© 2016 IJSRSET | Volume 2 | Issue 6| Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Modelling the Factors Influencing Kerosene Consumption for Lighting among Rural Households in Tanzania

Patrick N. Malakasuka

Department of Biometry and Mathematics, Sokoine University of Agriculture, P.O.BOX 3038 Morogoro, Tanzania

ABSTRACT

This study was designed to identify the key variables influencing kerosene 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 the use of binary logistic regression model in assessing the effect of the independent variables on the dependent variable. It was found that majority of household in the study area used kerosene for lighting. Kerosene consumption consisted 40.2 per cent of households while 23.8 percent used torch, 23.2 per cent used electricity, 11.5 per cent used solar, 0.8 per cent used candle and 0.5 per cent used generator for getting light. The study indicated that the most significant determinants of kerosene consumption in the area are price of kerosene, distance to kerosene and distance to electricity source. Regarding high consumption of kerosene in the study area, Ministry of Energy need to recheck and refine friendly policy that will promote the use of more efficient and modern sources of energy with good quality light.

Keywords: Binary Logistic Regression; Energy; Kerosene; Lighting; Mbeya District Council.

I. INTRODUCTION

Around 1.3 billion people worldwide still lack access to electricity. For many, kerosene (paraffin) is a common lighting fuel and kerosene lamp use is widespread in the developing world. Dependency of people on kerosene for lighting energy in developing nations still prevails especially in rural areas. Poverty, lack of modern energy and lack of education are the main causes of this phenomenon. It is reported that nearly 800 million people in Asia live in a state of near darkness, coping with unreliable or non-existent or no access to electricity on a daily basis. The effects on these vulnerable communities are severe. Medical and educational opportunities and services are severely constrained, health risks are heightened by unclean lighting alternatives and opportunities for income generating activities are reduced. Many people also pay a great deal over time for paltry service offered by most fuel-based lighting. There is a great need for clean, sustainable and affordable products to bring light to these households. Many existing initiatives already aim to upgrade lighting sources from fossil fuel sources such as kerosene, either through increasing electricity access with grid expansion or by promoting and making available modern off-grid lighting alternatives. Grid expansion efforts are often expensive and slow-moving to implement, however, off-grid solutions are important for achieving rapid action. Decentralized off-grid lighting and energy projects can be more easily financed and implemented by combinations of international development agencies, local and international NGOs, and private companies. A number of off-grid lighting initiatives already exist, focusing largely on developing Sub-Saharan Africa and South Asia, where more than 95 per cent of people without electricity live as reported by Tedsen (2013).

Research report from REPOA (2011) indicated that kerosene is affordable but electricity is far too expensive for poor urban households. Based on estimates of the upfront cost of accessing different energy sources, the cost of electricity was found to be 1.2 times the cost of using LPG and 16 times the cost of using kerosene. Electricity accounts for the lowest share of the households' energy budget with households spending the minimum on electricity while spending more on cheaper sources of energy such as kerosene. The report indicated that as income increases, households shift to efficient sources of energy such as electricity. Mkiramweni (2012) showed 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 kerosene for getting light.

AFREA (2012) reported that lighting sources in Tanzania can be divided into grid connection, kerosene (and traditional methods), modern off-grid lighting technologies, and photovoltaic (PV)-battery based systems. The report explained kerosene to be predominant fuel for lighting in both rural and urban areas accounting for 84 percent of total lighting fuel. Assuming an estimated 123 metric tons of kerosene used for lighting in 2002, this is about 2 liters per month per unelectrified family. The data excluded Dar es Salaam in which electricity is predominant denoted by 56 per cent while kerosene amounted to 40 per cent of the total lighting fuel. The report shows that other urban areas with the exclusion of Dar es Salaam consume 70 per cent of total lighting from kerosene. Kerosene accounts to 90 per cent of the total lighting fuel consumed by households in rural areas while 84 per cent is used by Tanzania mainland.

