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Assessing the Welfare value of Fuel Wood Commercialization among Rural Households in the Northern Region of Ghana: Application of Poisson Model

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Abstract
Many developing countries including Ghana has not given so much attention to issues of environmental and natural resources. This is often lacking in development and policy planning. The contribution of the natural resources to the Gross Domestic Product of some of these developing countries worth is not even accounted for. This study established fuel wood commercialization and households' welfare by the individual travel cost method. The study focused on six districts in the Northern Region of Ghana based on poverty and rural dependence mode. The study used the purposive and the systematic random sampling along with a structured questionnaire to elicit information from the respondents. The results showed that a unit increase in travel costs to the forested site's led to reduced number of visits in search for fuel wood. The Poisson model analysis results revealed that there is a statistically significant negative relationship between the number of visits for fuel wood and travel costs. The study recommended that government, community organization and international organizations should facilitate the cultivation of forest sites solely for fuel wood harvesting to enhance environmental sustainability. In addition, appropriate harvesting techniques taught to households could facilitate conservation strategies.

Keywords: fuel wood; commercialization; households'; welfare; livelihood, poisson model, Ghana

INTRODUCTION

Forests are one of the most diverse biological systems on earth and comprised a wide variety of ecosystems that range from open savannah woodlands to dense tropical rain forests (Alastair, 2007), covering approximately one-third (4 billion hectares) of the earth's surface (FAO, 2005). It has been explained that, increases in fuel wood harvesting for commercial purposes and usage have been among the biggest threat to forest covers (Chidumayo and Gumbo, 2013; Kissinger et al, 2012; Agarwal, 2006).

Bojo and Reddy (2001) argued that poverty-environmental usage initiatives which sought to explain the dependence on commercial harvest of fuel wood, have described it as a poverty-development driven nexus. Interestingly, the continuous dependence on fuel wood as a safety net to reduce livelihood vulnerability of fuel wood harvesters defeats the strategies put in place to reduce fuel wood trade.

Poverty and poverty reduction in Ghana are therefore linked to the attainment of safety nets by both rural and urban households which is a welfare function. Tutu (2011) explained that, any effective poverty reduction initiatives should aim at tackling issues of income and income inequality, wealth redistribution, equitable resource allocation, access to education and reducing barriers in education, food security and provision of adequate social amenities to influence economic development. Therefore, the attempts at poverty reduction should be embedded in sustainable livelihoods approach to hasten poverty reduction.

Angelsen and Wunder (2003) explained that, the Sustainable Livelihoods Approach (SLA) has emerged as an approach to reducing poverty. This approach is embedded in forestry livelihood initiatives to slow down poverty while maintaining sustainable development principles in the forestry sector and also improving quality of life of households and the society at large.
Langat et al. (2016) explained that, fuel wood has remained a dominant resource within the category of biomass energy from the forest and has substantially contributed to reducing livelihood vulnerability. In developing countries, forests are an integral part of local people's livelihood. Agrawal et al. (2013) reported that,

in terms of history, forest has influenced substantially and supported livelihoods and poverty reduction, nature of economic growth and development and pattern of economic change in any nation's development path.
The problem of the study is founded on the ensuing debate about the contribution of fuel wood to environmental degradation and deforestation while other literature stressed that fuel wood is met by dead and over aged trees. Policy in Ghana has not adequately taken care of the role of fuel wood in household and at the same time national policy on fuel wood harvest is non-existent.

The specific objective was to: establish fuel wood commercialization and households' welfare in the selected districts in the Northern Region of Ghana. The research question of the study is that: how is the linkage between fuel wood commercialization and households' welfare in the selected districts in the Northern Region of Ghana?. The specific objective of the study is achieved by employing the individual travel cost method to estimate a trip generation function. The consumer surplus computes from the trip generation serves as a proxy for economic welfare. The study incorporated other important issues which are indirectly related the study. Such important issues included determining the most preferred fuel wood specie by households and also ascertain the availability of income inequality among selected districts in the Northern Region of Ghana.

The study hypothesises that:
H_o: fuel wood commercialization has no effect on the welfare of individuals (household heads) in the Northern Region.
H_A:fuel wood commercialization has effect on the welfare of individuals (household heads) in the Northern Region.

This study is a novel one being an original application of the individual travel cost method on fuel wood using Poisson model in the study area. Empirical review showed that the application of the travel cost methodology has largely been used for recreational areas and not fuel wood commercialization.

