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# Econometric Analysis of Factors Influencing Fuel Wood Demand in Rural and Peri-Urban Farm Households of Kogi State

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**Abstract**

This study was designed to determine variables influencing fuelwood demand in rural areas of Kogi State. Eighty households were randomly sampled from all the Agricultural Zones of the state. A 2SLS method was then used for estimation of the coefficients of the simultaneous equation model. The most significant determinants of fuelwood demand in the study area are the price of fuelwood, kerosene's price, household size and personal incomes of the household heads. In light of this study's findings, recommendations included reduction of kerosene prices, investment in renewable energy, cooking gas and electricity and use of agricultural extension agents to educate farmers on sustainable farming.

**Author's Note**

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**Keywords:** fuelwood, deforestation, Two Stage Least Squares, Kogi State, demand function.

## 1. Introduction

Forestry is a source of livelihood for many farmers and rural households in developing countries, especially in sub-Saharan Africa (SSA) (Ayotebi, 2000; Adebaw, 2007). However, the utilization of fuelwood in Nigeria contributes greatly to desert encroachment, and consequently has implications with regard to climate change. Yet, little is understood about the drivers and dynamics of fuelwood consumption in Nigeria and other African countries (Adebaw, 2007; An et al., 2002) Evidence from China, another developing country, indicates that a considerable majority of households in the Wolong region still remain dependent on fuelwood despite their access to electricity. Scholars have proposed reasons for this trend in different parts of the developing world. One of the main reasons for this lack of inter-fuel substitution is that household choice, and use of a given source of fuel, hinges on a host of socioeconomic (e.g. income, and wealth), demographic (e.g. family size, household composition, lifestyle, and culture) and location attributes (e.g. proximity to sources of modern and traditional fuels) in addition to fuelwood availability (Dovie et al., 2004; An et al., 2002; Karekezi et al., 2002; Israel, 2002). This may also hold true in the context of Nigeria, as the country has different climates and a diverse mix of ethnic, religious and linguistic backgrounds. Ayotebi (2000) noted that urban and rural areas of Nigeria largely depend on fuelwood, however, the factors influencing the pattern and magnitude of fuel consumption by urban and peri-urban households are still inadequately understood. For instance, there is a gap in knowledge regarding how household characteristics and wealth endowment influence use of firewood and charcoal (Adebaw, 2007).

The Food and Agricultural Organization, FAO, (1998) observed that the challenge of bridging the gap between demand and supply of about 6 million tons per year led to the depletion of forests and consequent loss of soil fertility. In the absence of forests, flooding from rainstorms led to serious damage to material objects, as well as human casualties. FAO's "Scenario Analysis" on Nigeria (2005), observed that in Nigeria, "The land and environment is very highly devastated by climate, farming, fires, erosion and population pressures." The report further projected that by 2020, "oil is deemphasized and the demand for renewable natural resources including wood and non-wood forest products is on the increase." In addition, Nwafor (2006) asserts that during the period from 1981-1990, the rate of deforestation in Nigeria was 0.7 percent, and Okafor (1990) indicates that this rate was further exacerbated by the fuelwood extraction rate, approximately 3.85 times the rate of re-growth and almost 10 times the rate of regeneration. Empirical evidence indicates that this unfortunate scenario persists across the forest reserves of Nigeria located in Kogi, and five other states (Ayotebi, 2000). The findings of the African Institute of Applied Economics, (2005) demonstrate that real fuelwood prices in various parts of the country were doubling in the last two decades. Despite the uncertainty as to what could be responsible for such a harsh environmental scenario, Botkin & Keller (1997) and Cooke, Köhlin & Hyde (2008) stress that an economic analysis can help us understand why and how environmental resources of forests are being utilized and conserved.

