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Analysis of the Impact of Deforestation on Agricultural Productivity in Nigeria: An Error Correction Modeling Approach

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Abstract
This study analyzed the impacts of deforestation on agricultural productivity in Nigeria. The specific objectives were to assess the trend of deforestation and the impact of deforestation on agricultural productivity. Time series data on all the variables in the study spanning from 1975 to 2010 were used. Descriptive statistic and Error Correction Model were the analytical techniques used for the study. The Unit root test results reveal that all the variables of deforestation, agricultural productivity, average rainfall and number of tractors were found to be non-stationary at 5% level but stationary at first difference, which give way for long-run co-integration. Analysis of Error Correction Model (ECM) results indicated an inverse long- run relationship between deforestation and agricultural productivity. The result reveals that 1% increase in deforestation will result in 1.7% decrease in agricultural productivity. Average rainfall and number of tractors show a long-run positive relationship with agricultural productivity. With 1% increase in average rainfall and number of tractors, agricultural productivity will increase by 0.5% and 2.4%, respectively. The result of the short- run analysis shows positive relationship between previous year's agricultural productivity and rainfall on current agricultural productivity with elasticity of 0.9 and 0.2, while deforestation portrayed a negative effect on agricultural productivity with elasticity of -0.7. Error Correction Model shows a permanent impact of deforestation and agricultural productivity. Policies should gear up towards finding alternative sources of energy, while unnecessary clearing of forests should be legislated against to minimized causes of deforestation and its impacts on agricultural productivity.
Keywords: Deforestation, Productivity, Error- correction and Nigeria

Introduction

Deforestation is an act of destroying forest vegetation with little or no effort to soften the harm done and it invariable results in ecological degradation (Nzeh *et al.,* 2015). Deforestation affects economic activity and threatens the livelihood and cultural integrity of forest-dependent people. It reduces the supply of forest products and causes siltation, flooding, soil nutrient lost, desertification and soil erosion.

Nigeria is not exempted from the global issue of deforestation. This concern dates back since 1930s, when the United Nation (UN) sent a signal on the desert encroachments in sub- Saharan Africa. FAO (2007) reported that between 1990 and 2000, Nigeria lost an average of 4,097 hectares of forest every year, equal to an average annual deforestation rate of 3.8 percent. 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 was ranked the highest country with rate of deforestation in the world.

Some of the driving factors of deforestation in Nigeria today are fuel wood and agricultural land expansion. The rate at which fuel wood consumption and forests are converted to agricultural land is enormous, with available forest being converted to agricultural land by farmers who cultivate land to support themselves. Logging activities, population, poverty, livestock rearing, population density and infrastructural development were among the other causes that account for 40 percent of Nigeria's deforestation (Udofia *et al*., 2011).

Deforestation is a major problem that can lead to global warming, nutrient loss, accelerated soil erosion, desertification and siltation. All these contribute to loss in agricultural productivity, which has the potential future impacts on income, employment and food security to Nigerians. Aggregate data for major crops shows decline in agricultural productivity by 25% between 1990 and 2010, the yield level were far below level required for global competitiveness in agriculture (Anna, 2013). With these effects, the potential benefit of agricultural sector in terms of income and employment for majority of Nigerian will disappear as a result of deforestation.

Various policies and programmes have been put in place in order to curtail deforestation in Nigeria. These policies and programmes include ban on logging of 1975, Annual Afforestation (AP) of 1988, National Forest Action Plan (NFAP) of 2005, educating farmers about danger of environmental degradation, providing farmers with high yielding varieties of crop and irrigation equipment. But inspired of these programmes, deforestation continues 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 (Ibrahim, 2014).

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.

In recent years, the level of agricultural productivity continues to decline drastically. For instance, agricultural productivity declined from 258.26 in 1987 to 214.32 and 108.20 in 1999 and 2005 respectively (Ayinde *et al.,* 2011). This can be attributed to low rainfall, temperature variability, nutrient loss, drought and desertification, which are attributed to deforestation. Although much of the motives of deforestation were based on efforts to gain economic prosperity, the issue has continued to cause a lot of economic problems by threatening the sustainability of the agricultural sector through decline in agricultural productivity and the economics of Nigerian farmers. Deforestation, therefore, puts at risk all aspect of the environment, economy and to some extent agricultural productivity.

A number of studies (Oni *et al.,* 2013, Ayinde *et al*., 2011), have established the effects of deforestation on agriculture, but the impacts of deforestation on agricultural productivity were not spelt out. This study, therefore, was designed to analyze the trend and impacts of deforestation on agricultural productivity 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, deforestation rate, number of tractors, agricultural productivity index, rainfall and any related 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), International Monetary Fund (IMF), World Bank (WB) and Federal Ministry of Environment statistical publications.

