



MODELING CHOICE OF FIREWOOD AS A SOURCE OF ENERGY AMONG RURAL HOUSEHOLDS IN TANZANIA

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Abstract: This study was designed to identify the key variables influencing firewood consumption by households in Tanzania. A total of 400 households were randomly selected from Mbeya region focusing on rural areas. Data analysis was done through Inferential Statistics by using binary logistic regression model in assessing the effect of the independent variables on the dependent variables. It was found that majority of household in the study area used firewood for cooking. The most significant determinants of firewood consumption in the study area are the household size, price of firewood and distance to the firewood source. Regarding high consumption of firewood in the study area (81.8 per cent), recommendations suggested the National Environmental Committee, Ministry of Natural resources and Ministry of Energy need to recheck and refine friendly policy that will promote the use of other sources of energy to conserve the environment. Also since the main cooking energy in rural areas is firewood, the government under the ministry of natural resources should continue addressing the issues of deforestation all over the country and put more emphasis on forestation in areas where households are victims of firewood consumption making the nation a better place to live.

Keywords: Firewood; Energy; Deforestation; Binary Logistic Regression; Mbeya District Council.

I. Introduction

Firewood is of great importance in developing countries both in rural and urban livelihoods. It is well documented that firewood extraction for energy is one of the leading causes of deforestation and environmental degradation (Malawi Government, 2006a, b) besides permanent land conversion for agriculture, settlement and infrastructural development (FAO, 2010; Zulu, 2010). Although the effect of firewood collection to forest degradation is much debated in literature, wood harvesting for charcoal production is also estimated to contribute to deforestation (Kambewa et al. 2007). Large populations in developing countries depend much on firewood as source of energy with few having access to electricity (MARGE, 2009). Ahmed (2013) noted electricity to be an ideal alternative to wood fuel but remains far beyond the poor majority as its cost remains high. Firewood remains the primary source of energy for heating and cooking. Poverty in rural areas has been a limitation to opt for other alternative sources such as kerosene, gas and electricity. Access to efficient and modern energy is extremely crucial for the developing nations to improve their economies and health status. It is worth noting that the utilization of efficient and modern energy has not been made possible due to lack of resources, effective energy policies and energy systems in the developing nations. People's dependency on traditional biomass for cooking in the developing nations is still a challenge especially in rural areas. Poverty, lack of modern energy and education are the main causes of this phenomenon.

Evidence from Tanzania indicates that firewood collection affects the forest and wealth classes of villagers. Firewood is a major resource in rural areas due to social dimensions, economic aspects and the availability of alternative fuel sources in the area. Firewood is the primary source of fuel used in the village, with the middle and upper classes occasionally supplementing firewood with charcoal. (Preston, 2012). Kilahama (2004) presented the impact of increased firewood consumption to forests and woodland in Tanzania.

The reality indicated that wood or biomass is the major source of energy for domestic uses on Tanzania mainland especially for cooking meals. Majority of households in rural areas depend on wood energy more than other sources of energy. The problems faced as a result of deforestation are further compounded by high population pressure and poverty. The deforestation rate can be significantly felt due to increased demands on the use of forest and woodland resources for the majority to gain livelihoods. Mkiramweni (2012) observed that the overall performance of the country's social and economic development requires the minimization of the existing energy challenges. Currently, about 80 per cent of Tanzanians live in rural areas, and 90 per cent of the populations have no access to grid electricity but rely on firewood and charcoal, causing annual deforestation rates of about 500,000 hectares. Naasegnibe et al. (2013) reported the most determinant factor for firewood use in Western Ghana to be the level of education.

Household heads that attained only basic level of schooling tend to use more of firewood while those who attained tertiary education are more likely to use modern fuels. The report showed that household head's level of schooling is statistically significant related to the type of fuel used by households. The number of years of completed schooling by the household head negatively affects the possibility of the particular household to decide on using firewood.