Even though a holistic understanding of the economic systems that perpetuate consumption of fuelwood and lead to deforestation will provide better evidence for policy makers interested in addressing efficient energy use and abatement of deforestation in SSA, unfortunately, the available works on fuelwood economics in Nigeria (e.g. Ebe, 2006; Yusuf, 2006; Cooke et al., 2008) do not use the most appropriate and reliable econometric models to capture the complex nature of the fuelwood crisis. This leaves a void in research on this topic. Against this background, this study was designed to find out the drivers and variables influencing fuelwood demand in Kogi State, Nigeria.

# 2. Framework

## 2.1 Theoretical Framework

This study is anchored on the economic theory of land degradation. Meyeres (1985) held that land clearance or land reclamation involves a *market failure*—the market does not value naturally occurring resources, or "natural capital", in the production process. These are known as *externalities* and have value as the biosphere's *environmental protection functions,* despite absence of produced goods or clearly defined ownership. As a consequence, they are regarded as free goods. The theory of land degradation further posits that destruction of forested areas, wetlands, grasslands and bodies of water arises because of the difference between the *discount rate* of the individual and the society as a whole. As a result of the pressing need for fuel, fodder, water and land for cultivation, people of a lower economic status are subject to a larger share of these losses, assigning a higher discount rate to these resources than society as a whole.

According to the theory of land degradation, the private interests of the impoverished and the social interests of the broader society diverge. The interests of the local people in using these land and water resources is intense, immediate, and focused--food, fuel, fodder, cropland, and irrigation water. They will, often unknowingly, incur almost any social cost to permit the immediate exploitation of these environmental resources to sustain their livelihood. The interests of loggers, commercial farmers, builders and others who exploit the forests, range and grasslands and water resources are equally intense, but driven more by immediate profit considerations rather than the need to survive.

Society, as a whole, has traditionally not placed a monetary value on the benefits derived from these resources since they are not marketable. When society has recognized these resources as having value, it has assigned a diffused, nonspecific value that has not been translated into market signals, such as financial incentives for preservation or disincentives for destruction of these resources. Thus, intense, focused private interests are permitted to discount the value of environmental resources, and thereby sacrifice the longer-term benefits to society. The costs of land clearance that arise from the exploitation of natural resources for financial gain highlight the problems clearly, as these resources provide a myriad of functional processes that go beyond the tangible areas of providing food and products for commerce. On the other hand, these functional processes do not correspond to a conservationist ideology, as they are not essential to a sound ecological balance. Rather, they are naturally occurring systems, on which the economic wellbeing of societies at local, national and international levels depend.

Cost of fuelwood and other commodities are primarily determined by the prices of inputs including time, labor, capital and technological advances (Samuelson & Nordhaus, 2005). Economic theory relates that an array of factors influence how much will be demanded of any given commodity at any given price: average levels of income, the size of the population (e.g household size), the prices of and availability of related goods (in this case, kerosene, cooking gas and coal), individual and social tastes, special influences (e.g. distance of household to common forests and region), and season (Samuelson & Nordhaus , 2005; Reddy, Ram, Sastry & Devi, 2008).

Igugu (2003) and Ebe (2006) noted that fuel wood demand in Nigeria is specifically determined by the above factors. According to Zakaria, Ampadu & Asante (2000), local people, particularly the resource poor farmers in the rural areas, contribute most to environmental resource degradation. Mortimore & Fabiyi (2003) blame environmental resource degradation mainly on problem of unclearly defined property rights of the Nigerian farmers. Hansen (1992) holds that environmental degradation itself can result in the poor's productivity. Desai (1992) establishes that population has linkages with poverty and environmental resource degradation. Thus household size can affect fuelwood consumption and scarcity. The Indicator theory given by Dewees (1989) considers other factors besides population explained by indices (factors) such as labor, time, consumption of less preferred biofuels, cutting of live wood and people's perception of fuelwood, as determinants of fuelwood crisis.

A rise in price of a commodity (fuelwood) therefore signals to suppliers (fuelwood producers) that the product is desirable by consumers and is scarce (Samuelson, 1981). Hence, they will allocate more resources (labor, time, technology and capital) to cutting down trees, leading to deforestation and increase in quantity of fuelwood supplied in the area.

