Econometric Analysis of Causes and Impact of Deforestation on Agriculture in Nigeria

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ABSTRACT

This study analyzed the econometrics causes and impact of deforestation on agriculture in Nigeria. The specific objectives were to estimate the magnitude of direct, indirect causes of deforestation and determine the relationship between demographic variables and deforestation. Time series data on all the variables in the study spanning from 1975 to 2013 were used. Block recursive and ordinary least square regressions were the analytical techniques used for the study. The results of the study revealed that fuelwood consumption (FWC), forest product for export (FPE), round wood consumption (RWC) and area of food crop production (AFP) were found to be the direct causes of deforestation. Fuelwood consumption was found to be the major causes of deforestation with elasticity of 3.1, followed by round wood consumption and area of food crop production with elasticity of 2.4 and 0.08, respectively. Among the indirect causes, Gross Domestic Product and population were found to be significant factors affecting fuelwood consumption at 5% and 1% levels respectively, while Gross Domestic Product and price of forest product were significant at 5% level in equation of FPE with elasticity 1.6 and 1.1 respectively. Population and forest total area were found to be positive and significant at 1% and 5% levels as indirect causes of round wood consumption. The coefficient of forest total area had inverse relationship with round wood consumption. The elasticity of population and forest total area were 0.31 and 0.14, respectively. Poverty, human population and livestock population were found to be positively related to forest decline at 1% level, while education was negatively related to deforestation at 1% level. Fuelwood consumption, round wood consumption, exported forest product and area of food crop production were found to be the direct causes of deforestation, while Gross Domestic Product, population growth rate and international price of forest product exported were found to be the indirect causes. Based on the findings of the study it was recommended that policies should gear up towards finding alternative sources of energy than concentrating on fuelwood, while unnecessary clearing of forests should be legislated against to minimize the direct and indirect causes of deforestation.

Keywords: Econometric, Causes, Deforestation and Nigeria

INTRODUCTION

Deforestation is any activity that disrupts the natural ecology of forest as a result of agricultural, social and economic activities carried out in the name of development (Ibrahim, 2014). It also affects economic activity and threatens the livelihood and cultural integrity of forest dependent people by reducing the supply of forest products and causes siltation, erosion, desertification, drought and flooding (Annan, 2013).Rapid deforestation is now a major problem affecting the daily lives of Nigerians through its effects. Some policy measures were put in place by government such as ban on logging (1975), Annual Afforestation (AP) (1988), National Forest Action Plan (NFAP) (2005), educating farmers about dangers of environmental degradation, providing farmers with high yielding varieties of crop and irrigation equipment. In spite of these policy measures, deforestation continued to increase at alarming rate. For instance, between 2000 and 2005, Nigeria lost 5.7 percent of its primary forest as a result of deforestation

and the rate continues to increase by 3.8 percent, which is equivalent to 4,000 hectares per annum. Based on these figures, Nigeria has the highest rate of deforestation in the world (Ayala, 2010).

Scientists and researchers in Nigeria have drawn attention to the serious and mounting ecological problems associated with deforestation in the country. This concern dates back to many years before the 1930s, when the United Nation (UN) sent a signal on the desert encroachments in sub- Saharan Africa. Since then, both policy makers and the general public have become aware of the fact that deforestation carries high opportunity costs in terms of the different economic and environmental benefits that the forest renders. Some of these opportunity costs are the loss of agricultural productivity, drought, desertification, erosion and climate change resulting from deforestation.

Agriculturally, deforestation and conversion of forest to arable land has drastic effect on soil properties. The principal effect of deforestation on chemical and nutritional properties of soil is related to a decrease in organic content. This leads to disruption of nutrient cycling mechanism as a result of the removal of deep rooted trees, which has serious effect on organic and nutrient content as such affects agricultural productivity. For instance, studies conducted from 1971 to 2005 revealed that there was a temperature increase in Nigeria by 1.1^0 C, compared to the global increase in mean temperature of 0.74^0 C. It was also found that in the same period the amount of rainfall in the country decreased by 81mm as against global average decrease of 52.8mm. It was noticed that these climatic changes had sharp effects on the agriculture (Udofia*et al*., 2011).

