Energy Sources for Cooking and the Determinants of its Choices in Rural Areas of Tanzania

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Abstract: This paper identified the types of energy sources and factors determining the choices of energy sources for cooking in rural areas of Njombe and Iringa regions, Tanzania using Cross sectional survey design. Multistage cluster sampling technique was employed to sample districts, wards and villages, and lastly 384 respondents were sampled randomly using fishbowl method. Descriptive and Multinomial Logistic Regression (MLR) were employed for the analysis. Descriptive analysis show that firewood (75%) is the major source of energy used for cooking in the study areas followed by charcoal (12%), Liquefied Petroleum Gas (11%) and electricity (02). The empirical results of Multinomial Logistic Regression show that household income, level of education, household size, occupation, and age of respondents are significant factors determining the choices of energy source for cooking purposes. Based on these empirical findings, this study recommends that apart from improving the level of income of people, other interventions such as educating people on sustainable use of energy sources, reforestation programmes to replace the harvested trees for firewood use by households with large family size and promoting the use of modern cooking stoves to people regardless of their occupations and age. By so doing, the social, environmental and economic development of people from study areas and other rural parts of Tanzania having similar characteristics as that of rural Njombe and Iringa regions will be improved.

Keywords: *Energy sources, Energy choices, Rural households, Rural areas, Multinomial Logistics regression, Tanzania*

1.0 Introduction

Majority of people living in rural areas of developing countries especially Sub-Saharan countries including Tanzania are being confronted with a problem of having no access to modern, clean and sustainable source of energy for domestic use such as cooking purposes. Lacking of access to modern and clean sources of energy for cooking has resulted into large number of people in rural areas of developing nations to continue relying on traditional sources of energy in form of biomass such as firewood, charcoal as well as animal and plants remains as their major sources of energy for cooking (Fransis, 2014). Although the challenge of relying on traditional sources of energy is reported to be a global one, this problem is reported to be very serious in rural areas of Tanzania. The study by Mwakapugi (2010) and that of Swai (2014) indicate that despite having plenty of energy sources such as biomass, hydro-electric power, wind power and solar power, yet more than 85% of people living in rural areas of Tanzania rely on traditional sources of energy for cooking purposes. Besides, the study by Kusekwa (2011) establishes that the traditional part of the economy, mainly rural households in Tanzania depend on charcoal and firewood as the main sources of energy for cooking. Similarly, the Household Budget Survey report of year 2012 revealed that majority of people dwelling in rural part of other regions in Tanzania except Dar es Salaam region do not have access to modern energy sources for cooking purposes (URT, 2012). Therefore statistics indicate that rate of using traditional and unsustainable sources of energy for

cooking purposes in Sub Saharan nations including Tanzania expect to increase up to more than 2.7 billion people in year 2030 if there is no any substantive intervention to be taken into consideration (IEA, 2016).

Prolonged use of traditional sources of energy for cooking in rural areas of Tanzania has negative impact to human health and environment. The study by Mainali (2014) portrayed that health problems such as lung and respiratory diseases, cancers and environmental problems such as air pollution, erosion, local and global warming have been exacerbated in rural areas of Tanzania because of the prolonged use of traditional sources of energy for domestic activities such as cooking, heating or lighting. Therefore, continued use of traditional sources for cooking despite the changes in level of income as hypothesized energy ladder theory which states that an individual tends to shift to modern affordable, reliable, quality, safe and environmentally friendly source of energy as income increases is a major challenges facing people living in rural areas of Tanzania.

Various approaches have been made locally and globally as an attempt to address the challenges of prolonged use of traditional sources of energy for domestic activities such as cooking in rural areas of developing nations and Tanzania in particular. For instance, the study by Malla and Timilsina (2014) evidence that United Nation (UN), World Health Organizations (WHO) and the World Bank have put their efforts as an attempts to address the prevailing challenge of prolonged use of traditional sources in rural areas. The focus of these efforts made by UN and WHO were to enforce people from rural areas to adopt and use modern sources of energy for cooking in order to improve the social, environmental and economic development of people in a given nation or community. The sustainable energy for all (SE4ALL) campaign launched by the General Secretary of United nation in year 2010 among its focus was to ensure that there is universal provision of clean, affordable and reliable sources of energy cooking, heating or lighting in rural areas of developing nations and Tanzania inclusive. Besides, efforts including establishment of African Clean Cooking Energy Solutions also aimed at promoting the use of modern cooking facilities. Additional the East Asia and Pacific region's Clean Stove Initiative have been also introduced as an effort to scale up the use of modern cooking facilities to rural areas of developing nations (IEA, 2012). Despite of all these efforts made to promote the use of modern energy sources in developing nations, yet majority of people in rural areas of Tanzania still rely on traditional sources of energy for various domestic uses such as cooking, heating or lighting, implying that most of these efforts have not yielded desirable results (Kichonge *et al.*, 2014). Therefore what determines the choices of energy sources for cooking in rural areas of Tanzania is a key question which needs to be addressed in this study.

