



## **ENERGY SOURCES FOR COOKING AND THE DETERMINANTS OF THEIR CHOICES IN RURAL AREAS OF TANZANIA**

*Michael S. Mangula  
Mzumbe University, Tanzania  
E-mail: [msmangula@mzumbe.ac.tz](mailto:msmangula@mzumbe.ac.tz)*

*Joseph A. Kuzilwa  
Mzumbe University, Tanzania  
E-mail: [jakuzilwa@mzumbe.ac.tz](mailto:jakuzilwa@mzumbe.ac.tz)*

*Simon S. Msanjila  
Mzumbe University, Tanzania  
E-mail: [simon.msanjila@gmail.com](mailto:simon.msanjila@gmail.com)*

*Isack Legonda  
University of Dar es Salaam, Tanzania  
E-mail: [legondaia@gmail.com](mailto:legondaia@gmail.com)*

*Submission: 06/09/2018*

*Revision: 15/09/2018*

*Accept: 21/11/2018*

### **ABSTRACT**

Continued use of traditional sources of energy for cooking in rural areas of Tanzania is associated with human health problems such as lung diseases and environmental problems including soil erosion and air pollution. This paper aimed at determining the types of energy sources used for cooking and the determinants of their choices in rural areas of Tanzania. Cross-sectional survey research design through questionnaires was used to collect data from 384 heads of households from rural areas of Njombe and Iringa regions in Tanzania. Multistage cluster sampling technique was employed to sample districts, wards and villages, while rural heads of households were sampled randomly using the fishbowl method to avoid biasness. Descriptive analysis such as frequencies and percentages were used while Multinomial Logistic Regression (MLR) technique was used to analyze factors determining choices of energy sources for cooking purposes.



The study show that firewood is the main source of energy used for cooking in rural areas of Tanzania, followed by charcoal, Liquefied Petroleum Gas (LPG) and electricity. The study also shows that education, household size, occupation, income, and age of respondents determine the choices of energy sources for cooking in rural areas of Tanzania. The study concludes that, apart from improving rural household income, other intervention such as family planning, reforestation programmers and promotion of the use of modern cooking stoves should be done to ensure provision of sustainable energy sources in rural areas of Tanzania.

**Keywords:** energy sources; energy choices; rural households, rural areas, Tanzania

## 1. INTRODUCTION

Majority of people living in rural areas of the developing countries including Tanzania have less access to modern, clean and sustainable sources of energy for cooking purposes. For more than a decade, the world has experienced large proportional of people who continue relying on traditional and unsustainable sources of energy such as firewood, charcoal, animal and plants remain as the major sources of energy for cooking purposes (FRANSIS, 2014).

The studies by MWAKAPUGI (2010) and that of SWAI (2014) show that more than 85% of people living in rural areas of Tanzania rely on traditional, unclean and unsustainable sources of energy for cooking or lighting purposes. Moreover, the study by KUSEKWA (2011) adds 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.

The Household Budget Survey (URT, 2012) similarly indicates that, with an exception Dar es Salaam region, the remaining rural part of other regions in Tanzania do not have access to modern cooking facilities. The IEA (2006) report show that the rate of using traditional and unsustainable sources of energy for cooking purposes in rural areas of developing countries including Tanzania expects to increase up to 2.7 billion people in year 2030 if no any intervention is taken into consideration.



The study by MAINALI (2014) shows that prolonged use of traditional, unclean and unsustainable sources of energy for cooking or lighting purposes causes health problems such as lung diseases and environmental problems such as air pollution, soil erosion, and global warming.

The increased use of traditional sources of energy in rural areas of Tanzania is due to the absence of sufficient choice in assessing adequate, affordable, reliable, quality, safe and environmentally friendly sources of energy. As among the intervention to the challenge of using traditional sources of energy in rural areas of the developing countries, various efforts and initiatives have been undertaken locally and globally so as to change the people's behaviors of relying on a traditional source of energy.

The studies MALLA and TIMILSINA (2014) evidence that United Nation (UN), World Health Organizations (WHO) and the World Bank are among the prominent organizations which been making recommendable effort to address the challenges on the current trends of prolonged use of traditional sources both in rural areas of the developing countries. Majority of the efforts made by World Health Organizations and World Bank emphasize that, rural households should ensure they adopt and use modern and sustainable sources of energy in order to improve their social and economic development.