Ndamase (2012) reported from his study conducted in South Africa that overdependence on firewood in rural areas has commonly been identified as one of the biggest threat to forestry ecosystems. This in turn has led to environmental degradation that includes among others species depletion, soil erosion and decline in water and air quality. Based on the myriad problems caused by over reliance on firewood, study sought to identify usage, management and perceived implication of woodland exploitation in Port St John's local municipality in the Eastern Cape, South Africa. The study identified two key threats to socio-ecological stability resulting from firewood exploitation namely; high poverty levels and lack of coordination in the management of firewood resources. Apart from using firewood for domestic use, local firewood exploitation has been commercialized to augment household incomes. Lack of coordination in the management of natural resources has also created a vacuum in the exploitation and management of firewood resources. Sikei et al. (2007) on their study conducted around Kakamega forest (Western Kenya) discovered that the debate on forest degradation in Kenya is mainly concerned with the utilization and exploitation of forest resources. Firewood gathered from the forested commons is the most important source of domestic energy in the rural areas of many developing countries. The study showed that there is a declining trend in the availability of firewood. Despite this state, rural households still depend largely on firewood for energy provision in the face of limited options constrained by low capital base. The study sought to examine how these households cope with the existing scarcity of firewood. Response mechanisms were analyzed through descriptive methods by looking at collection attributes, use patterns and fuel saving technologies applied by households. Majority of households in Kakamega have resorted to planting trees on their own farms to ease problems of firewood shortage. The study also revealed that households in their endeavour to circumvent the problem of continued scarcity have resorted to poorer quality tree/bushes for firewood, alongside other innovative methods of responding to the firewood scarcity.

Onoja and Ojochenemi (2012) reported from Kogi state in Nigeria that the most significant determinants of firewood demand in the rural areas are the price of firewood, kerosene's price, household size and personal incomes of the household heads. Fairly positive increase in elasticity of kerosene price led to the increase in the consumption of firewood. This shows that as the price of one product increases leads to the increase in the consumption of the substitute product. The report described that household size is statistically significantly related to firewood consumption in the sense that as household size increases firewood consumption also increases. Recommendations from this study include; reduction of kerosene prices, investment in renewable energy, cooking gas and electricity and use of agricultural extension agents to educate farmers on sustainable farming. Zenebe et al. (2010) asserts from Ethiopia that education of head significantly and negatively influence the decision to consume firewood and the price of kerosene positively and significantly influenced the decision to consume charcoal. Moreover, household income, family size, and age of household head significantly influence the decision to consume charcoal. The fact that education of the household head significantly and negatively influenced the decision to consume firewood implies that it is less likely a household will consume firewood the higher the level of education. The price of wood, price of charcoal, age of household head, and education of household head are the determinant factors for firewood use.

Oleg and Ralph (1999) reported that in many developing countries, particularly in rural areas, traditional fuels, such as firewood, charcoal and agricultural waste, constitute a major portion of total household energy consumption. High initial cost to the consumer, particularly relative to the low cash incomes in many rural areas becomes a limiting factor to opt for modern energy. Other factors include shortages of particular fuels, lack of a distribution network, and failures of the distribution system. Production and consumption of almost any type of energy have environmental impacts. Harvesting of firewood, in particular, contributes to deforestation, soil erosion, and desertification. Basing on household level, price of fuel and appliances, disposal income of the households, availability of fuels and appliances, particular requirement related to fuel and cultural preferences to be the key determinants of energy demand. It is often difficult to estimate the effect of price in developing countries where a major part of energy consumption is met by traditional fuels that are gathered informally with no cash outlays. With increasing disposable income and changes in lifestyles, households tend to move from the cheapest and least convenient fuels (biomass) to more convenient and normally more expensive ones (charcoal, kerosene) and eventually to the most convenient and usually most expensive types of energy (LPG, natural gas, electricity). Jumbea and Angelsen (2010) reported from Malawi the attributes of the firewood sources (size and species composition), family size and distance to the sources to be the most important determinants of firewood choice. The report shows that increase in the family size by one unit increases the probability of firewood collection from plantation forests and customary forests by 1.6 percentage points and 0.3 percentage points respectively. Household with large number of members consume more firewood than households with few

members. An extra kilometer distance from the forest reserve reduces the propensity of firewood collection from both forest reserves by 3.7 per cent.