This study is of enormous importance as it serves to open up the debate as to whether harvest of fuel wood for commercialization should be banned or policymakers should consider establishing fuel wood forest for harvesters to harvest from it; owing to the fact that it serves as a form of trade. Also the magnitude of fuel wood use is complex to understand and thus, especially the rise in the population of the Northern Region. The essence of this study is to help the society, government and other policymakers understand the fuel wood harvesting for commercialization and sustainable development from the context of sustainable livelihood approach. When harvesting of fuel wood is done sustainably natural resources particularly those harvested for fuel wood would thrive.

Empirical studies included Siebert and Belsky (2015) studied managed fuel wood harvesting for energy, income and conservation: An opportunity for Bhutan has supported the current study regarding fuel wood commercialization and poverty reduction in the Northern Region. Their study gave credence to the fact that, fuel wood was a major source of energy for rural and deprived communities in developing countries. It also demonstrated that demand for fuel wood has increased in recent times and therefore has become a cause for consent from a government perspective. They explained that, the government has not provided an alternative which is sustainable enough to warrant a switch to the alternatives among Bhutanese. They recommended that since fuel wood is a source of employment, income provision and dependence of the rural communities, government must stimulate policies aimed at making the harvest of fuel wood to be sustainable with local participation and monitoring.

Ogwumike et al. (2014) opined that firewood has been a dominant source of energy for most Nigerians because of difficulty in accessing other forms of energy for cooking and heating. They employed the multinomial logit models to determine whether energy demand in Nigeria supports the energy ladder hypothesis. They found out that demand for energy in Nigeria does not support the energy ladder hypothesis, but rather supports the fuel stacking hypothesis. They found out that, educational levels of father and mother, per capita expenditure and household size among other factors influenced fuel wood preference and dependence. They recommended that, good measures aimed at making the availability of cleaner energy would enhance sustainable development in Nigeria in terms of energy usage.

Kankam and Boon (2009) studied the linkages between government energy policies and energy use for rural development in Northern Ghana using social surveys in selected rural communities. They found that, lower energy availability and usage patterns was responsible for slow nature job existence, gender roles, and health related issues. Their study also recognized the important role played by energy in the education of rural and urban households. Their study called for a mix of policy tools to influence energy usage and availability to promote growth in Northern Ghana.

METHODOLOGY

This study was carried out in six focused districts in the Northern Region of Ghana.The focus of the study was in these six districts in the Northern Region because, these six districts were homogenous in terms of poverty and education (per the characteristics under study). The districts are (1) Chereponi, (2) East Mamprusi, (3) Sawla-Tuna-Kalba, (4) Karaga, (5) Gushegu, and (6) Bunkpurugu-Yunyoo. The districts were fairly homogeneous in terms of income and education.The other factors used to choose the selected districts were the district level poverty, market access for fuel wood, and individuals (household heads/those involved in fuel wood commercialization) access to the forest for fuel wood using data provided by the Ghana Statistical Service (2010).

The optimal sample size for the study was 285 based on the statistical formula. The target population was individuals (household heads) involved in fuel wood commercialization across the six districts considered for the study and the size is 991. The SPSS IBM version 20 software was used for data analysis with regard to estimation of the Poisson model and therefore captured 280 respondents instead of 285 respondents.

The study obtained list of house numbers and by using Systematic Random Sampling; a sampling interval was obtained for each district and using proportional allocation, the houses were selected. In each sampled house, each individual involved in fuel wood commercialization was involved in the study. Purposively, individuals involved in fuel wood commercialization each sampled house, were involved in the study. Generally, in the rural districts of the Northern Region, majority of the houses were made up of only one household. And therefore, the study did not envisage a situation where a house would be made of more than one household. However, in the urban areas, in the Northern Region, houses were made up of more than one household. In terms of equivalence, the number of houses is equal to the number of households.

Justification for the use of the Travel Cost Method Valuation

An externality relates to the production or consumption decisions of some agent, either a household or firm depends not only his/her activities but also the activities of another agent (Tietenberg, 2006). Externalities have both positive and negative effects on production and consumption decision. In general terms, the presence of an externality makes the market undersupply any given resources (Tietenberg, 2006). Invariably, the effect of an externality is not paid for on grounds where compensation is required. Externalities are major source of market failure (Perman, et al., 2003). The existence of pecuniary externalities transmits through external effect and thus alters resource prices (Tietenberg, 2006). Fuel wood commercialization is considered a market product even though under normal condition it is supposed to be a non-market commodity. It is important to place an economic value on fuel wood commercialization atrium in terms of methodology. It appears that the price of fuel wood is undervalued and does not reflect the actual price of fuel wood in the commercialization process. This obviously is due to the presence of externalities and therefore, by extension.