On one hand, sustainable energy for all (SE4ALL) campaign launched by the United Nation in 2010 aimed at ensuring that there is a universal provision of clean, safe as well as modern cooking facilities in rural areas of the developing nations. On the other hand, organization such as 'Africa Clean Cooking Energy Solutions' was established in order to promote the use of modern cooking facilities, while 'East Asia and Pacific region's Clean Stove Initiative' (CSI) scaled up access to modern cooking facilities to rural areas of the developing countries (WORLD BANK, 2013).

Despite all the foregoing efforts made to address the challenges of using traditional sources of energy for cooking, rural population in the developing countries still rely on traditional, inefficient and unsustainable energy sources. In this case, it suffices to notice that most of the efforts have not yielded desirable results. Therefore what determine the choice of particular source of energy for cooking or

lighting is not known both in theory and practices as far as rural areas in Tanzania is concerned (KICHONGE ET AL., 2014)

Studies have been conducted from both developed and developing nations in an attempt to explain energy sources choices by households using Energy Ladder Theory (JOHANNA; LEONARD, 2017). The Energy Ladder establishes that households with low level of income prefer to use traditional sources of energy such as firewood or charcoal for cooking purposes.

However, the theory states that households will only shift the ladder from traditional to modern sources of energy as their level of income improves. Apart from Income, the study by BELLO (2010) found that households' level of income, social and environmental factors determine the choices of energy sources. Additionally, the study by FRNSIS and GEMMA (2014) indicates that, consumption expenditure welfare, area of residence, household size, personal preferences, education level, occupation, existence of internal cooking facilities and geographical location determine the choices of energy sources for cooking. Moreover, Studies have shown that household size, age, sex level of education and the household income influence constitute the factors triggering an individual to respond to energy ladder model (JUSTINE; GEORGE, 2013; PAUL; EDWARD; HAMDIAH, 2013; NNAJI; UKWUEZE; CHUKWU, 2012).

However, the use energy ladder theory has been challenged because of its failure to consider other factors such social, cultural family differences as well personal preferences in choosing sources of energy for cooking (YONEMITSU, 2015).

Although studies have shown that several factors determine the choices of energy sources in rural areas including levels of household's income, little is known regarding the factors determining the choices of energy sources for cooking in rural areas of Tanzania. This study, therefore, attempted to fill this knowledge gap by determining the types of energy sources and the factors determining the choices of energy sources for cooking in rural areas of Tanzania.

## **2. METHODS AND MATERIALS**

This study employed a cross-sectional survey research design with a structured questionnaire as a survey instrument to collect primary data from 384



heads of households 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.

Households in rural areas of Njombe and Iringa Regions were sampled randomly using fish-bowl method to avoid biases and also to ensure the principle of randomness in the parameter estimate of energy source choice model holds true. Considering the sampling techniques employed, the sample size used in this study comprises of 130 (33.86%) respondents from Mufindi district, 139 (36.19%) respondents from Njombe district, 62 (16.15%) from Iringa District and 53 (13.80%) respondents were from Makambako Town council making a total of 384 respondents. Collected data were analyzed descriptively using frequencies and table. Multinomial Logistic Regression (MLR) Model was employed was employed to identify factors determining the choices of energy sources for cooking in rural areas of Tanzania

MLR analysis technique is used if the dependent variables are measured at the nominal level and there is more than one independent variable which is continuous, ordinal or nominal level. Using MLR analysis technique in this study is also supported by HOSMER and LEMOSHOW (2000) who established that MLR is used when the dependent variable is nominal for which the number of categories is more than two and one or more continuous level (interval or ratio scale) independent variables.

In this study, the dependent variable is the energy source choices which are nominal having four categories named electricity, charcoal, firewood and Liquefied Petroleum Gas (LPG) of which electricity is used as a reference category. The independent variables in this study are education level, age, average monthly income, occupation, household size and marital status of respondents which are either continuous, ordinal or even nominal one.

In using the MLR, a household has a set of alternatives source “i” of energy choice from which household members may choose for cooking or lighting. These energy source choices alternatives vary among the household dwelling in rural areas depending on various assumed factors “j” such as education level age, marital status, occupation, average monthly income, and the household of the respondents.