Although several studies have been conducted globally as an attempt to explain behaviors of households' members in choosing energy sources for cooking purposes, yet there has been no consensus on the common and unified factors determining the choices of energy sources (Fidel, *et al*., 2016). While energy ladder theory point out that income is a major determinant of energy sources choice, still majority of people in rural areas of developing nation continue relying on traditional sources despite of improvement of their level s of income (Johanna and Leonard, 2017). Continued relying on traditional sources of energy for cooking despite harmful effect they cause to human health and environment has brought an attention to various researchers globally to conduct studies in order to ascertain what factors determine the choices of

energy sources apart from income?. For instance, The study conducted by Fransis (2014) indicate that, factors such as consumption expenditure pattern of households, areas of residence, family size, personal preferences, education level and occupation of household members have significant impact on making decision of energy sources choices for cooking. Besides, other researches indicate that household size, sex, and education are among the factors for an individual to make decision about the type of energy to use given available alternative (Justine and George, 2013; Nnaji *et al*., 2012). Moreover, study by Abubakar *et al*. (2015) conducted in Nigeria on determinants of household choice and consumption pattern in developing counties established that household size, age, and nature of employment determine the choices of energy sources for cooking in rural areas. Additionally, the study conducted by Getamesay *et al*. (2016) in Ethiopia on determinants of household energy demand revealed that households size, proportion of women in households, education, owning of dwelling and electric appliance are important factor determining the choice of energy sources for cooking.

Despite the fact that vast researches conducted on energy sources choices in the body of knowledge, the reviewed literature reveal that, factors determining energy source choices vary from one nation, region or community to another. Therefore the ability to generalize the findings from other nations to rural context of Tanzania is not well documented in literature. Consequently factors determining the choices of energy sources for cooking in rural areas of Tanzania are not well known in literature and to the best of knowledge of a researcher. To this end, identifying factors determining the choices of energy sources for cooking in rural areas of Njombe and Iringa regions, Tanzania was inevitable in this study in order to ensure energy sources are used by rural households without causing harm to human health and environment.

2.0 Methodology

This study employed a cross-sectional survey research design to collect data from 384 respondents from rural areas of Njombe and Iringa regions in Tanzania. Multistage cluster sampling technique was employed to select districts, wards and villages from study areas. Thereafter, simple random approach was employed using fish-bowl method. Collected data were analysed descriptively using frequencies and table. Multinomial Logistic Regression (MLR) technique was employed to identify factors determining the choices of energy sources for cooking in rural areas of Tanzania. The choice of this model is based on its ability to perform w better with varieties of choice models. Mathematically, this model is expressed as shown in equation 1.0:

$$\Pr[Yi = j) = \frac{\exp(\beta j' \beta i)}{\sum_{j=0}^{j} \exp(\beta j' \beta i)} \quad \text{,…..……..(1.0)}$$

Where: $\Pr[Yi = j)$= is the likelihood of choosing firewood, charcoal, or Liquefied Petroleum Gas (LPG): "j" is the number of energy source choice in the choice set, "j=0" is the reference category namely electricity. "βi" Is a vector of factors determining the choices of energy sources for cooking in rural areas of Njombe and Iringa regions. "βj" Is a vector of the estimated parameter in a model. The equation used to estimate coefficient using likelihood method in the model is as expressed in equation 2.0 herein

$$\ln\left[\frac{pi}{1!\ pi}\right] = bo + biXi + \square bvXv \quad \text{……..(2.0)}$$

Whereby: $\left(\frac{pi}{1!\ pi}\right)$ is the odd ratio, $(bi)$is the coefficient estimates and $(Xi)$are the independent variables such as household family size, occupation, education level, age and average monthly income of respondents.

Results and Discussions

This section provides the research results and discussions on the types of energy sources and the factors determining the choices of energy sources for cooking in rural areas of Njombe and Iringa regions in Tanzania.