The individual travel cost method which is a revealed Reference approach in appropriate to capture the value of fuel wood since fuel wood has nonuse value. Therefore, the market price of fuel wood is not a fair estimate because of the presence of externalities. The source of the externalities is attributed to the nature of property rights regimes in the study, the open access nature of the resource and in some cases common challenges as to how these resources are managed. Theses have influenced the choice of the travel cost method to capture the cost of access to the forested sites.

Model Specification

The Travel Cost Method is robust when it comes to placing an economic value on an environmental and natural resource (like fuel wood). The main thrust being its ability to capture the use value of the resource (Arcadio, 2005). Willis and Garrod (2001) reported that the functional form for the travel cost method is not specifically provided for by economic theory and what prevails in economic theory is to help by testing the significance of the variables in the model along with their respective signs. The most widely used functional forms include the linear, log linear and the semi-log dependent variable functional forms. The log linear and the semi-log forms predict finite number of visits for situations when cost is zero and not negative with very high costs (Willis and Garrod, 2001).

Poisson distribution with Count Data

Applications of the count data model involve the use of the Poisson regression (Parsons, 2003). Count data analysis includes cases tilted towards normal distribution whiles others fit binomial distribution. The Poisson distribution is widely used for count data referring to the number of times an event occurs, for instance, the number of visits that a person undertakes to collect fuel wood.

Estimated Model

Travel cost (TC) method depends on information about the amount of money and time people expend to access the site for fuel wood and a value is inferred for the site. The dependent variable (number of visits for fuel wood) can be considered to be count data and therefore the Poisson model is used. Parsons (2013) reported that single site relates to one site and several sites can be aggregated to become one site for analytical purposes. The study considered the travel cost method for the fuel wood commercialization study because fuel wood has a human use value (Arcadio, 2005).

Current study used the Poisson distribution model because of the uniquely count nature of the dependent variable (Tang, 2009).The number of visits by households to harvest fuel wood is an illustration of a count data (integer values which is non-negative). Following Tang (2009) the functional form for the model is expressed below:

ln $V = \beta_0 + \beta_1 TC + \beta_2 Y + \beta_3 AG + \beta_4 SX + \beta_5 ED + \beta_6 ImD + \beta_7 MS + \beta_8$ ALT+ ε

Where: **V**= number of visits for fuel wood commercialization undertaken by each individual i (Household head), $\boldsymbol{\beta_0}$= intercept of the trip generation function, **TC**= travel cost for fuel wood commercialization by each individual (household head) (expressed in cedis-continuous), **Y** = income of the individual (household head) (expressed in cedis-continuous) , **AG** = age of each individual household head (expressed in years-raw age), ***SX*** = is the sex of each individual (household head) (expressed as: 0=female, 1= male), **ED**= formal educational attainments status by each individual (household head) (expressed as: 0= no formal education, 1= formal education), ***ImD***= is the highest number of immediate dependants for each individual(household head) (continuous), ***MS***= current marital status of each individual (household head) (expressed as: 0=unmarried, 1= married), **Alt** = Knowledge about existence of alternative site by each individual household head (expressed as: 0= no, 1= yes), **ε** = error term.

RESULTS AND DISCUSSIONS

The result of this study is hinged on welfare value of fuel wood commercialization and consumer surplus is proxy for welfare derived from fuel wood commercialization.

Table 1: Poisson Regression Analysis Results

Variable	β	SE	P-value	Exp(B)
Age	-0.003	0.0032	0.038*	0.997
Sex	0.580	0.1385	0.000*	1.787
Marital Status	-0.316	0.1000	0.002*	0.729
Education	0.438	0.1457	0.003*	1.646
Immediate Dependants	0.028	0.0277	0.013*	1.028
Substitute Site	0.277	0.1204	0.021*	1.319
Income	0.360	0.0478	0.000*	1.434
Travel Cost	-0.001	0.0006	0.045*	0.001
Constant	-1.014	0.3819	0.008	0.363

***Significant variables; SE= Standard Errors;Exp (B) = the exponential (exp) of a coefficient**

Source: Field Survey, 2015

Table 1 above shows the results of the model parameter estimate of the Poisson regression model. The Poisson estimation process ensures that estimates for factors (categorical variables) are provided for each category. The interpretation of the coefficients in a Poisson model is not straight forward as those expected for OLS model. For a standard count model, the exponential (exp) of a coefficient shows the expected change in the dependent variable as a result of a unit change in the predictor, holding all other predictors constant (Tang, 2009).