Model Specification

The Error Correction Model (ECM) was applied directly to estimate the rate of changes in agricultural productivity in relation to deforestation in long-run and short-run. This model is relevant as it shows changes in both dependent and independent variables, including the error correction term. This model was used to examine the effects of deforestation on agricultural productivity.

In order to capture the relationship among the inflow variables such as error correction term and the previous agricultural productivity in the long-run, the error correction model was used to determine the short-run effect of deforestation on agricultural productivity was specified in equation, while the long term impact was obtained from the least square regression estimation.

$$\Delta AP_t = \beta_0 + \beta_1 \sum^{n} AP_{t-1} + \beta_2 \sum^{n} DEF_{t-1} + \beta_3 \sum^{n} TECH_{t-1} + \beta_4 \sum^{n} ARF_{t-1} + ECM_{t-1} + \varepsilon_t \quad \text{.........1}$$

Where, Δ = Differencing operator, AP_t = Agricultural productivity in the previous period (index), DEF_{t-1} = Deforestation rate in the previous period (%), ARF_{t-1} = Average Rainfall in the previous period (mm), $TECH_{t-1}$ = Technology change (number of tractors) in the previous period, AP_{t-1} = productivity in the previous period, $\beta_1, \beta_2, \beta_3$ = Co-integration parameter, which characterizes the short-run, ECM_{t-1} = Error correction term in the previous period, $\sum_{j=1}^{n}$ = Summation of j ranges from 1 ... n, ε_t = Standard error of estimate and β_0 = Constant .

Unit Root Test

Time series data are largely non-stationary and can give misleading results, if estimated without making the data stationary. Augumented Dickey Fuller (ADF) and Philip Perron (PP) Unit Root Tests were conducted in order to check the stationarity of the data. ADF and PP methods were based on the following model:

$$\Delta_{xt} = \alpha_o + \beta_1 T + aX_{t-1} + \sum_{i=1}^{k} \Delta X_{t-1} + \epsilon_t \quad \text{...2.}$$

The unit root test was then carried out under the null hypothesis that a = 0 against alternative a < 0. All integrated variables can be de- trended by differencing (Ayala, 2010).

The variables were found to be non-stationary, and then the study proceeds to the next step of cointegration test. Casual nexus among the variables has also been studied, such as serial correlation test, white test and Durbin Watson test which clearly confirmed that no multicollinearity, heterocedesticity and autocorrelation problems exist.

Cointergration Test

Eagle Granger and Johansen approach to cointegration were used to test if there is cointegration among the variables. Eagle Granger view that two variables $(A_t \text{ and } X_t)$ are cointegrated if they are non-stationary, because there exists a linear combination between the variables A_t and X_t if they are cointegrated.

$$A_t = Q_t + \beta X_t + V_t \quad \text{.......} 3.$$

$$V_t = A_t - Q_t - \beta X_t \quad \text{.......} 4.$$

If the residual error term are found to be stationary at level, then variables A_t and X_t are cointegrated (Khan, 2010). The maximum likelihood procedure of Johansen (1985) was used on the likelihood ratio principal. The method tests the restriction imposed by cointergration on the unrestricted vector auto-regression (VAR) involving series.

Results and Discussions

Trend of Deforestation in Relation to Productivity

Results of trend of deforestation in relation to agricultural productivity index revealed that deforestation rate in 1975 were estimated at 1.4%, while agricultural productivity index was 28.59. But between 1975 and 1988 there was steady increase in deforestation rate from 1.70 % in 1975 to 2.04% and 2.74% in 1983 and 1988 respectively, which resulted to decline in agricultural productivity index of 28.59, 26.69 and 28.40 for the same years .This decline in agricultural productivity could be as a result of increased deforestation rate, caused by soil nutrient loss, erosion, desertification, climate change and drought, which are associated with deforestation.

Between 1992 and 1996, there was decline in deforestation rate from 2.50 percent in 1992 to 2.06 percent in 1996, while agricultural productivity index portrayed an increase from 57.0 to 68.7 in the same period. The decline in deforestation could be as a result of impacts of world Bank assisted afforestation programmes carried out in that period of time with the aim of tackling the problem of desertification, erosion and soil degradation in northern Nigeria. These precautionary measures taken have led to improvement in agricultural productivity in Nigeria between 1992 and 1996, in addition to climate and technology on a given environment. The outcome of the trend analysis revealed that deforestation actually affects productivity in Nigeria.