MLR assumes that, household chooses energy sources that maximize their utility as expressed mathematically herein:

$$\Pr[Y_i = j] = \frac{\exp(\beta_j \chi_i)}{\sum_{j=0}^J \exp(\beta_j \chi_i)}, \quad (3.1)$$

Where:  $\Pr[Y_i = j]$  is the probability of choosing firewood, charcoal, or gas with electricity being considered as the reference category in the present study: “j” is the number of energy source choice in the choice set, “j=0” is the reference category namely electricity. “ $\chi_i$ ” is the vector is a vector of the predictor (exogenous) household factor (variable). On the other hand, “ $\beta_j$ ” is a vector of the estimated parameter of the variables. When the MLM above is re-arranged using algebraic express, it follows in equation 3.2 that

$$P_i = \frac{e^{(b_0 + b_1 x_1) + \dots + b_v X_v}}{1 + e^{(b_0 + b_1 x_1) + \dots + b_v X_v}}, \quad (3.2)$$

The equation which has been used in estimating the coefficient of the research variables is as presented in equation 3.3

$$\ln\left[\frac{p_i}{1 - p_i}\right] = b_0 + b_1 X_1 + \dots + b_v X_v \quad (3.3)$$

The MLR used in the present study is estimated using the maximum likelihood method. On the one hand, a positive estimated coefficient implies an increase in the likelihood that a household-dwelling in rural areas will choose a particular source of energy. On the other hand, a negative estimated coefficient indicates that there is less likelihood a household will choose that particular source energy given the available alternatives. In this study, MLR is considered as an appropriate analysis method because it does not assume normality, linearity and homoscedasticity (STARK, 2011). The use of MLR is also more appropriate if a study uses more than three choices in the model. This study used four choices namely electricity, firewood, LPG and charcoal

### 3. RESULTS AND DISCUSSIONS

This section provides the results and discussions on the energy sources, and the factors determining the choices of energy sources used for cooking in rural areas of Tanzania.

### 3.1. Energy Sources used for Cooking in Rural Areas of Tanzania

In determining the types of energy sources for cooking in rural areas of Tanzania, four energy sources named electricity, firewood, charcoal and LPG were used. Respondents were requested to choose the type (s) of energy source they use for cooking given the available alternative. The study findings on the types of energy sources for cooking in rural areas of Tanzania are presented in Table 1.

Table 1: Energy Sources used for Cooking in Rural Areas of Tanzania

Types of Energy sources for cooking in rural areas of Tanzania	Frequency (N )	Percentage (%)
Electricity	07	01.80
Charcoal	47	12.20
Firewood	289	75.30
Liquefied Petroleum Gas (LPG)	41	10.70
Total	384	100.00

In Table 1, the results show that firewood is used as the main source of energy for cooking by the majority (75.30%) of people living in rural areas of Tanzania followed by charcoal (12.20%). Other sources of energy used in rural areas of Tanzania for cooking purposes include Liquefied Petroleum Gas (10.70%) and electricity (01.80%).

These results indicate that people living in rural areas of Tanzania use varieties of energy sources such as firewood, charcoal, electricity and LPG for cooking purposes. More importantly, the results in this study demonstrate that firewood is the dominating source of energy used for cooking by the majority of people in rural areas of Njombe and Iringa regions followed by charcoal, gas and electricity.

The increased use of firewood as a source of energy for cooking in rural areas of Tanzania is influenced not only by its availability of forest in rural areas, rather the prevalence of poverty among rural households and thus they cannot afford to procure modern sources of energy such as electricity and LPG which are very expensive.

The results in this study correspond with ABDULLAHI (2017) who found that continued use of solid fuels such as firewood by people in rural areas for cooking is



influenced by availability and its affordability as well as the prevalence of incidence of poverty among people in a nation. Conversely, Electricity and LPG are used by few people for cooking purposes because they are not only available but also not affordable.

The high cost of installation, operating costs and lack of training on to use modern cooking stoves significantly contribute to low usage of electricity and LPG respectively in rural areas of Tanzania.

