VECTOR AUTOREGRESSIVE MODEL OF OVER-POPULATION AND FAMILY PLANNING ON ENVIRONMENTAL DEGRADATION

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ABSTRACT: The exponential rate of increase in Nigeria population without complementary increase in science and social economic indicators not only lead to suffering from natural environmental curse, but more importantly the loss of renewable natural resources beyond sustainable limits and general environmental degradation. Soil degradation, rapid deforestation, desertification, and others are some of the current environmental problems facing Nigeria. Many efforts have been made on environmental degradation by both the government and researchers, but most of which prove abortive in finding everlasting solution to this problem. Therefore, the focus of this work is to adopt the Vector Autoregressive Model to different variables that affect environmental quality. The relationships among forest area, population, family planning, agricultural area and unemployment rate of Nigeria were examined between 1990 and 2018. The data for the study were obtained from the National Bureau of Statistics (NBS) and World Development Indicator (WDI), World Bank. The unit root test was conducted to examine the stationary level of the selected variables. Results from augmented Dickey Fuller test showed that family planning, forest area, unemployment, and agricultural area were stationary at difference of two, while population was stationary at difference of three. Information criteria were carried out to determine the lag length of the Vector Autoregressive Model and the maximum lag length for the real-life data was set to three. Correlation analysis was examined to show the level of relationship between the variables considered. The Pearson statistic showed a negative bidirectional relationship between forest area and population rate, agricultural rate and unemployment rate while a positive directional trend was experienced between forest area and family planning. Granger causality test showed that each of the variables has impact on one another. Results showed that population, family planning, agricultural area and unemployment rate significantly influence the rate of forest area of Nigeria. This study recommends that family planning should be embraced by the masses to reduce population growth in order to curb environmental degradation. Government should create job to prevent people from finding life sustenance in forest and more importantly land use act should be strictly implemented on forest area and agricultural area as there must be specification on cultivated land from forest area.
KEYWORDS: Vector autoregressive model, Population, Forest area, Unemployment, Family planning

1. INTRODUCTION

The exponential rate of increase in Nigeria population without complementary increase in science and social economic indicators not only lead to suffering from natural environmental curse, but more importantly the loss of renewable natural resources beyond sustainable limits and general environmental degradation. Soil degradation, rapid deforestation, desertification, and others are some of the current environmental problems facing Nigeria. The over-exploitation, degradation and unsustainable management of environmental resources which is as a result of human activities can threaten economic growth and poverty reduction efforts. In the last few years in Nigeria, losses in non-timber forest products (NTFPs). According to the statistics from the Central Bank of Nigeria (CBN) and the International Institute for Tropical Agriculture (IITA) (2016), Nigeria is losing about 3.5% (350,000-400,000 hectares) of forest land per annum. If Nigeria should continue to lose its remaining forest resources, the economic cost will be higher than the current losses with a consequent loss in revenue, fuel wood supply and non-timber forest products (NTFPs) supply. In Nigeria today, environmental resource human population and limited access to electricity, all of these frequently lead to degradation or conversion of environmental resources into unsustainable forms of use. Intensive intrusion, vegetation degradation, de-reservation for agricultural use and other factors has led to Nigeria recording less than 10% forests coverage having lost about 95% of its forest coverage to a high rate of deforestation (FAO, 2006).