II. Purpose and Rationale of the Study

The purpose of this study based on modeling the choice of firewood as sources of energy among rural households. This made to the rise of important question of what determine the choice of firewood as source of energy among rural households. Since forests are essential to life on earth, performing an amazing life sustaining role through their ability to combine sunlight, water nutrients and carbon dioxide to produce woody biomass and release oxygen that supports all life, there is a need to pay attention on firewood extraction from the forest by households. Otherwise environment and human life will be in danger. Findings from this study will contribute to understanding the choice of firewood as source of energy among rural households and its environmental impacts in the community. The findings will unfold and document various mechanisms through which the government should take action by supplying alternative sources of energy with least cost in order to preserve the environment. The study will provide information to various communities and stakeholders including local government authorities, policy makers, livelihood community based organizations with the purpose of bringing awareness on the current status of firewood consumption and its environmental impact. The research will contribute to baseline information useful for further studies and academic references mainly on energy studies by providing valuable information for policy makers, analysts, and community development planners for sustainable environmental protection.

III. Model description

A. Binary Logistic Regression model:

A binary logistic regression model was employed to analyze the main cooking fuel used by grouping households into two main categories; the first category comprising those using firewood for cooking and the second category comprising those using other types of energy for cooking. The response variable Y is the main cooking fuel in the household. If the household used firewood cooking, then (Y= 1) and if the household used other type of energy, then (Y=0)

$$\text{logit}(\pi) = \beta_0 + \beta_1 H_{size} + \beta_2 E_{level} + \beta_3 P_{fwd} + \beta_4 P_{charc} + \beta_5 D_{fwd}$$

Where by

$$\text{logit}(\pi) = \log\left(\frac{\pi}{1-\pi}\right)$$

π is the probability of using firewood

H_{size} = Household size

E_{level} = Education level of the households head

D_{fwd} = Distance that household walk from home to where firewood is found (in kilometers)

P_{fwd} = Price of firewood per bundle

P_{charc} = Price of charcoal per sadolin (small measure)

β_i = Coefficients , $i = 0, 1, 2, \dots, 5$

For the variable to suit for logit model their coding appeared as follows:

- i. Household size = X_1 (5+ people=1, < 5 people=0)
- ii. Education level = X_2 (< college and university=1, college and university=0)
- iii. Price of firewood= X_3 (≤ 500 Tshs=1, > 500 Tshs=0)
- iv. Distance to firewood = X_4 (≤ 3 km=1, > 3 km =0)
- v. Price of charcoal per minimum measure= X_5 (> 600 Tshs=1, ≤ 600 Tshs=0)

IV. Results and Discussion

A. Binary Logistic Regression Estimates

This section utilizes the significant predictors which are household size, price of firewood per bundle, distance to firewood and price of charcoal per sadolin (small measure) as suggested by the chi-square test for modeling the firewood use for cooking. Having managed to identify the significant association between the dependent variable and these predictors, binary logistic regression were used to assess the impact of independent variables on the dependent variables. All independent variables that were found to be statistically significant at the 5 per cent level

of significance were included in the binary logistic regression model. Total number of 400 cases was included in the analysis. The dependent variable was coded 1 for firewood consumption and 0 otherwise.

Table 1: Binary Logistic Regression Estimate for the Intercept

	B	S.E.	Wald	df	Sig.	Exp(B)
Step 0 Constant	-1.153	.117	96.940	1	.000	.316

Source: *Author's Survey 2015*

Under Variables in the Equation we see that the intercept-only model is $\ln(\text{odds}) = -1.153$. If we exponentiate both sides of this expression we find that our predicted odds $[\text{Exp}(B)] = 0.316$. That is, the predicted odds of households to use other types of energy are 0.316.