## 2.2 Analytical Framework

According to Gujarati (2006) and Koutsoyiannis (2001), in simultaneous equation models, unlike single equation models, what is a dependent (endogenous) variable in one equation appears as an explanatory (exogenous) variable in another equation. Thus, there is a feedback relationship between the variables. This feedback creates the *simultaneity problem*, rendering OLS inappropriate to estimate the parameters of each equation individually. In addition, a simultaneous equation model in econometrics may result in an *identification problem*. One of ways of resolving this problem is through the *order condition of identification*; an equation has a unique statistical form if it is *exactly identified* or *over-identified* and can only be estimated using Two Stage Least Squares (2SLS), but not OLS. If it is over-identified, in addition to being 2SLS, maximum likelihood methods can be used to estimate the coefficients. The system of equation similar to the aforementioned can be exemplified as follows:

$Y_{1t} = A_1 + A_2Y_{2t} + A_3X_{1t} + U_{1t}$

$Y_{2t} = B_1 + B_2Y_{1t} + B_3X_{2t} + U_{2t}$

In this model, the Ys are the endogenous variables (e.g. quantities of fuelwood consumed by the households and price of fuelwood). The Xs are the exogenous variables (such as household size of fuelwood consumers, annual disposable income of the household, distance from home to common or open forest [in kilometers], price of substitute [i.e. kerosene per liter], cost of labor estimated for equivalent quantity of fuelwood demanded and average cost of capital used in supplying the quantity demanded) and U is the stochastic error term. All prices are quantified in Naira.

# 3. Methodology of Research

## 3.1 Area of study

Kogi State lies between longitudes 5˚40'E and 7˚49'E, and latitudes 6˚33'N and 8˚44'N. It is bounded to the South by Anambra and Edo States and to the North by Niger, Nassarawa and Federal Capital Territory; to the East by Benue and Enugu States. On the Western flank it shares a common border with Ondo, Ekiti and Kwara States (Kogi A.D. P, 1993). In the 2006 population census, the state pooled a population of 3,278,487, representing 2.34% of the Nigerian population.

## 3.2 Data Collection

Primary data used for the study was obtained through the use of structured questionnaires and interviews of the farm and non-farm households that make use of fuelwood in the study area. The secondary sources of data used came from published texts, journals, periodicals, and online and offline computer resources, such as DVDs and CDs.

## 3.3 Sampling Plan

A multi-stage random sampling method was employed to draw the sample for the survey. Farm households who make use of fuelwood in cooking at peri-urban and rural areas of the four (4) agricultural zones of Kogi State constituted the sampling frame. The Zonal headquarters for the four (4) agricultural zones include Aiyetoro Gbede (Zone A), Anyigba (Zone B), Koton Karfe (Zone C) and Alloma (Zone D). From each zone, one rural and peri-urban area were selected randomly (giving a total of eight sites). From these eight sites, five farm households and five non-farm households were randomly selected (i.e. 10 fuelwood consumers from each site) giving a total sample size of eighty (80) farmers from all the sites. Specific sites in the order of peri-urban and rural are as follows: in Zone A, Kabba-Bunu and Ijumu; Zone B, Anyigba and Ejule; Zone C, Lokoja and Ganaja Village; and Zone D, Idah and Emonoja-Aludu. In order to deduce price of inputs forty (40) fuelwood producers/marketers took questionnaires.

