National Planning Authority.

Nsasira, R., Basheka, B. C., & Oluka, P. N. (2013). Public Private Partnerships (PPPs) and Enhanced Service Delivery in Uganda: Implications from the Energy Sector. *International Journal of Business Administration, 4*, . http://dx.doi.org/10.5430/ijba.v4n3p48

OAG (2011). *Value for Money Audit Report on Implementation of Rural Electrification Programme by the Rural Electrification Agency in the Ministry of Energy and Mineral Development*. Kampala: Office of the Auditor General.

Okure, M. A. E. (2008). *EAC Strategy to Scale up Access to Modern Energy Services Uganda Country Report and Implementation Work plan*. Arusha: East African Community.

Pallant, J. (2011) *SPSS Survival Manual. A Step by Step Guide to Data Analysis Using SPSS* (4th ed.). Australia: Allen & Unwin.

Palmer, C., & Macgregor, J. (2009). Fuelwood Scarcity, Energy Substitution, and Rural Livelihoods in Namibia. *Environment and Development Economics, 14*, 693-715. http://dx.doi.org/10.1017/S1355770X08005007

Reddy, A. K. N. (2000). Energy and Social Issues. In Goldemberg, J. (Ed.), *World Energy Assessment: Energy and the Challenge of Sustainability*. New York: UNDP.

Ric Coe (1996). *Sampling Size Determination in Farmer Surveys* (11 p). ICRAF Research Support Unit Technical Note No 4, Kenya: ICRAF World Agroforestry Centre Nairobi.

Schocker, L. (2012). How Power Outages Wreak Havoc on Your Sleep. http://www.huffingtonpost.com/2012/11/04/power-outages-sleep_n_2068597.html

Schure, J., Dkamela, G. P., van de Goes, A., & McNally, R. (2014). *An Approach to Promote REDD+ Compatible Wood-Fuel Value Chains*. Vietnam: SNV.

Shively, G., Jagger, P., Sserunkuuma, D., Arinaitwe, A., & Chibwana, C. (2010). Profits and Margins along Uganda's Charcoal Value Chain. *International Forestry Review, 12,* 270-283. http://dx.doi.org/10.1505/ifor.12.3.270

Sserunjogi, E. M. (2014). Is Uganda Prepared for the Looming Charcoal Crisis? http://mobile.monitor.co.ug/News/Is-Uganda-prepared-for-the-looming-charcoal-crisis-/-/691252/2451346/-/format/xhtml/-/6r0t0y/-/index.html

Tabuti, J. R. S., Dhillion, S. S., & Lye, K. A. (2003). Firewood Use in Bulamogi County, Uganda: Species Selection, Harvesting and Consumption Patterns. *Biomass and Bioenergy, 25,* 581-596. http://dx.doi.org/10.1016/S0961-9534(03)00052-7

UBOS (2013). *Statistical Abstract 2013*. Kampala: Uganda Bureau of Statistics.

UBOS (2015). *Statistical Abstract 2014*. Kampala: Uganda Bureau of Statistics.

UBOS (2010). *Uganda National Household Survey 2009/2010*. Kampala: Uganda Bureau of Statistics.

UNDP (2013). *Nationally Appropriate Mitigation Action Study on Sustainable Charcoal in Uganda*. New York: United Nations Development Programme.

United Nations Centre Human Settlements Programme (UN-Habitat) (2007). *Situation Analysis of Informal Settlements in Kampala: Cities without Slums: Sub-Regional Programme for Eastern and Southern Kivulu (Kagugube) and Kinawataka (Mbuya 1) Parishes*. Nairobi: UN-Habitat.

United Nations Human Settlements Programme (UN-Habitat) (2012). *Mbarara Municipality Urban Profile*. UN-HABITAT Nairobi.

Veld, V. K., Narain, U., Gupta, S., Chopra, N., & Singh, S. (2006). *India's Firewood Crises Re-Examined*. Discussion Paper, Washington DC: Resources for the Future.

Walekhwa, P. N., Mugisha, J., & Lars, D. (2009). Biogas Energy from Family Sized Digesters in Uganda: Critical Factors and Policy Implications. *Energy Policy, 37*, 2754-2762. http://dx.doi.org/10.1016/j.enpol.2009.03.018

Wallmo, K., & Jakobson, S. K. (1998). A Social and Environmental Evaluation of Fuel Efficient Cook Stoves and Conservation in Uganda. *Environmental Conservation, 25,* 99-108. http://dx.doi.org/10.1017/S0376892998000150

WFP, WRC, & GTZ (2009). *Safe Access to Firewood and Alternative Energy in Uganda: An Appraisal Report*. Rome: World Food Programme.

Whitley, S., & Tumushabe, G. (2014). *Mapping Current Incentives and Investment in Uganda's Energy Sector: Lessons for Private Climate Finance*. Working Paper, Overseas Development Institute and ACODE.

Winzer, C. (2011). *Conceptualizing Energy Security*. EPRG Working Paper 1123, Cambridge Working Paper in Economics 1151, Electricity Policy Research Group, Cambridge: University of Cambridge.

World Bank (2003). *Poverty Reduction Strategy Paper*. Annual Progress Report and Joint IDA-IMF Staff Assessment, Report No: 26567-UG, Washington DC: World Bank.

World Bank (2007a). *Joint IDA-IMF Staff Advisory Note on the Poverty Reduction Strategy Paper Annual Progress Report*. Washington DC: World Bank.

World Bank (2007b). *Uganda: Moving Beyond Recovery: Investment and Behaviour Change, for Growth*. Country Economic Memorandum Volume I: Summary and Recommendations, Report No. 39221-UG, Washington DC: World Bank.

World Bank (2010). *Addressing the Electricity Access Gap. Background Paper for the World Bank Group Energy Sector Strategy*. Washington DC: World Bank.

Zanchi, G., Frieden, D., Pucker, J., Bird, D. N., Buchholz, T., & Windhorst, K. (2012). Climate Benefits from Alternative Energy Uses of Biomass Plantations in Uganda. *Biomass and Bioenergy, 59,* 128-136. http://dx.doi.org/10.1016/j.biombioe.2012.03.023