In the quest for solution to the problems of deforestation, Nigeria has been trying to achieve capacity development, human resource and technological development on environmental problems, but most of the studies conducted on causes of deforestation such as Onyekale (2007) and Ibimilua (2012) used models that incorporated both the variables of direct and indirect causes of deforestation, without distinguishing them. Such analyses may result in making misleading conclusion. In addition, socio-economic variables in a given environment such as poverty, population, bush fire, price of wood substitutes and infrastructural development that have direct link to deforestation were not properly captured by previous studies. Studies of this nature may result to in conclusive outcome. This study, therefore, was designed to analyze the magnitude of direct and indirect causes and socio-economic factors affecting deforestation and their impact on agriculture in Nigeria using econometric modeling approach, with the aim of bridging the gap of previous studies and providing a blue print of the variables to be considered in tackling the problems of deforestation and its impacts on agriculture in Nigeria.

METHODOLOGY
Study area and data collection
The study was conducted in Nigeria, located between Latitudes 4^0 and 14^0 north and Longitudes 3^0 and 15^0 east, situated south of the Gulf of Guinea of West Africa (FAO, 1981). Secondary data (Time Series) were collected to cover the periods of 1975 to 2010 for the analysis. Data were collected on area of forest cover and macro-economic variables that are related to the study. These data were collected from national and international sources such as Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS), Food and Agriculture Organization (FAO), World Bank (WB) and Federal Ministry of Environment statistical publications.

Model specification
Block recursive regression was applied to estimate the direct and the indirect causes of deforestation in Nigeria. This model is relevant as it shows equations that consist of direct causes of deforestation (i) and five equations of the underlying causes of deforestation (ii).The equations were explicitly expressed as follows:

First Stage Estimation Equation
$$DEF = bo + b_1FPE + b_2RWC + b_3FWC + b_4TCP + b_5FCP + U_1 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots i$$

Where: DEF   =   Annual decline of forest cover (km^2)
         FPE   =   Annual forest product for export including non-timber (₦)
         RWC   =   Annual domestic round wood consumption (tons)
         FWC   =   Annual fuelwood and charcoal consumption (tons)
         TCP   =   Area of tree crop production (hectare)
         FCP   =   Area of food crop production (hectare)
         bs   =   Coefficients
         bo   =   Constant
         U_1 =   Error term

Second Stage Estimation Equations

$$FPE = bo + b_1GDP + b_2PFP + b_3EDT + b_4EXR + U_2 \dots\dots\dots\text{ii}$$
$$RWC = bo + b_1GDP + b_2PPI + b_3FTA + b_4ATP + U_3 \dots\dots\dots\text{iii}$$
$$FWC = bo + b_1GDP + b_2PCS + b_3FTA + b_4ATP + U_4 \dots\dots\dots\text{iv}$$
$$TCP = bo + b_1GDP + b_2FTA + b_3ATP + b_4PPS + U_5 \dots\dots\dots\text{v}$$
$$FCP = bo + b_1GDP + b_2ATP + b_3FPI + b_4FTA + U_6 \dots\dots\dots\text{vi}$$

Where: GDP= Gross Domestic Product (%)
         PFP   =   Real Price of forest product (₦ / m^3)
         EXR   =   Real Exchange Rate (2000=100)
         EDT   =   External debt (₦)
         PPI   =   Real Producer Price Index (2000=100)
         FTA   =   Forest total area (hectare)
         TCP   =   Annual total population (numbers)
         PCS   = Real Price of kerosene (₦ /liter)
         FPI   =   Food Production Index (2000=100)
         bs   =   Coefficients
         bo   =   Constant
         Us   =   Error terms

Double-log was chosen as lead equation to determine the relationship between deforestation and demographic characteristics. The model was explicitly expressed in equation vii.
$$LnDEF= bo + b_1LnPVT + b_2LnINF + b_3LnEDU + b_4LnPOP + b_5LnLPOP + U \dots\dots\dots\text{vii}$$
Where:
         DEF   =   Annual decline in forest cover (km^2)
         PVT   =   Absolute Poverty Level (%)
         INF   =   Infrastructure (Index)
         EDU   =   Education (Number of Enrolled in Tertiary Institution).
         POP   =   Population (Numbers)
         LPOP   =   Livestock Population (Numbers)
         bs   =   Coefficients
         bo   =   Constant
         Ln   =   Natural Logarithm
         U   =   Error term

RESULTS AND DISCUSSION
Direct causes of deforestation
Results of the direct causes of deforestation are presented in Table 1. Based on statistical and econometric criteria the results are significantly explained by forest product for export (FPE), domestic round wood consumption (RWC), fuel wood consumption (FWC) and area of food crop production (FCP).