### **3.2. Determinants of Choices of Energy Sources for Cooking in Rural Areas of Tanzania**

This section sought to identify factors that determine the choices of energy sources for cooking in rural areas of Tanzania. A Multinomial Logistic Regression Model was employed in which independent variables were education levels of the respondent, the age of respondent, a household size of the respondent, the occupation of respondent and average monthly income of the respondent.

The dependent variables used in this study include energy source choices having various categories such as firewood, charcoal, electricity and LPG. Before estimating the parameters in the model, tests such as an overall test of relationship and strength of Multinomial Logistic regression were performed. The results of these tests are presented herein.

#### **3.2.1. Overall Test of Relationship in the Model**

In this study, the overall relationship between the independent and dependent variables in the model were tested using model fitting information. The existence of a relationship between dependent and combination of independent variables was evaluated based on the statistical significance of the final model chi-square shown in Table 2.

**Table 2: Model Fitting Information**

Model	-2 Log Likelihood	Chi-Square	df	p-Value
Intercept only	354.563			
Final	209.125	145.438	15	0.000

As it is observed in Table 2, the results indicate that, the probability of the model chi-square (145.438) was 0.000, less than the level of significance of 0.05 (P-Value<0.05) indicating that the null hypothesis that there was no difference between



the model without independent variables and the model with independent variables was rejected. These results imply that there is an existence of a relationship between the independent variables and the dependent variable used in this study.

### 3.2.2. The Strength of Multinomial Logistic Regression Relationship

The strength of the relationship between independent and dependent variables used in this model was established using Pseudo R square measures such as Cox & Snell R Square value, Nagelkerke R Square value and McFadden R Square value as presented in Table 3 hereunder.

Table 3: Pseudo R- Square values

Step	Cox & Snell $R^2$	Nagelkerke $R^2$	McFadden $R^2$
	0.32	0.40	0.24

The results from Table 3 establish that the values of Cox and Snell, Nagelkerke and McFadden are 0.32, 0.40 and 0.24 respectively; suggesting that between 24%, 32% and 40% of the variations in the dependent variables is explained by this set of independent variables used in this model. Alternatively, the results imply that dependent variables define 40% of the variance in independent variables according to Nagelkerke R-Square value, 32 % according to Cox and Snell R square value and 24% according to Mc Fadden R-Square value.

These Pseudo R square values are large enough to predict the model as MCFADDEN (1984), and KLINE (2011) suggested that Pseudo R square values should range from 0.20 to 0.40 for a mode to be strong.

### 3.2.3. Relationship of Independent and Dependent Variables in the model

The relationship between each independent variable and dependent variable in the model was evaluated using the likelihood ratio test. Summary of the likelihood ratio test results are presented in Table 4.

Table 4: Likelihood Ratio Tests

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	P-value
Intercept	213.57	04.446	3	0.200
Household size of respondent	246.42	37.295	3	0.000
Occupation of respondent	213.80	04.679	3	0.100
Education level of respondent	216.64	07.512	3	0.057
Age of respondent	222.87	13.740	3	0.003
Average monthly income of respondent	212.99	03.867	3	0.270

In Table 4, the findings indicate that there is statistically significant relationship between the independent variables such as household size of respondents ( $p < 0.05$ ), age of the respondent ( $p < 0.05$ ), education level of respondent ( $p < 0.01$ ) occupation of the respondent ( $p \leq 0.1$ ) energy sources (independent variables) in rural areas of Tanzania.

### 3.2.4. Estimation of Parameters in the Model

The parameters used in the model on factors determining the choices of energy sources for cooking in rural areas of Tanzania was estimated using maximum likelihood method. The estimated coefficient in the model measures estimate change in the Logit for a one-unit change in the predictors' variable while other predictors are kept constant.

It should be noted that a positive estimated coefficient implies an increase in the likelihood that a household will choose the alternative energy source. Likewise, a negative estimated coefficient indicates that there is less likelihood that a household will change to alternative energy sources. Table 5 present summary results.