Under the Poisson regression (distribution) the β (Beta) is less informative, it only tells the directional sign. For a count model, the exponential of the coefficient shows the expected change in the dependent variable (Number of visits for fuel wood) as a result of a unit change in the predictor, holding other factors constant. That is [exp (β) x 100] – 100: the exponential of the coefficient is multiplied by 100 and 100 is deducted from the answer to arrive at the estimate for a percentage change in the dependent variable (Number of visits for fuel wood).

The Poisson regression results is explained. With respect to Age, the number at visits for fuel wood reduces by 0.3% (100%-99.7%) as one grows in age by one year. The rate of the number of visits for fuel wood increases by 78.7% (178.7%-100%) for being a female, which means that females make more visits for fuel wood compared with males. The number of visits for fuel wood decreases by 27.1% (100%-72.9%) for unmarried respondents. The results showed that married respondents make more visits for fuel wood. The number of visits for fuel wood increases by 64.6% (164.6%-100%) for respondents with no formal education. This means that those with formal education make less visits for fuel wood.

The number of visits for fuel wood increases by 2.8% (102.8%-100%) for a unit increase in the immediate number of dependents. The number of visits for fuel

wood increases by 31.9% (131.9%-100%) for respondents who do not have knowledge about the existence of substitute site. This means that respondents with knowledge of the existence substitute sites make less visits to the current site. A unit increase in income would increase the number of visits for fuel wood by 43.4% (143.4%-100%). The number of visits for fuel wood is reduced by 99.9% (100%-0.1%) for a unit increase in the cost of travel for fuel wood. A study Twerefou and Ababio (2012) and Tang (2009) support the findings of this study in relation with the a prior expectation of these independent variables.

Consumer Surplus

The motivation for this study is hinged on establishing welfare derived from fuel wood commercialization. The consumer surplus from the travel cost methodology perspective is used as a proxy for welfare for individuals' who are engaged in fuel wood commercialization. The study estimated the individuals' welfare (total consumer surplus) by dividing one (1) over the absolute value of the coefficient of the travel cost (Twerefou and Ababio, 2012). The basic assumption is that price is absent (zero) (Parsons, 2013). Blackwell et al. (2007) estimated consumer Surplus (CS) is $\frac{CS}{q} = \left| \frac{1}{\beta} \right|$ for an individual making q visits to harvest fuel wood.

Based on Blackwell et al. (2007) the consumer surplus for this study is estimated as follows:

Number of visits = -1.014 - 0.001**Total costs**

$$\left| \frac{1}{0.001} \right|$$

= 1000

Therefore, multiplying consumer surplus (GH₵ 1000) by the total population (991) will give the total welfare GH₵ 991, 000. The study computed the total consumer surplus to be GH₵ 991, 0000 (GH₵ 1000 × 991).The value computed is the total welfare of all sampled households who engaged in fuel wood commercialization. This becomes an implied opportunity cost for individuals' (households) for which they must sacrifice something to obtain this value. The implication here is that, if there is a government policy or an externality which makes this value **(**GH₵ 991, 000) unavailable, the household heads will be worst off by that amount of consumer surplus.

The rejected the null hypothesis which stated that, fuel wood commercialization has no effect on the welfare of individuals (household heads) and accepted the alternative hypothesis which stated that, fuel wood commercialization has effect on the welfare of individuals. This is because individuals who engaged in fuel wood commercialization had a consumer surplus of GH₵ 991,000 which impacted their lives.

CONCLUSIONS AND POLICY RECOMMENDATIONS

This study assessed fuelwood commercialization and households' welfare in the Northern Region of Ghana. The study focused on six (6) districts and elicited information from household heads. The study analysed fuelwood commercialization and households' welfare using the travel cost method. The results showed that an increase in travel costs reduced the number of visits for fuel wood. The study showed that, the total consumer surplus (household heads welfare) was GH₵ 991,000 annually for the sampled households.

A negative relationship exists between the number of visits for fuel wood and travel cost. The impact of travel cost on the number of visits is statistically significant. The knowledge of the presence of substitute sites led to reduced number of visits to the site. The major conclusion drawn from the study is that fuel wood commercialization in the study areas contributes significantly to income generation and overall poverty reduction in the area. The study recommended that government, community development organization and international organization should facilitate the cultivation of forested sites for fuel wood harvest. Harvested should be sensitized and taught sustainable harvest processes and conservation techniques.

Limitation of the study

This particularly study is limited in scope to the six (6) focused districts in the Northern Region of Ghana. The generalization of the findings of this study is to the six (6) focused districts.

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