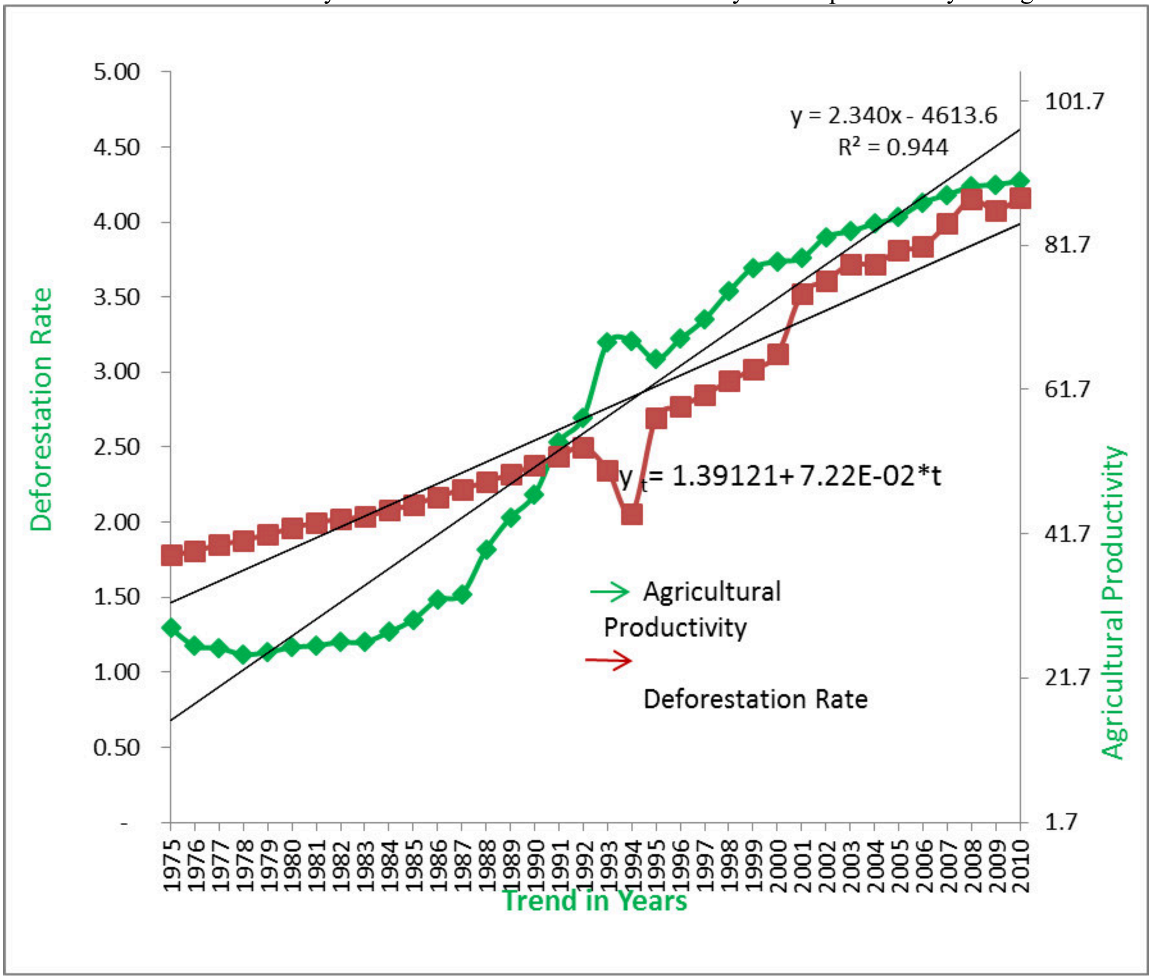

Figure 1: Trend of Deforestation Rate and Agricultural Productivity in Nigeria.

Impacts of Deforestation on Agricultural Productivity

Unit Root Results.

The co-integration model was estimated using Eviews 7.0 computer package. Prior to the test, an investigation into integration properties of each of the variables was made by applying a unit root testing to ascertain all variables are integrated of order 1 (1). To avoid the possibility of spurious results, the study utilized two unit root tests namely; Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests.