Table 1   First stage of block recursive results of direct causes of deforestation

Variable's	Coefficient	STD Error	t-value	Elasticity
FPE	0.2120	0.0419	5.0584***•	1.058
RWC	7.6333	1.7774	4.2945***•	2.444
FWC	10.2024	1.0397	9.8126***•	3.131
TCP	0.4442	0.8105	0.5480[NS]	0.463
FCP	1 .0357	0.3691	2.8060***	0.810
Intercept	24.2736			
R^2	0.8710			
Adjusted	0.8542			
Akaike Information criterion	0.7000			
Schuwarz criterion	0.9200			
Hannan-Quinn criterion	0.7767			
Durbin – watson stat	2.1854			

Source: Computed data, 2013.Note: ***= significant at 1%, NS= Not significant.

The coefficient of forest product for export was positive and significant at 1% level. This means that forest product for export is one of the main causes of forest cover decline in Nigeria. The result implies that as forest product for export increases, deforestation increases. The possible reason for positive and significant relationship between FPE and decline in forest area cover is that FPE are directly obtained from the forest. For any forest product exported, some volume of forest must have been lost. In other words, the volume of forest product exported is a direct measure of forest product extracted from the forest. Correspondingly, another possible reason could be based on Federal Government policies on promoting non-oil export in order to improve the economic growth, considering tremendous increase in real value of FPE which stood at 8.8 million dollars in 1975 to 12.1 and 45.6 million dollars in 1995 and 2009 respectively (FAO, 2011).The elasticity of forest product for export in respect to area of forest cover decline was 1.06, implying that with 1% increase in value of forest product for exported, area of forest cover will decline by 1.06%. This also implies that forest product for export was exposing the land to low agricultural productivity by 1.06% through erosion, soil degradation, nutrient loss and climate variability.

Coefficient of domestic round wood consumption was positive and significant at 1% level. This clearly indicates that domestic round wood consumption is one of the major causes of deforestation in Nigeria. The positive sign of the coefficient reveals that as domestic round wood consumption increases, area of forest cover decline increases. The result shows that despite ban on exportation of wood and wood products in 1975, domestic round wood consumption in Nigeria remains high and still decreases area of forest cover. The possible reason for this may be reflection of high demand of domestic wood product for infrastructural development such as building and household furniture in the country. The elasticity of domestic round wood consumption with regards to area of forest cover decline was 2.4, which implies that with 1% increase in domestic round wood consumption, deforestation will increase by 2.4% in Nigeria, which makes the land unsuitable for agricultural production as a result of the 2.4% depleting of soil nutrient and climate change, causing decline in agricultural productivity. The coefficient of fuelwood and charcoal consumption was positive and statistically significant at 1% level. This portrays that fuelwood consumption is one of the major causes of forest cover decline in Nigeria. This could be as a result of huge demand of energy due to increase in population and recent increase in oil price in Nigeria (Onuche, 2011). This result corroboratethe findings of Oni *et al.* (2013) that forest biomass has remained the most common source of household energy in Nigeria. As such, it serves as a major cause of deforestation in Nigeria. The elasticity of fuelwood and charcoal consumption in respect to area of forest cover decline indicated that increase in fuelwood and charcoal consumption by 1 % will lead to 3.13%

decline in forest cover. This may lead to drought, degradation and desertification as well as decline in agricultural productivity.

Coefficient of annual area of food crop production was positive and statistically significant at 1%. This is obvious because agricultural land expansion and ranching are considered as major causes of tropical deforestation in Africa (Mahapatara and Kant, 2007). This implies that as area of food crop production increases, area of forest cover declines, which corroborate the findings of Onyekale (2007) that agricultural land expansion plays a major role in decreasing area of forest cover in Nigeria. The elasticity of area of food crop production with regards to decline in forest revealed that with 1% increase in annual area of food crop production in Nigeria, area of forest will decline by 1.03% and also exposed land to low productivity by the same percentage through nutrient loss, erosion and soil degradation.

Indirect causes of deforestation
Four independent variables that were found to be significant in the first stage of the block recursive analysis were incorporated in the second stage as dependent variables. In the second stage of the block recursive analysis, the variables were also estimated in term of coefficient, standard error, t-values and elasticity as presented in Table 2.