LRLPT (2010) reported that Tanzania has one of the lowest rates of electrification in the world. Only around 10 per cent of the entire population of Tanzania has access to electricity. In rural areas where about 70 per cent of the national population lives, only 1 per cent has access to electricity. For the overwhelming 90 per cent of all Tanzanian households currently are not connected to the main power grid and kerosene is the main energy source used to provide light to them. The project explains that the most common kerosene lighting device is a wick lamp with or without glass cover. Kerosene lamps are poor quality lights and a major source of both indoor air pollution and carbon dioxide emissions. In an effort to provide affordable and clean lighting, the company light has developed different lighting products. Under the light Rural Lighting Project Tanzania introduces solar lighting systems to rural Tanzanian households. Solar lighting systems are a viable alternative to the traditional kerosene lamps.

Annemarth (2013) also revealed that Tanzania is facing energy problem. With a very low per capita energy use of about 78 kWh per annum, the consumption is only 10 per cent of the consumption of developing countries and only 0.9 per cent of the consumption of developed countries. Only 0.6 per cent of national energy consumption is electricity, and there is an estimated 5-15 per cent grid connection. It is revealed that 90 per cent of rural households use kerosene for lighting.

Roger and Peter (2011) reported that the high costs of installing pipes in Basque Country prohibited many households from accessing and using gas. For poorer households, paraffin or kerosene became available, required much less expenditure on lamps and offered increasingly widespread fuel access as well as portability. Poorer populations were able to consume substantially more lighting. Kerosene-lighting was cheaper than candle-lighting that's the reason for the poor people to depend much on kerosene for lighting due to low price of kerosene.

Habtamu (2012) estimated the key determinants of kerosene consumption of the Ethiopian households. A model for kerosene consumption by households included the total household expenditure, household size, sex, education and age of the household head. The study examined the place of kerosene use in total household energy consumption and expenditure decision. The study spelled its hypotheses as that total expenditure, household size and education of the household head positively influence kerosene consumption of Ethiopian households. Furthermore, variables like sex, age location factors and substitutability among other energy sources influence expenditure on kerosene. Both at the national and urban level scenarios, total household expenditure, household size, education and electricity showed a positive and significant relation with kerosene demand.

Fidelis et al. (2014) reported that despite the high level of urbanization and resurgence of the middle class after the structural adjustment programme, a significant proportion of households' still use kerosene for lighting. Kerosene is mostly consumed by households in the urban areas because of easy accessibility and relative affordability. Most households in Nigeria use kerosene for lighting via kerosene lanterns. There are many sources of energy for lighting in Nigeria. These include batteries, candles, kerosene, LPG, main electricity and electricity from generator. However, the main energy sources for lighting purpose are electricity (from the national grid) and kerosene. Nationwide, about 50 per cent of households use kerosene for lighting.

Nicholas et al. (2013) identified that kerosene has been an important household fuel since the mid-19th century. In developed countries its use has greatly declined because of electrification. However, in developing countries, kerosene use for lighting remains widespread. Globally, an estimated 500 million households still use fuels, particularly kerosene for lighting. However, there are few studies, study designs and quality are varied and results are inconsistent. Well-documented kerosene hazards are poisonings, fires, and explosions. Less investigated are exposures to and risks from kerosene's combustion products. Some kerosene-using devices emit substantial amounts of fine particulates, carbon monoxide (CO), nitric oxides (NO_x), and sulfur dioxide (SO_2). Studies of kerosene used for lighting provide some evidence that emissions may impair lung function and increase infectious illness (including tuberculosis), asthma, and cancer risks.

Janosch et al. (2012) on their study conducted in Kenya revealed that kerosene (paraffin) was the dominant lighting fuel among Kenyan households. Nearly three quarters of all Kenyan households use kerosene as their main lighting fuel followed by electricity. Data show that (2005/2006) solar and dry cells (torches) were less common, but still used by a number of households as the main lighting fuel. The most common combination of lighting fuels for households that used more than one fuel was a combination of kerosene and dry cells. In cases where kerosene was not the primary fuel, it was typically the secondary fuel. The survey reported that 73.5 per cent of households in Kenya use kerosene as the main lighting fuel followed by electricity which is defined by 16.4 per cent of household using it. The data suggests that the majority of kerosene consumed was for lighting implying that most of kerosene expenditure must have been for meeting lighting needs.