Energy Source for Cooking in Rural areas of Tanzania

The research findings on type of energy sources used for cooking by people from rural areas of Njombe and Iringa regions are presented in Table 1 hereunder

Table 1: Energy sources used for cooking in rural areas of Njombe and Iringa regions, Tanzania (n= 384)

Types of Energy sources for cooking in rural areas of Tanzania	Frequency (n)	Percentage (%)
Electricity	07	02
Charcoal	47	12
Firewood	289	75
Liquefied Petroleum Gas (LPG)	41	11
Total	**384**	**100**

The research findings from Table 1 show that firewood is a major source of energy used for cooking by majority of people from rural areas of Njombe and Iringa regions in Tanzania followed by other energy sources such as charcoal, Liquefied Petroleum Gas (LPG) and electricity. The use of firewood by large number of people in the study areas is because of the availability of forest for firewood collection and charcoal making, and prevalence of poverty among people in these areas. Equally, electricity and Liquefied Petroleum Gas (LPG) were found to be used by small number of people in rural areas of Njombe and Iringa regions because majority of villages in these areas are not connected to national electricity grid and lack of training on how to use modern cooking stoves.

Determinants of Choices of Energy Sources for Cooking in Rural Areas of Tanzania

Multinomial Logistic Regression technique using maximum likelihood method was employed to identify factors determining the choices of energy sources for cooking in rural areas on Njombe and Iringa regions in Tanzania. The empirical research findings of these factors are presented in Table 2.

The research findings from Table 2 indicate that the ages of heads of households in the study areas have positive coefficient values for the choice of charcoal, firewood, and Liquefied Petroleum Gas (LPG) These study findings imply that the likelihood or probability of using either firewood or charcoal or Liquefied Petroleum Gas (LPG) as a source of energy for cooking over electricity increase as the age of people in rural areas of Njombe and Iringa regions of

Tanzania increase. The increased in use of firewood and charcoal over electricity is because of the availability of forest for firewood collection and the ability to afford to procure charcoal or firewood by people from the study areas.

Table 2: Factors determining the choices of energy sources for cooking purposes (n= 384)

Factors	Energy sources for cooking in rural areas of Njombe and Iringa regions in Tanzania								
	Charcoal			Firewood			LPG		
	!	S. E	EXP (!)	"	S. E	EXP (!)	!	S. E	EXP (!)
Household size	0.18	0.80	1.20	1.31	0.76	03.69	-0.62	0.86	0.54
Occupation	0.02	0.53	1.02	-0.29	0.51	00.75	0.21	0.54	1.24
Education level	0.74	0.67	2.09	-0.37	0.64	01.45	1.15	0.69	3.14
Age	1.31	0.87	3.72	2.31	0.85	10.04	2.00	0.93	7.39
Income	-1.55	0.92	0.21	-1.66	0.86	00.19	-1.15	0.92	0.32

The empirical findings on the increase use of firewood, charcoal or LPG for cooking over electricity as the age of respondents increase in this study is also evidenced by the study conducted by Nnaji, Ukwueze and Chukwu (2012) who also revealed that older household members use charcoal or firewood for cooking than electricity because of affordability and availability reasons. Besides, the present findings on the increased in use of traditional sources of energy such as firewood and charcoal for cooking purposes over electricity in the study areas is also supported by the study conducted by Dil Bahadur *et, al,*. (2017) which established that,
the increase in age of respondents increase the likelihood of using traditional sources of energy such as firewood and charcoal when compared with other modern sources of energy such as electricity and LPG. Additionally, the empirical research findings of this study on age of respondents and choices of energy sources for cooking in rural areas of Iringa and Njombe regions concur with the theoretical explanation that the increase in age of respondents forces older people to use firewood or charcoal for cooking purposes than electricity due to its availability and affordability reasons.

Regarding the household size, the empirical research findings of this study found that, household size has positive coefficient values for both charcoal and firewood but negative coefficient value for Liquefied Petroleum Gas (LPG). These research findings on how household family size determines the choice of energy sources for cooking inform that the likelihood of using traditional sources such as firewood or charcoal for cooking over electricity increase as the family size of rural households in the study areas increase. As it was theoretically expected, the increase in use of firewood or charcoal over electricity for cooking as the family size of people from rural areas of Njombe and Iringa regions Tanzania increase is because these sources of energy are cheaper in the sense that the energy consumption per unit is low compared with when LPG and electricity are used for cooking and hence using these sources of energy reduces cost of acquiring them. The other reasons for increase in use of firewood for cooking purpose when compared with electricity by those families having large number of people is because large family has large number of man power who can collect firewood even fro far distances. Besides, poverty among people living from the study areas forces them to switch to firewood and move away from electricity or LPG which are comparatively more expensive than firewood. The research findings of this study on the increased use of firewood for cooking over electricity as family size of people from the study areas increase correspond with study findings of Pundo and

Fraser (2006) which also revealed similar findings that large family size prefer to use firewood for cooking than electricity because firewood is cheap and available than electricity of LPG in rural areas. The research findings regarding family also revealed that the use of Liquefied Petroleum Gas (LPG) decreases as family size of people from the study areas increase implying that LPG is mainly used by people with small family size. Large family size from the study areas do not prefer to use LPG because its energy consumption per unit is high.