Table 5: Parameter estimates results in energy source choice factors in rural areas

Explanatory Variables	Energy sources for cooking in rural areas of Tanzania								
	Charcoal			Firewood			LPG		
	$\beta$	S. E	EXP ( $\beta$ )	$\beta$	S. E	EXP ( $\beta$ )	$\beta$	S. E	EXP ( $\beta$ )
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 results in Table 5 indicate that the age of heads of households in rural areas of Tanzania has positive coefficient values for charcoal, firewood and LPG. These study findings imply that the use of charcoal, firewood, and LPG as a source of energy for cooking over electricity in rural areas of Tanzania increase as the age of respondents increased. In this case, the use of charcoal, firewood, and LPG over electricity for cooking purposes is highly preferred by adult heads of households when compared with young heads of households in rural areas of Tanzania.

The possible explanation could be its affordability, and availability of forest for firewood collection as well as charcoal making in rural areas of Tanzania. These findings correspond with NNAJI, UKWUEZE and CHUKWU (2012) who also found

that older household members prefer to use charcoal or firewood than electricity because of the affordability and its availability in rural areas. Equally, the affordability and availability of forests for firewood collections accelerate rural heads of households' choices to use firewood or charcoal than electricity for cooking purposes.

The increased use of traditional sources of energy for cooking purposes over electricity by rural heads of households in Tanzania in this study is also supported by DIL BAHADUR ET AL. (2017) who revealed that, the increase in age of the respondents increases the likelihood of choosing a source of energy such as firewood compared with another commercial source of energy such as electricity. In this present study, the findings on the age of heads of households also concur with the theoretical explanation that the increase in age of rural heads of households forces stimulate the use firewood or charcoal for cooking purposes due to availability and affordability when compared electricity in rural areas.

However, the present study findings contradict with that of MAGANGA ET AL. (2015) which revealed that an increase in age of the heads of household decreases the probability of using firewood charcoal for cooking over electricity. The possible explanation could be the older the heads of the household, the decrease of their physical strength and thus it becomes difficult to collect or gather firewood at a far distance from their households. Again, the contradiction might be because the study by MAGANGA ET AL.(2015) was conducted in urban areas whereby traditional sources of energy for cooking are not available as results heads of households are being forced to use an alternative source of energy

This study also found that, household size has a positive coefficient value for both charcoal and firewood but negative coefficient value for Liquefied Petroleum Gas (LPG). As it was theoretically expected, the study findings inform that the likelihood of using firewood and charcoal for cooking purposes increase as household size increase in rural areas of Tanzania when compared with electricity.

The possible explanation could be that a large household prefers to use firewood or charcoal since it is comparatively cheap, available as well as its low energy consumption per unit when compared to LPG or electricity in rural areas of Tanzania. The other possible reason could be because of a large family size which



implies considerable man powers that are capable of collecting firewood in the place of their residence are needed. Moreover, the larger the family size the larger the amount of energy for cooking which has a cost implication.

The poverty among the majority of the household in rural areas forces them to switch to firewood and move away from electricity or gases which are more expensive than firewood. Moreover, the findings of this study correspond with that of PUNDO and FRASER (2006) who found that it is cheap and convenient to use firewood for cooking when you have a large family because the cost of acquiring another source of energy such as electricity, charcoal or gas is higher.

In contrast, the study findings of the present study on household size contradict with the study done by OUEDRAOGO (2006) which showed that small family size prefers to use charcoal as a source of energy for cooking than the larger family. The reason for the small family to charcoal could be the choice of energy use as the study used only firewood and charcoal.

However, it was found that charcoal was preferred by households having a smaller family than those having a larger family. Also, the findings show that household size has negative coefficient value on LPG, implying that the use of LPG as a source of energy for cooking decrease as household size increases when compared with electricity. Also, the findings imply that high energy consumption per unit when using LPG for cooking forces heads of households with a large family to use other sources of energy with sufficient energy consumption per unit

The findings of the present study found that occupation of the respondent has a positive coefficient value for charcoal and LPG and negative coefficient value for firewood. These findings imply that the use of charcoal or LPG changes with changes in the occupation of respondents. It is likely that in rural areas of Tanzania, heads of households engaging in agricultural activities have a low level of income and thus they rely on firewood as their sources of energy for cooking.

On the one hand, the findings indicate that heads of households who are employed by the government prefer much to use modern sources of energy such as electricity. On the other hand, employed heads of households have higher earnings which help to procure modern and sustainable sources of energy while heads of

households who engage with farming activities continue to use traditional sources of energy.