Ahmed (2013) reported that nearly 2/3 of the rural villages living in Bangladesh are not electrified so kerosene is the main fuel used for lighting. However, the people in electrified villages use electricity for meeting their lighting needs as well as for small business and other activities. In electrified villages main appliances are incandescent bulbs and fluorescent tubes. The common household appliances for lighting in non-electrified rural Bangladesh are kerosene lamps. Kerosene lamps utilized for lighting energy are less efficient and have a poor light quality. Access to efficient and modern energy is extremely crucial for the developing nations to counter the economic and health issues and at the same time with the productive use of energy increase the economic growth and life standard of the deprived people. A well performing energy system can provide these people with income generating opportunities as well as to escape them from the awful impacts of poverty. Unfortunately, this has not been made possible due to financial issues, lack of resources, effective energy policies and energy systems in the developing nations.

II. METHODS AND MATERIAL

1. Purpose and Rationale of the Study

The purpose of this study based on modelling the factors influencing kerosene consumption for lighting among rural households. This brought forth the important question concerning the factors responsible for kerosene consumption among rural households. Since human health with clear mind is essential to the development of any nation, there is a need to pay attention on modern lighting energies. Otherwise, human life will be in danger. Findings from this study will contribute to understanding the factors that determine kerosene consumption for lighting among rural households and its impacts to human being. The findings will unfold and document various mechanisms through which the government should take action by supplying most efficient sources of energy with least cost in order to preserve human health. The study will provide information to various communities and stakeholders, policy makers, livelihood community based organizations with the purpose of bringing awareness on the current status of kerosene consumption and its 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 preservation of human health.

2. Model Description

A. Binary Logistic Regression model:

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

$$\text{logit}\ (\pi) = \beta_0 + \beta_1 H_{size} + \beta_2 E_{level} + \beta_3 P_{\ker o} + \beta_4 D_{\ker o} + \beta_5 D_{elec} + \beta_6 P_{torch}$$

Where by

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

π is the probability of using kerosene for lighting

H_{size} = Household size

E_{level} = Education level of the households head

$P_{\ker o}$ = Price of kerosene per minimum measure

$D_{\ker o}$ = Distance that household walk from home to where kerosene is found

D_{elec} = Distance to electricity source

P_{torch} = Price of torch

β_i = Coefficients , i= 0, 1, 2, . . . , 6

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 kerosene = X_3 ($\leq$500Tshs=1, >500Tshs=0)

iv. Distance to kerosene = X_4 ($\leq$ 3km=1, > 3km =0)

v. Distance to electricity= X_5 (>3km=1, $\leq$ 3km=0)

vi. Price of torch = X_6 (>3000Tshs=1, $\leq$ 3000Tsh=0)

III. RESULTS AND DISCUSSION

A. Binary Logistic Regression Estimates

This section presents the modeling of the significant predictors for the most common lighting fuel in the household. Education level, price of kerosene, distance to where kerosene is found, distance to electricity source and price of torch are significant factors as suggested by the chi-square test for modeling kerosene use for lighting. 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 5 per cent level of significance were included in the binary logistic regression model. Number of cases included in the analysis was 400 households. The outcome was 1 if households use kerosene for lighting in their homes and 0 otherwise.

Table 1: Binary Logistic Regression Estimate for the Intercept

	B	S.E.	Wald	df	Sig.	Exp(B)
Step 0 Constant	.586	.104	31.575	1	.000	1.797

Source: *Author's Survey 2015*

Under Variables in the Equation we see that the intercept-only model is ln (odds) = 0.586 If we exponentiate both sides of this expression we find that our predicted odds [Exp (B)] = 1.797. That is, the predicted odds of households to use kerosene are 1.797 Since 257 of households use kerosene and 143 do not use kerosene. Our observed odds are 257/143 = 1.797.