Table 2: Omnibus Tests of Model Coefficients

	Chi-square	df	Sig.
Step 1 Step	118.851	4	.000
Block	118.851	4	.000
Model	118.851	4	.000

Source: *Author's Survey 2015*

Now look at Table 2 output. The predictor variables are introduced which are household size, price of firewood, price of charcoal and the distance where firewood is found. Omnibus Tests of Model Coefficients gives us a Chi-square of 118.851 on 4 *df*, significant beyond 0.000. This shows that at least one of the independent variable is statistically significant in explaining the dependent variable.

Table 3: Binary Logistic Regression Estimates for Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a Household Size	1.190	.173	47.436	1	.000	3.288
Price of Firewood	-.308	.098	9.870	1	.002	.735
Price of Charcoal	15.488	2.147E3	.000	1	.994	5.325E6
Distance to firewood	-.008	.101	.005	1	.941	.993
Constant	-66.232	8.588E3	.000	1	.994	.000

a. Variable(s) entered on step 1: Household Size, Price of Firewood, Price of Charcoal and Distance to Firewood.

Source: *Author's Survey 2015*

Table 3 above shows that household size and price of firewood are statistically significant in explaining firewood consumption in the household, with p-values of 0.000 and 0.002 respectively at 5 per cent significance level. Price of charcoal and distance to the firewood source are not found to be statistically significant at 5 per cent level in with p-values of 0.994 and 0.941 respectively.

The binary logistic model is thus;

$$\logit(\hat{\pi}) = -66.232 + 1.19H_{size} - 0.308P_{fwd} + 15.488P_{charc} - 0.008D_{fwd}$$

From Table 3, the only predictors that contain significant variables at 0.05 levels are the one for the predictor household size and for the price of firewood.

Under this model, household size and the price of firewood are the only variables that are significantly associated with categorizing households as being more than 5 members and purchasing firewood for 500 Tanzanian shilling per bundle.

The odds ratio for household size predictor is 3.288. This means that the households that have more than five members are 3.288 more likely to use firewood as compared to those households that do not exceed 5 people. This depicts that the more the number of people in household exceeds 5 the more the budget is allocated in buying firewood.

The odds ratio for the price of firewood is 0.735 indicating that the households who buy a bundle of firewood at a price of more than 500 Tanzanian shillings are $1.36 \left(\frac{1}{0.735} \right)$ less likely to use firewood for cooking as

compared to those households who buy bundles of firewood at a price of not more than 500 Tanzanian shillings. The high price of firewood may limit the consumption of firewood due to the fact that many people in rural areas are poor in the sense that they cannot afford higher price. This makes them to rely on collecting firewood from the forest.

The findings of this study do not differ with that of Jumbea and Angelsen (2010) who focused on household characteristics such as age, gender and sex ratio and found them to have no significant influence on the choice of firewood source. From the study they found family size to be statistically significant the same to this study indicating that an increase in the family size by one unit increases the probability of firewood consumption by households. Household with large number of members consume more firewood than households with few members. Their study differs with this study in the fact that distance to the firewood source is not statistically significant while from their study it was found to be statistically significant showing that an extra kilometer from the firewood source reduces the propensity of firewood consumption.

V. Conclusion and Recommendation

A. Conclusion

This study gives the results of firewood consumption by households in the study area. The findings reveal that the highest proportion of the households consumes firewood as their main source of energy for cooking followed by charcoal to a little extent. A binary logistic regression model revealed that household size and price of firewood are statistically significant in explaining firewood consumption for cooking.

B. Recommendations

Basing on the foregoing findings, the following recommendations are made:

- i. There is a need for government under the ministry of energy to continue putting emphasis on different gas agencies to supply gas in rural areas where gas is not accessible. This is due to the fact that households in the study area were much interested to use gas for cooking and were very much aware about impact and changes to the general environment brought by cutting trees from the forests.
- ii. Since the main cooking energy in rural areas is firewood, the government under the ministry of natural resources should continue addressing the issues of deforestation all over the country and put more emphasis on forestation in areas where households are victims of firewood consumption making the nation a better place to live.

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