## 3.4 Data Analysis

The objective was obtained using descriptive statistics such as mean, range, standard deviation etc. A Two Stage Least Squares method was used for estimation of the coefficients of the following simultaneous equation model. It is of the form:

$$\ln Y_{fwd} = \alpha o + \alpha_1 \ln P_{fwd} + \alpha_2 \ln PK_{ero} + \alpha_3 \ln HSize + \alpha_3 \ln HIncm + \alpha_4 \ln Dist + \mu_1 \quad (1)$$

$$\ln P_{fwd} = \beta o + (\alpha o + \alpha_1 \ln P_{fwd} + \alpha_2 \ln PK_{ero} + \alpha_3 \ln HSize + \alpha_3 \ln HInc + \alpha_4 \ln Dist + \mu_1) + \beta_2 \ln PLabor + \mu_2 \quad (2)$$

The above equations were estimated simultaneously using SPSS 14 econometric software. The program estimates the parameters on the following principles:

Since $\ln P_{fwd} = \beta o + \beta_1 \ln Qty_{fwd} + \beta_2 \ln PLabor + \beta_2 \ln Transptcost + \mu_2$ (3)

$\tilde{Y}_{fwd}$ was used as a proxy for $Y_{fwd}$ because of the error term, $\mu_1$ in the second equation. Hence, equation (2) becomes

$$P_{fwd} = \beta o + \beta_1 \ln \tilde{Y}_{fwd} + \beta_2 \ln PLabor + \beta_3 \ln Transpcost + \mu_2 \quad (4)$$

The simultaneous equation is now equivalent to:

$$\ln Y_{fwd} = \alpha o + \alpha_1 \ln HSize + \alpha_2 \ln HInc + \alpha_3 \ln Dist + \alpha_4 \ln P_{fwd} + \alpha_5 \ln PK_{ero} + \mu_1 \quad (1)$$

$$\ln P_{fwd} = \beta o + \beta_1 \ln \tilde{Y}_{fwd} + \beta_2 \ln PLabor + \beta_3 \ln Transpcost + \mu_2 \quad (4)$$

Where

$Y_{fwd}$ = Quantity of fuelwood in consumed per month in kgs.
HSize = Household size of fuelwood consumers.
HIncm = Annual disposable income of the household (Naira)
Dist = Distance from home to common (or open) forest (in kilometers).
$P_{fwd}$ = Price of fuelwood per kg
$PK_{ero}$ = Price of kerosene per liter
PLabor = Cost of labor estimated for equivalent quantity of fuelwood demanded
PTranspt cost = average cost of capital used in supplying the quantity demanded.
$\tilde{Y}_{fwd}$ = Estimated values of $Y_{fwd}$ using the linear form in equation (1).
$\alpha_1$ = coefficients of the main (demand) equation.
$\beta_i$ = coefficients of instrumental variables ($2^{nd}$ equation)
$\mu_i$ = Stochastic error terms.
Ln = exponential log to base e.

# 4. Results and Discussion

The estimated model is as follows:

$\ln Y_{fwd} = 4.096 - 0.76 \ln P_{fwd} + 0.373 \ln PK_{ero} + 0.316 \ln HSize - 0.228 \ln HIncm - 0.192 \ln Dist + \mu_1$ *S. E.*

(1.088) (0.114) (0.135) (0.081) (0.050) (0.027)

*t ratios* 3.765* -0.732 3.862* 2.149** -1.842*** -1.517

NB: * Significant at 1%; **significant at 5% and ***significant at 10%. Standardized coefficients were used.

**Model Summary**

| | | |
|---|---|---|
| Equation 1 | Multiple R | .860 |
| | R Square | .739 |
| | Adjusted R Square | .701 |
| | Std. Error of the Estimate | .153 |

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Equation 1 | Regression | 2.271 | 5 | .454 | 19.287 | .000 |
| | Residual | .801 | 34 | .024 | | |
| | Total | 3.071 | 39 | | | |

**Coefficients**

| | | Unstandardized Coefficients | | | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| Equation 1 | (Constant) | 4.096 | 1.088 | | 3.765 | .001 |
| | lnPricefuelwoodkg | -.083 | .114 | -.076 | -.732 | .469 |
| | lnpriceKeropricelitre | .520 | .135 | .373 | 3.862 | .000 |
| | lnHouseholdsize | .174 | .081 | .316 | 2.149 | .039 |
| | lnmonthlyincome | -.092 | .050 | -.228 | -1.842 | .074 |
| | lnDistanceKm | -.041 | .027 | -.192 | -1.517 | .138 |