Table 2: Omnibus Tests of Model Coefficients

		Chi-square	Df	Sig.
Step 1	Step	372.711	5	.000
	Block	372.711	5	.000
	Model	372.711	5	.000

Source: *Author's Survey 2015*

Now look at table 2 output. The predictor variables are introduced which are education level, price of kerosene, distance where kerosene is found, Distance to the source of electricity and the price of torch. Omnibus Tests of Model Coefficients gives us a Chi-Square of 372.711 on 5 *df*, significant beyond 0.000. This shows that at least one of the independent variable is relevant 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]	Education Level	-.556	.531	1.096	1	.295	.574
	Price of Kerosene	-2.398	1.034	5.379	1	.020	.091
	Distance to Kerosene	-.815	.254	10.315	1	.001	.443
	Distance to Electricity	2.060	.346	35.529	1	.000	7.845
	Price of Torch	1.687	1.368	1.522	1	.217	5.405
	Constant	-4.504	3.358	1.799	1	.180	.011

a. Variable(s) entered on step 1: Education Level, Distance to Kerosene, Distance to Electricity, Price of Kerosene, and Price of Torch.
Source: *Author's Survey 2015*

The table above shows that price of kerosene, distance to kerosene station and distance to electricity source were found to be important factors (statistically significant) in explaining the most lighting fuel in the household, with p-values of 0.020, 0.001 and 0.000 respectively at 5 per cent significant level. Education level and the price of torch were found not to be statistically significant at 5 per cent level with p-values of 0.295 and 0.217 respectively.
The binary logistic model is thus;

$$\text{logit}(\hat{\pi}) = -4.504 - 0.556E_{level} - 2.398P_{kero} - 0.815D_{kero} + 2.060D_{elec} + 1.687P_{torch}$$

From Table 3, the only predictors that contain significant variables at 0.05 levels are the one for the price of kerosene, distance to kerosene station and distance to the source of electricity.
Under this model, price of kerosene, distance to kerosene station and distance to the source of electricity are the only variables that are significantly associated with categorizing the price of kerosene not more than 500Tshs per small measure, distance less than 3km to the kerosene station and more than 3km to the source of electricity.
The odds ratio for the price of kerosene is 0.091 indicating that the price of kerosene that is above 500 Tanzanian shillings is 11, $\left(\frac{1}{0.091}\right)$ less likely to convince the households to use kerosene for lighting than the price that do not exceed 500 Tanzanian shillings per small measure. This depicts that most of rural households are poor thus they can afford the low price energy.

The odds ratio for the distance that households walk to kerosene station is 0.443. This means that the distance which is more than 3km is 2.3, $\left(\frac{1}{0.443}\right)$ less likely to encourage the households to use kerosene than the distance which is less than 3km. This shows that the shorter the distance to kerosene station the more households use the energy. There is low consumption of energy if it is found far from the household's area.

The odds ratio for the distance to the electricity source is 7.845 indicating that the distance that is more than 3km to the electricity source is 7.845 more likely to encourage the households to use kerosene for lighting than the distance that do not exceed 3km. The more one type of energy is found far away from household area the more the households consume the alternative source of energy which is found near the households area. The findings differ with that of Habtamu (2012) who estimated the key determinants of kerosene consumption of the Ethiopian households. The study revealed that total expenditure, household size, and education of the household head positively influence kerosene consumption of Ethiopian households.

Furthermore, variables like sex, age and location factors, and also substitutability among other energy sources influence expenditure on kerosene. Both at the national and urban level scenarios, total household expenditure, household size, education and electricity showed a positive and significant relation with kerosene demand. The difference with this study is that education level is not statistically significant in explaining kerosene consumption due to the absence of the other lighting energy that's why the distance to electricity source is statistically significant. This means that as the distance to the electricity source increases more households consume kerosene. Also the study goes in line with that of Jumbea and Angelsen (2010) who reported from their report that distance to the source of energy is an important determinant of households' energy choice. An extra kilometer from energy source reduces the propensity of energy consumption. This demonstrates the importance of closeness to energy source. Thus, the value attached to the time spent to walk for energy is an important factor in the household choice of energy source.