Table 1: Unit root Estimations

Variables	Level		First Difference	
	ADF	PP	ADF	PP
API	-1.05063 (-3.6329)	-1.05618 (-3.6329)	-5.91744 (-5.6394)***	-0.93918 (-0.9391)***
DEF	-1.54419 (-3.6329)	-2.57542 (-3.6400)	-2.99197 (-3.6394)***	-0.00050 (-0.6394)***
ARF	-0.47702 (-2.6327)	-0.09555 (-2.6327)	-5.71563 (-3.65537)***	-16.01229 (-0.6394)***
TR	-2.93943 (-3.6329)	-11.35987 (-3.6329)	-5.23489 (-3.6394)***	-5.23168 (-0.6394)***

Sources: Computed data, 2014.

***, Denote significant at 1% level. Figures in parentheses are critical values. API= Agricultural productivity; DEF= Deforestation; ARF = Average Rainfall and TR = Number of tractors

Table 1 presents the results of non-stationary test (Unit root test) for agricultural productivity (API), deforestation (DEF), average rainfall (ARF) and number of tractors (TR) based on ADF and PP root tests. All these variables are presented at levels and first difference. The results in Table 1 indicate that all the ADF as well as PP statistics at 5% level are greater than the critical values, which clearly indicates that all the variables were not stationary at level, implying the acceptance of the null hypothesis of non-stationarity at level. On the other hand, the variables were found to be stationary at first difference, which signifies the rejection of the null hypothesis of non-stationarity. The variables are therefore, integrated of order 1(1) under the assumption of constant trend, which avoids possibility of spurious regression result (Alaya, 2010). Since all the variables become stationary at first difference, they can be used to test for co-integration.

Co-integration Results

The co-integration results help to verify long-run relationship between agricultural productivity and deforestation, because is the outcome that will show change in both dependent and the independent variable including the error correction term. The Johansen Estimation type of co-integrations method was used.

Johansen Estimation

Results in Table 3, Show the outcome of Johansen test, which rejects the null-hypothesis of no co-integration at 5%. Both trace statistics and maximum Eigen value statistics provide statistical evidence of co-integration among agricultural productivity, deforestation, average rainfall and number of tractors at 5% level of significance.

Table 3: Johansen Co-integration Result for ln (API), ln (DEF), ln (ANF) and ln (TR)

Hypothesized number of Co-integration equation		Eigen Value	Trace statistics	Critical Value
None*	K = 0	0.57856	27.58434	24.85813
At most 1*	K = 1	0.44769	21.13162	19.79707
At most 2	K = 2	0.30152	15.00620	15.49471
At most 3	K = 3	0.07906	2.800366	2.841466

Source: Computed data, 2014.

*Denote rejection of the hypothesis at 0.05 level test Mackinnon- Haug-Michillis (1999) P-values

The trace statistics of 27.58434 and 21.13162 are well above the 5% critical value, indicating that the null hypothesis of no co-integration is easily rejected at 5% level of significance. Under the null hypothesis of k = 2 and k = 3 the trace statistics are 15.006 and 2.800, which are below the 5% critical values of 15.495 and 2.84. The null hypothesis is therefore accepted. The results imply existence of co-integration, indicating that agricultural productivity, deforestation, average rainfall and number of tractors in Nigeria have a common trend, which would lead to estimation of long-run impact of deforestation on agricultural productivity under the error correction framework.

Long-run Impacts

The co-integration equation defined the long-term relationship when agricultural productivity is treated as dependent variable, while deforestation rate, average rainfall and number of tractors are treated as independent variables. The value of the coefficient of multiple determinations (R^2) shows that the independent variables explain 82% of the variations of the dependent variable (productivity) .The results are presented in Table 4.

Table 4, indicates that all the variables have long-run relationships. Agricultural productivity responds significantly to deforestation, rainfall and number of tractors as expected. The coefficient of deforestation in the long -run is negative and significant at 5% level, which implies that as deforestation increases, agricultural productivity in Nigeria decreases. The possible reason to this could be as a result of continued changes in soil physical and chemical properties, which resulted to soil nutrient loss and accelerate soil erosion. Elasticity of deforestation with regard to agricultural productivity revealed that 1% rise in deforestation will lead to 1.7% decline in agricultural productivity in Nigeria. This result corresponds to the finding of Ehui and Hertel (1989) that there is negative impact of deforestation and agricultural productivity in Cote d` Ivore..

Table 4: Long-run Impact of Deforestation Rainfall and Number of Tractors on Agricultural Productivity

Variable	Co-efficient	Standard Error	T-value	Prob.
Constant	- 26.2108	4.52300	- 5.66966	0.0000
Ln DEF	- 1.72381	0.70624	- 2.44081	0.0204
Ln ARF	0.57468	0.22907	2.50878	0.0903
Ln TR	2.45983	0.42359	5.80714	0.0000
R^2	0.8205			
Adjusted R^2	0.8036			
F- Statistics	48.7475			
A I criterion	0.0795			
Schwarz Criterion	0.8694			
Durbin-Watson Statistic	2.1380			

Source: Computed data, 2014.