Table 2. Second stage of block recursive results of underlying causes of deforestation

i. Forest product for Export (FPE)				
	Intercept	**GDP**	**PFP**	**EDT**	**EXR**
	19194.6	-0.1042	247.8322	0.0013	-1311.39
	(26496.9)	(0.0331)	(61.4215)	(0.0014)	(1016.72)
t-values	0.7244	-3.1427***	4.0349***	0.8790 NS	-1.2897 NS
Elasticity		-1.1401	1.5631	0.7994	-3.0566

R^2 0.61
Durbin Watson 2.096

ii. Domestic Round wood consumption (RWC)				
	Intercept	**GDP**	**PPI**	**FTA**	**ATP**
	20284.39	-0.0015	0.4441	-939.183	1.2014
	(15374.37)	(0.0099)	(0.81047)	(404.353)	(0.0940)
t-value	1.3193	-0.1563 NS	0.5480 NS	-2.3226**	12.7749***
Elasticity		0.4301	0.1483	-0.1483	0.3087

R^2 0.69
Durbin-Watson 2.177

iii. Fuel wood consumption (FWC)				
	Intercept	**GDP**	**PCS**	**FTA**	**ATP**
	5656.27	-15.2310	1.8484	-249.35	0.6250
	(10395.97)	(2.4576)	(28.9636)	(229.015)	(0.0682)
t-value	0.5440	-6.1975***	0.0638 NS	-1.0888 NS	9.1575***
Elasticity		-0.4790	0.0089	-0.0499	0.9894

R^2 0.72
Durbin- Watson 2.150

vi Area of Food crop Product (FCP)				
	Intercept	**GDP**	**ATP**	**FPI**	**FTA**
	0.3021	-0.4750	0.000	0.0289	-0.3417
	(7.7832)	(0.1383)	(0.0002)	(0.0142)	(0.0451)
t-value	0.0388	-3.433***	0.2962 NS	2.0332**	-7.5719***
Elasticity		-0.2555	10.7144	1.2063	11.8007

R^2 0.54
Durbin-Watson 1.832

Source: Computed date, 2013. Note: ***= significant 1% ** significant at 5%, NS= Not significant.

Forest Production for Export (FPE)
Table 2 revealed that the value of forest product for export was significantly affected by Gross Domestic Product (GDP) (proxy for national income) and real price of forest product. The coefficient of GDP was negative, which suggest that as national income decreases forest product for export increases, hence increase in the decline of forest area. In contrast, the coefficient of international price of timber was found to be positive, indicating that increase in international price of timber leads to increase in export of forest product, thus increasing deforestation. This is in line with the economic theory that suggests a positive relationship between export prices received by exporters. This implies the higher the price of forest product, the more forest product is exported and as such encourages deforestation.

The coefficient of external debt and exchange rate were statistically insignificant, meaning, external debt does not have effect on forest product for export in Nigeria. The reason for this could be as a result of ban on forest product as such less is generated from the export, while real exchange rates could be as a result of various exchange rates regulatory policies which result to devaluation of export products

Forest products for export were found to be elastic with respect to GDP and international real prices of timber. The elasticity is 1.56 with respect to real price, implying that 1% increase in real price of timber would lead to 1.56% increase in export of timber. In contrast, 1% decrease in national income, would lead to 1.14% increase in export of timber product.

Round wood Consumption (RWC)
The results of domestic round wood consumption equation as presented in Table 2 revealed that population and forest total area were found to be significant at 1% and 5% levels. The elasticity of FTA was 0.15, implying that with 1% decrease in FTA, domestic round wood consumption will increase by 0.15%. On the other hand, the elasticity of population was 0.31, which suggests that 1% increase in population would lead to 0.31% increase in domestic round wood consumption. This result indicated that FTA and population were important factors in domestic round wood consumption in Nigeria.

Fuelwood and Charcoal Consumption (FWC)
Analysis of FWC equation indicated that the coefficients of GDP and total population were found to be significant at 1% level with their expected signs. The negative sign of GDP implies that with an increase in GDP (proxy of national income), FWC decreases. The elasticity of FWC with respect to GDP was 0.5, implying that with 1% decrease in GDP, which is the proxy of economic growth, fuelwood and charcoal consumption among Nigerian population increases by 0.5%. This result agrees with the findings of Onuche (2010) that poverty associated with income of households in Nigeria is the key culprit in rapid loss of forest resources. The result shows that the elasticity of FWC with respect to population is 0.99, indicating that 1% increase in population, fuelwood and charcoal consumption increases by 0.99% in Nigeria. This clearly portrays that fuelwood and charcoal consumption serve as major sources of energy and tremendously cause deforestation in Nigeria.

The coefficients of price of substitute (kerosene) and forest total area were found to be positive but insignificant. The insignificance of price of substitute (kerosene) and FTA could be as a result of changes in policies on domestic energy and forest in Nigeria, such as constant changes in prices of kerosene over the years in the country since 1978 and contradicting forest policies. For instance, over the years government had embarked on annual tree planting campaigns and ways to safeguard the country's game reserves, while on the other hand policies were made to promote export of forest product to stimulate economic development.