Table 1. Results of 2SLS Estimation (Model Summary, ANOVA and Coefficients).
Source: Field Data Analysis' Result using SPSS

The descriptive statistics for the data used in modeling this relationship is not discussed (see Appendix for results). The model summary, reporting a multiple correlation of 0.860, indicates that there is a very high statistical association between the exogenous variables chosen in the model and the endogenous variable of the main equation (demand function). The R Square and adjusted R square of 0.739 and 0.701 respectively confirmed that the model has very good fittings, with the variations in the values of the explanatory variables of the first equation being responsible for seventy four percent (74%) and seventy percent (70%), respectively, of the variations of the quantity of fuel wood demanded or utilized by the consumers sampled in the study area. To corroborate this assertion, the ANOVA results of the model, with F value of 19.28, estimated at 5 and 34 degrees of freedom (and a low standard error of 0.15), gave a ϱ value of 0.000. This means that at a significance level of 1%, the null hypothesis of no significant effect of the exogenous variables on the quantity of fuel wood demanded is rejected, and the alternative hypothesis of the model, that the exogenous variables influences the variations in the quantity of fuel wood demanded significantly, is upheld. In evaluating the theoretical validity of the model it was observed that all the exogenous variables of the main equation conformed to the *a priori* expectations.

The unstandardized coefficient of the intercept, which recorded a value of 4.096, was significant with a p value of 0.001, signifying that even when all the included exogenous variables remain at zero, there will still be a significant fuelwood demand increase at 1% probability level. This may be due to cultural factors or other reasons that were not explained in the model. The coefficient of -0.76 recorded for price of fuelwood implies that for every unit change in price of fuelwood the quantity demanded of fuelwood in the in the study area falls by 76%. This is in line with the theory of demand which held that as price of the commodity falls, *ceteris paribus,* the quantity demanded increases. The effect of this variable is, however not significant at 5% and 10% level given a t ratio of -0.732 and a ϱ value of 0.469. This situation could be explained by the fact there are other alternative sources of energy in the state that consumers can fall back on when prices of fuelwood rises.

The fairly positive increase in elasticity of kerosene price (37% or 0.373) is in line with theoretical expectations that the higher the price of the substitute product (kerosene in this case), the higher the consumption of the product (fuelwood). So for every unit increase in kerosene price (1 naira), a 37% increase in the quantity of fuelwood demanded by Kogi State citizens is recorded. The effect of kerosene is significant at 1% alpha level with a ϱ value of 0.000. For household size, the elasticity is 31% or 0.316, meaning that for every unit change in household size in the study area fuelwood consumption will increase by 31 percent. This factor has a significant effect at 5% alpha level (with a ϱ value of 0.039). Monthly income of the consumers of fuelwood also has a significant effect (ϱ value of 0.074 or 10 percent level of significance) on quantity of fuelwood consumed or demanded in the area. With an elasticity of -0.192 (19%), one can assert that for every 1 unit of income increased in the study area, the people will reduce their demand for fuelwood by 19%. This means that higher incomes can lead to less consumption of fuelwood as those whose income are increasing could resort to use of cooking gas, kerosene and, probably, electricity. The negative sign on the distance to forest coefficient implies that the farther a consumer of fuelwood resides from sources of fuelwood supply, the less fuelwood he consumes, ceteris paribus. Thus the elasticity value of -0.192 recorded for distance implies that for every kilometer distance in residence away from the forests where fuelwood are sourced there is a decrease of nineteen percent (19%) in level of fuelwood demanded.

The coefficient correlation matrix of the model estimate was evaluated and the exogenous variables did not display any high correlation. The highest value recorded was 0.493 which was between distance and household size. Thus multicollinearity could not be established as a threat in the model estimated.