IV. CONCLUSION AND RECOMMENDATION

Conclusion and recommendations are given basing on the foregoing findings

i. The study revealed that majority of households in the study area use kerosene for lighting in their homes. The government under the ministry of energy should push its effort on supplying electricity to villages that do not have access of it and should encourage electricity agencies such as REA to continue supplying electricity in villages where electricity is not available. The process of rural electrification needs to be implemented earlier than later for the sake of protecting human health and avoiding problems caused by the use of kerosene to the people who are the productive resource of the country.

ii. Regarding health problems associated with smoke from the use of Kerosene, there is a need for the government under ministry of energy to reduce costs and electricity tariff setting should be harmonized to minimize costs transfer to low income households.

iii. Since kerosene hazards increases time after time due to high consumption, the government under ministry of energy need to put in place deliberate measures to improve penetration of renewable technologies by providing fiscal incentives as well as credit facilities for both consumers and providers of energy. Self-regulations in the renewable energy such as solar and other forms of energy should be promoted to ensure quality supply of products in order to safeguard human wellbeing.

V. REFERENCES

[1]. AFREA (2012). Lighting Africa, A case of Tanzania. An Innovation of International Finance Corporation, World Bank Group and Program update Paris, November 27, 2012. Available at www.support@lightingafrica.

[2]. Ahmed, H. (2013). Energy need assessment and preferential choice survey of rural people in Bangladesh, Master of Science Thesis KTH School of Industrial Engineering and Management. Energy Technology EGI-2013-030MSCDivision of Energy and Climate studies SE-100 44 STOCKHOLM.

[3]. Annemarth, E. M. (2013). Diffusion of Solar PV from a TIS Perspective & its Transnational Factors, A case study of Tanzania, Faculty of Earth and Life Sciences VU University Amsterdam.

[4]. Fidelis, O. O., Uchechukwu, M. O. and Gabriel, A. A. (2014). Household Energy Use and Determinants: Evidence from Nigeria. International Journal of Energy Economics and Policy Vol. 4, No. 2, 2014, pp.248-262 ISSN: 2146-4553 www.econjournals.com

[5]. Habtamu, T. (2012). Determinants of demand for Kerosene in Ethiopia. Association of African Thesis and Dissertations. URI:http://hdl.handle.net/123456789/37551

[6]. Janosch, O., Stover, J., Lay, J. and Jacobson, A. (2012). Household Lighting Fuel Costs in Kenya, Lighting Africa, An Innovation of International Finance Corporation, World Bank Group, Catylising market for modern lighting, Market intelligent note issue 2 December 2012.

[7]. LRLPT (2010). Gold Standard Passport, Premium Quality Carbon Credits. Local Stakeholder Consultation Report of the ‘‘D. Light Rural Lighting Project Tanzania’’Msasani Peninsula, Dar es Salaam. Tanzania.

[8]. Mkiramweni, L. L. N. (2012). The Impact of Biogas Conversion Technology for Economic Development: A Case Study in Kilimanjaro Region, Dar es Salaam Institute of Technology.

[9]. Nicholas, L. L., Smith, K. R., Gauthier, A. and Bates, M. N. (2013). Kerosene: A review of household uses and their hazards in low- and middle-income countries. Journal of Toxicology and Environmental Health, Part B: Critical Reviews, 2013.15(6): 396-432.

[10]. REPOA (2011). Affordability and expenditure patterns for electricity and kerosene urban households in Tanzania. Research Report 11/2, Dar es Salaam. ISBN: 978-9987-615-63-6.www.repoa.or.tz.

[11]. Roger, F. and Peter, J. G. P. (2011). The Long Run Demand for Lighting: Elasticities and Rebound Effects in Different Phases of Economic Development. Basque centre for climate change, Klima Aldaketa Ikergai. BC3 Working Paper Series. http:/Ideas repec.org/r/bcc/wpaper.html.

[12]. Tedsen, E. (2013). Black Carbon Emissions from Kerosene Lamps Potential for a new CCAC Initiative, Ecologic Institute, Berlin www.ecologic.eu.