Furthermore, the findings of the present study align with VIJAY and ADILI (2011) who found that self-employed heads of households dealing with farming and livestock keeping activities use traditional energy sources such as firewood and crop residue in Njombe rural areas because of having low and unstable sources of income. Consistently, the 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, clean and efficient source of energy for cooking.

In the present study, the findings regarding the education level of heads of households show a positive coefficient value for both charcoal and LPG but negative coefficient value for firewood. The findings imply that the use of firewood as a source of energy for cooking over electricity in rural areas of Tanzania decrease as the level of education increase.

The results imply that the use of charcoal or LPG as sources of energy for cooking in rural areas of Tanzania increase as education level also increases. The reason could be that educated people are aware of the impact of traditional sources of energy such as firewood on the environment. Another reason is that educated rural households opt to use clean and sustainable sources of energy such as electricity or Liquefied Petroleum Gas (LPG) for environmental reasons.

It is found that educated heads of households are less likely to engage in using a traditional source of energy in such a way that reduces the tendencies of environmental degradation through deforestation in the process of searching for firewood. The findings are in line with JOHANNA and LEONARD (2017) who found that households with the highest level of education are more likely to use clean fuels as their main cooking fuels than households without primary education.

The results also comply with ADEYEMI and ADERELEYE (2016) who revealed that if all factors are held constant, heads of households having more education are likely to switch to modern sources of energy. The findings also conform to theoretical assumption that household having more education usually demand for modern sources of energy such as electricity.

Regarding the average monthly income, the study findings show negative coefficient values for charcoal, firewood, and LPG. The findings indicate that the used charcoal, LPG, and firewood for cooking over electricity in rural areas of Tanzania decrease as the average monthly income of heads of households increase.

The findings imply that heads of households in rural areas of Tanzania shift from traditional and unsustainable sources of energy to modern, clean and sustainable sources of energy as their level of income increase. Those in rural areas with a higher level of income assume that firewood is a source of energy for the poor, and thus they engage in using another source of energy.

It was found that the findings 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. The findings on income correspond with NYEMBE (2011) who found that people with low level of income prefer to use traditional sources of energy because apart from being available, they are affordable.

The study findings further concur with OLUGBIRE ET AL. (2016) and STEPHEN (2011) who substantiated that, poor heads of households are the main user of firewood compared with another source of energy, while rich heads of household switches from dirty to clean source of energy such as electricity or gas. The decrease in use of traditional sources of energy for cooking purposes also supports the existing national environmental policy which discourages cutting trees to get charcoal as it leads to detrimental effects to the environment including soil erosion and environmental pollution.

However, the current findings contradict with MEKONEN and KOHLIN (2013) who found that use of charcoal for cooking among people in rural areas decrease as their level of income increase. The reason might be the use of only two types of energy sources namely firewood and charcoal. In her study, charcoal was considered cleaner than firewood because it cannot produce smokes and also leaves the cooking pot clean after use.

Additionally, the decrease of LPG use over electricity based on the level of income increases to the rural household in Tanzania is attributed by shortage gases





cylinder in rural areas and lack of training on how to use these gases. The findings of this study also report that lack of training and un-availability of cooking gases in shops are among of the factors for low usage of LPG for cooking in rural areas of Tanzania.

#### **4. CONCLUSION AND RECOMMENDATIONS**

This study concludes that, apart from rural household income, other factors such as education level, age, occupation and household family size determine the choices of energy sources for cooking in rural areas of Tanzania. Therefore, instead of striving in improving only the income of people in rural areas of Tanzania, other intervention such as family planning, reforestation programmers and promotion of the use of modern cooking stoves should be done to ensure provision of sustainable energy sources in rural areas of Tanzania.

However this study was confronted with several limitations. Firstly, this study employed cross sectional survey design which allows collection of data once. Future research using longitudinal survey design where by data can be collected for a long time and thus enhance reliability and power of generalization of study findings. Secondly, the current study covered energy sources for cooking purposes at household level.

Future study should cover the energy sources for production in small and medium enterprises Limited or large manufacturing companies. Lastly the study employed only quantitative approaches in its analysis. In order to enhance validity and reliability of study findings, future studies should employ both qualitative and quantitative approaches.

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