Coefficient of average rainfall indicated a positive and significant relationship with agricultural productivity. This shows that as rainfall increases, agricultural productivity increases. This is true, since agriculture in Nigeria is mostly rain-fed, which follows that any change in rainfall is bound to impact on agricultural productivity. The long-run elasticity indicated that 1% increase in average rainfall in Nigeria will give rise to 0.5% increase in agricultural productivity.

Coefficient of Number of tractors is another variable having positive and significant long-run impact on agricultural productivity at 1% level. This portrays that as number of tractors increases, agricultural productivity in Nigeria increases. This could be as a result of timeliness, better quality and precision in operations, which gives higher yield than non tractor operated farms. The elasticity of number of tractors indicated that with 1% increase in number of tractors, agricultural productivity will increase by 2.5%.

Short-run Effects

Table 5 presents an estimation of short-run relationship among deforestation, rainfall, number of tractors and agricultural productivity. The short run co-integration series can be modeled by ECM provided that variables in the error correction mechanism are co-integrated. In order to determine short-run effects, theory suggests that variable of agricultural productivity has to be included because there is tendency that previous year productivity will have effects on current year's productivity.

Table 5. Estimation of Short- run Equation

Independent variables	Coefficient	t-statistic	Probability
Constant	0.05535	0.54960	0.5871
ΔAPI (-1)	9.04396	4.04610	0.0002
ΔDEf (-1)	- 0.74013	-2.15892	0.0331
ΔARF (-1)	0.20271	5.49460	0.0004
ΔTRC (-1)	0.03816	0.25739	0.7988
ECT (-1)	- 0.26979	-2.23904	0.0336
R^2 Square	0.64162		
Adjusted R^2	0.56199		
E. Statistic	8.05665		
Akaike Information Criterion	-0.21936		
Schwarz criterion	-0.11219		
Durbin-Watson Statistics	2.04092		

Source: Computed data, 2014.

The result of the short-run analysis indicated positive and significant relationship between previous year productivity and current year productivity at 1% level. This is possible since factors that affect previous productivity such as rainfall and fertilizer have long-term effects and as such can affect current year productivity. The result indicated that 1% in previous year productivity this year productivity will increase by 9% in Nigeria.

Coefficient of lagged rainfall shows positive and significant relationship between rainfall and agricultural productivity at 1% level. This clearly indicated that rainfall have positive short-run effects on agricultural productivity in Nigeria. This is obvious because agriculture in Nigeria is mostly rain-fed, which clearly follows that any change in rainfall is bound to have effects in agricultural productivity. The positive sign of the coefficient also indicated that the amount of rainfall experienced in the short-term is adequate without causing flooding and leaching that may result to negative effects. Table further reveals that 1% increase in rainfall and previous year productivity may result to 0.2% and 9% increase in agricultural productivity in Nigeria.

Deforestation coefficient was found to be negative, which is contrary to the *a priori* expectation. The negative sign of deforestation portrays a negative effect of deforestation on agricultural productivity even in the short-run. The possible reason could be as a result of the fact that even in the short-run deforestation accelerates soil erosion and shifts agriculture to less suitable area. The result reveals that with 1% increase in deforestation, agricultural productivity will reduce by 0.7% in Nigeria in the short-run.

As expected, the Coefficient of Error Correction Term in the short- run has negative sign and statistically significant (-0.26979). This confirms the appropriateness of the error correction framework to this kind of study. The coefficient of ECT indicated that 26% of the disequilibrium between short-run and long-run impacts of deforestation on agricultural productivity is corrected in each period compared to the previous or next period.

Conclusion.

This study has analyzed the impact of deforestation on agricultural productivity in Nigeria an error correction model approach. The trend of deforestation in relation to agricultural productivity revealed an inverse relationship most especially from 1992 to 1996 were deforestation drastically decrease, while agricultural productivity rapidly increases. Error Correction Model shows a permanent impact of deforestation on agricultural productivity in Nigeria, since the impact exist both in the long-run and short-run analysis with 26% adjustment of the short-run effect equilibrium with the long-run impact. Programmes to slow down the speed of deforestation like World Bank assisted programme of 1992 to 1996 needs to be revitalized with aim of curtailing the increasing rate of deforestation. This will enhance micro climate, improve soil nutrient, checkmate soil degradation, reduce desertification, erosion and improve agricultural productivity

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