Area of Food Crop Production (FCP)
In the equation of area of food crop production, the coefficients of forest as a percentage of total area and population have positive sign as expected and significant at 5% level. The positive and significant effect suggest that, the more the available forest area, the more people perceive the abundance of forest and hence encroach on it for their food crop production. GDP was also found to be significant at 5% level, but with negative sign of the coefficient, which means that as GDP increases, AFCP decreases. AFCP is highly elastic with respect to population and FTA. The elasticity indicated that with 1% decrease in GDP, FCP increases by 0.26%, while with 1% increase in population and FTA, FCP increases by 1.2% and 11.8% respectively.

Relationship between socio-demographic factors and annual deforestation
Based on statistical and econometric criteria double-log function was chosen in estimating equation vii. The lead equation with R^2 of 0.51, which implies, that approximately 51% of variation in the dependent variable have been caused by the independent variables in the model.
Table 3 revealed that the coefficient of poverty was positive and significant at 1%. This implies that as the level of poverty increases among the people, the rate of deforestation increases. The possible explanation for this is that as people get poorer, the resources readily available to them is the forest, hence, they go into the forest, fetch resources from them in the form of firewood, round wood or wildlife to alleviate their situation. The elasticity of poverty with respect to area of forest lost indicated that with 1% increase in poverty, deforestation will increase by 0.2% and as such the land will be degraded to minimum level, which has tremendous impact on agriculture.

Table 3: Socio-demographic factors affecting deforestation

Variable	Coefficient	Standard Error	T-value
Ln PV	0.2270	0.0076	3.0070***
Ln EDU	-0.0184	0.0066	- 2.7928***
Ln INF	3.9E-07	2.6E-07	1.4939^{NS}
Ln POP	0.2238	0.0650	3.4413***
Ln LPOP	0.1533	0.03221	4.7579***
Constant	10.896		
R^2	0.5096		
Adjusted R^2	0.4995		
F statistics	1239.2		
Durbin Watson	1.8126		

Source: Computed data, 2013.Note: ***= significant 1%, NS= Not significant.

Education has a negative coefficient and significant at 1% level, which implies that as education increases, deforestation decreases. The reason for this inverse relationship is obvious. Educated people are more likely to be aware of the dangers associated with forest decline such as climate change and effect of deforestation when compared to uneducated people. The elasticity of forest cover with respect to education was - 0.012, implying that 1% increase in level of education, will result to 0.012% increase in forest cover.

Coefficient of population growth was negative and statistically significant at 1%. This means that as population increases, deforestation increases. Population growth is widely cited as one of the main causes of deforestation in the world, because rising population accelerates migration of rural people to urban areas, increasing pressure on forest area (Mahapatara and Kant, 2009). A rise in population will decrease

area of forest cover, because of the demand for land for shelter, agricultural land expansion and logging activities for income generation.

The elasticity of area of forest cover with respect to population revealed that 1% increase in population in Nigeria will decrease area of forest cover by 0.2 %. This result also conforms to the finding of Panta (2009) who found positive relationship between population growth and area of forest lost in Nepal.

The coefficient of livestock population was positively related to area of forest loss and significant at 1%. This means that as the number of livestock increases, the level of area of forest cover in Nigeria decreases. Excessive free grazing on forest land in Nigeria is common, and this has created huge negative impact on area of forest cover. The increasing population of livestock demands large quantity of grass or fodder, resulting in forest destruction. Thus, the amount of livestock is negatively linked to forest cover. The elasticity of livestock population with respect to deforestation was 0.15, which implies that with 1% increase in number of livestock in Nigeria, deforestation will increase by 0.15%

CONCLUSION AND RECOMMENDATIONS

This study has developed an econometric model for deforestation and its impact on agriculture in Nigeria. Result of the causes of deforestation shows that fuelwood consumption, round wood consumption and area of food crop production directly aggravate deforestation in Nigeria. Macroeconomic variable such as Gross Domestic Product, population growth, price of forest product for export and forest total area were some of the underlying causes. Another pressure of deforestation comes from the socio-demographic variables such as poverty, human population and livestock population.

Programmes to slow down the speed of deforestation in Nigeria most take into account the influence of significant variables that causes deforestation in Nigeria in addition to Policies that will help towards minimizing fuelwood consumption. These will help in curtailing the impacts of deforestation on climate change, soil degradation, desertification, erosion and decline in agricultural productivity.

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