## 5. Recommendations

Based on the foregoing findings, the following policy recommendations are hereby made:

1. The Nigerian federal government should intervene and urgently reduce the price of kerosene, as such a policy would reduce deforestation, and as such would help mitigate global climate change.

2. The Nigerian government should hasten to invest in the development of cooking gas, developing this as an alternative fuel source, instead of continuous flaring of this gas, which contributes to global warming.
3. The use of renewable energy sources, such as solar powered cookers and electricity, should be pursued with utmost vigor.

In conclusion, more efforts need to be made by Agricultural Extension Departments in the state to educate farmers on the use of renewable energy sources, and more action needs to be taken by the federal government to promote the use of alternative fuel resources, such as kerosene and cooking gas.

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# Appendix

**Model Description**

| | | Type of Variable |
|---|---|---|
| Equation 1 | Inqtyf wdkg | dependent |
| | InPricefuelwoodkg | predictor & instrumental |
| | InpriceKeroricelitre | predictor & instrumental |
| | InHouseholdsize | predictor & instrumental |
| | Inmonthlyincome | predictor & instrumental |
| | InDistanceKm | predictor & instrumental |
| | InPricefwd | instrumental |
| | Inlabour | instrumental |
| | Intranspot | instrumental |

MOD_2

**Coefficient Correlations**

| | | | In Pricefuelwoodkg | Inprice Keroricelitre | In Householdsize | Inmonthlyincome | InDistanceKm |
|---|---|---|---|---|---|---|---|
| Equation 1 | Correlations | InPricefuelwoodkg | 1.000 | .168 | .408 | .320 | -.076 |
| | | InpriceKeroricelitre | .168 | 1.000 | .006 | .350 | -.104 |
| | | InHouseholdsize | .408 | .006 | 1.000 | .427 | .493 |
| | | Inmonthlyincome | .320 | .350 | .427 | 1.000 | -.208 |
| | | InDistanceKm | -.076 | -.104 | .493 | -.208 | 1.000 |

**Statistics**

| | | Unit Prices of Fuelwood/kg | Kerosine price/litre | Household size | monthly income(naira | Distance from forest in km | approx. ave labour p | monthly fwd qty/hs kg | approx. ave cost of transport |
|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| | Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | | 8.27 | 67.65 | 7.76 | 51293.75 | 19.35 | 501.88 | 254.15 | 440.13 |
| Std. Error of Mean | | .220 | 2.023 | .423 | 3744.360 | 1.300 | 17.394 | 7.111 | 15.587 |
| Median | | 8.00 | 55.00 | 7.00 | 50000.00 | 22.00 | 500.00 | 265.00 | 400.00 |
| Mode | | 6 | 55 | 6 | 50000 | 2 | 600 | 200 | 400 |
| Std. Deviation | | 1.971 | 18.097 | 3.787 | 33490.571 | 11.623 | 155.581 | 63.599 | 139.413 |
| Variance | | 3.886 | 327.484 | 14.342 | 1121618315 | 135.104 | 24205.301 | 4044.832 | 19436.060 |
| Skewness | | .262 | 1.148 | .407 | .918 | -.343 | .011 | -.221 | 1.154 |
| Std. Error of Skewness | | .269 | .269 | .269 | .269 | .269 | .269 | .269 | .269 |
| Kurtosis | | -1.267 | -.257 | -.737 | 1.438 | -1.049 | -.784 | -1.192 | .759 |
| Std. Error of Kurtosis | | .532 | .532 | .532 | .532 | .532 | .532 | .532 | .532 |
| Range | | 7 | 55 | 15 | 159000 | 41 | 600 | 245 | 650 |
| Minimum | | 5 | 55 | 2 | 6000 | 1 | 250 | 105 | 200 |
| Maximum | | 12 | 110 | 17 | 165000 | 41 | 850 | 350 | 850 |
| Sum | | 662 | 5412 | 620 | 4103500 | 1548 | 40150 | 20332 | 35210 |