In determining how occupation of respondents from the study areas determine the choices of energy sources for cooking, the research findings revealed that occupation of respondents has a positive coefficient values for charcoal and LPG. However, the research findings revealed that occupation of respondents had negative coefficient value for firewood. These research findings indicate that the choice of energy sources for cooking by people from the study areas is determine by their occupation. It was revealed that heads of households from the study areas who engage in agricultural activities and at the same time they are not employed prefer to use firewood than electricity because firewood was found to be cheaper and affordable to people in rural areas of Njombe and Iringa Tanzania than other modern sources of energy such as electricity or LPG. However, the research findings revealed that, those heads of households who were employed switched to modern sources of energy such as LPG and electricity because they can afford to buy them and also educated people are aware on the harmful effect of using traditional sources such as firewood on environment. Indicating that occupation of respondents determines the choices of energy sources, the study by Vijay and Adili (2011) revealed similar findings that heads of households dealing with farming and livestock keeping activities use traditional sources of energy such as firewood and crop residue in rural areas because of its availability and affordability. Similarly, the empirical findings of the present study concur with that of Adeyemi and Adereleye (2016) which disclosed that rural households engaging with farming activities use traditional source of energy while those working in employment sectors uses modern and clean sources of energy for cooking purposes.

Regarding education level factor, the research findings of this study depict that education level of respondents from the study areas had positive coefficient values for both charcoal and LPG but negative coefficient value for firewood. These research findings imply that the use of traditional sources of energy such as firewood or charcoal decreases as the level of education of people from the study areas increases. Educated people tend to switch from traditional to modern sources of energy such as LPG and electricity for cooking because they are aware that using traditional sources causes harmful effects to human health such as lung diseases and cancer caused large amount of smoke they produce and environmental problems such as soil erosion and air pollution. The findings on this study regarding how education level determine the choices of energy sources are also in line with the findings of the study conducted by Johanna and Leonard (2017) which also revealed that households with the highest level of education are more likely to use modern sources of energy for cooking than those having low level of education. Besides, the findings of this study on education level and the choices of energy sources also comply with the study conducted by Adeyemi and Adereleye (2016) which revealed, heads of households having more education are likely to switch to modern sources of energy. Apart from complying with previous studies, the findings of this study further conform to theoretical assumption that household having more education usually demand for modern sources of energy

such as electricity. These research findings imply that education level plays significant role in determining the choices of energy sources for cooking in a given nation or community.

Regarding the average monthly income, the study findings of this study showed negative coefficient values for charcoal, firewood, and LPG. These research findings indicate that the probability of using firewood, or charcoal or LPG as source of energy for cooking over electricity by people from the study areas decrease as the level of income increases. These research findings imply that household from the study areas having higher level of income shift from traditional and unsustainable sources of energy such as firewood and charcoal to modern, clean and sustainable sources of energy such as electricity. These research findings on how income determine the choices of energy sources also support the energy ladder theory which states that an individual will shift from traditional, unclean sources of energy for cooking to modern, clean and sustainable sources of energy as the level of income increase. Apart from confirming the energy ladder theory, the findings of this study also correspond with the study conducted by Nyembe (2011) which established that people with low level of income use traditional sources of energy for cooking due to its availability and affordability reasons. Besides, the findings of this study also concur with the study by Olugbire *et al*. (2012) and Stephen (2011) who also revealed that poor heads of households are the main user of firewood while rich family switches from dirty to clean source of energy such as electricity or gas. Similarly, the use of modern sources of energy also support national environmental policy which discourages cutting trees to get firewood or charcoal because deforestation lead to environmental problems such as soil erosion and air pollution.

4.0 Conclusion and Recommendations

This study concludes that, apart household income, the choices of energy sources for cooking is determined by other factors such as education level, age, occupation and household family size of people from rural areas of Njombe and Iringa regions in Tanzania. Based on this conclusion, this study recommends that, apart from improving the level of income of people, other intervention such as educating people on sustainable use of energy sources, reforestation programmes to replace the harvested trees for firewood use by households with large family size and promoting the use of modern cooking stoves to people regardless of their occupations and age. The social, environmental and economic development of people from study areas and other rural parts of Tanzania having similar characteristics as that of rural Njombe and Iringa regions will be improved.

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