The landmark report of the World Commission on Environment and Development (1987), titled “Our Common Future”, warned that unless we change many of our lifestyle, the world will face unacceptable levels of environmental damage and human suffering. The Commission, echoing the urgent need for tailoring the pace and the pattern of global economic growth to the planet's carrying capacity, said that: "Humanity has the ability to make development sustainable and to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (IFAD, 2017). Furthermore in 2002, ARD Inc. in its assessment of the overall state of Nigeria's environment concluded that Nigeria's natural environmental resources and the quality of its air, water, and soils are severely threatened. Exacerbated by a combination of expanding population (population growth and migration) and increasing poverty putting increasingly severe demands upon the natural environment, major threats of unsustainable use of environmental (renewable natural) resources is a reality (Joseph Fuwape, 2003). The impacts of forest industries and wood utilization on the environment were considered. The operational activities of sawmills, plywood veneer, particleboard and pulp/paper mills in Nigeria were reviewed. The effects of tree harvesting and logging operations on forest biodiversity, soil erosion, soil compaction and hydrological cycle are reported. Environmental pollution due to wood processing, wood utilization and waste management in forest industries was discussed. Methods of mitigating the detrimental effect of the operations of forest industries in Nigeria on the environment are suggested. Paul Sarfo (2005) in his work, An empirical analysis of the linkage between external timber trade in Ghana and the increased incidence of illegal chainsaw operations which do not only threaten the country's forests and other natural resources but also the erosion of the basis for sustainable agriculture which is the main-stay of the country's economy. He concludes that the country's forest and tree resources face massive degradation and overexploitation if the government does not take a bold decision on illegal logging, especially the activities of chainsaw operators. An option, though unpalatable and politically sensitive, may be the mainstreaming of chainsaw operations through the re-introduction of limited permits to registered local groups of timber traders and their chainsaw operators to supply the domestic market. This should be under a system which enjoins such groups to be collectively responsible for the activities of their members. And, the government should also strengthen the Forestry Services Division (FSD) to design and operationalize an enhanced monitoring. According to O'Neill, *et al.* (2010) earlier studies have oversimplified the role of population in emissions, using simple multiplicative models that do not account for relationships between population, economics, and technology. Their study uses survey data from 34 countries, covering 61% of the global population, for economic characteristics to calibrate the PET model (Population Environment Technology Model) with parameters like demand, labour supply, wealth, and projects population for several scenarios. PET accounts for the indirect relationships between age structure and labour supply, population growth and economic growth, urbanization and labour productivity, demographic change on savings/spending behaviour. It also considers the reality that the population will be aging in some places, and household sizes will decline (trending toward nuclear families and away from multigenerational households). Aging and urbanization are also found to impact emissions in certain places in the world. Overall, results suggest that slowing population growth could lead to 16-29% of the desired carbon emissions reduction deemed necessary by 2050 to prevent dangerous environmental degradation. Moreover, aging can reduce emissions by up to 20% in industrialized places, through lowered labour productivity, older labour forces and slower economic growth. Urbanization in less developed areas could lead to 25% increase in projected emissions, for the same, but converse, reasons. The authors conclude that FP policies that meet unmet need could lead to the low variant population projections scenarios referenced in the paper, realizing a decline of 0.2 births per US woman, and a 0.6-0.7 births per developing country woman. Environmental degradation, therefore, is the decline in environmental quality or reduction in its productivity and environmental regulatory capacity. This phenomenon results from mismatch between environmental quality and environmental use. Environmental degradation processes include physical, chemical and biological processes that set in motion the degradation trends (Eswaran, 2001). Maitima *et al.* (2004) define environmental degradation as a reduction or loss of biological or economic productivity or complexity of crop environmental, or range, pasture, forests and wood environmental resulting from environmental uses or from processes including those arising from human activities such as soil erosion, deterioration of the physical, chemical and biological or economic properties of and long term loss on natural vegetation. Bai *et al.* (2008) also defined environmental degradation as the loss long term loss of ecosystem function and productivity caused by disturbances from which the environmental cannot recover unaided. Environmental degradation thus encompasses a loss in the productivity of the environmental and the ability of the environment to support fully ecosystem functions. A degraded environmental scape lacks the ability to provide proper ecosystem services, and this will result to a change in the normal processes in the ecosystem. For the purpose of this research, we define environmental degradation as a process by which the natural or economic productivity of the environmental has been impaired due to human activities. We intently specify human activities so as to focus the discussion on environmental degradation caused by economic activities and not to cover the broader spectrum that includes degradation caused by natural forces. Environmental degradation is the loss of beneficial goods and services derived from terrestrial ecosystems, which include soil, vegetation, other plant and animal life, and the ecological and hydrological processes that operate within these systems. Among the more visible forms of environmental degradation are desertification, deforestation, overgrazing, salinization, and soil erosion, all of which can result from either human activities or natural causes (Nkonya *et al,* 2011). However, unsustainable environmental management practices, such as deforestation, forest degradation, soil nutrient mining, and cultivation on steep slopes, are also identified as the direct contributors to environmental degradation. Population density, poverty, environmental tenure, and access to agricultural extension, infrastructure, and markets, as well as policies that promote the use of environmental degrading practices were outlined as the underlying causes of environmental degradation by (Nkonya *et al* 2011). In most parts of the world, environmental degradation occurs due to human activities and natural factors. Pressure on environmental use due to urbanization and industrialization exerts excessive pressure on the environment's natural resource base thus causing environmental degradation in both poor and rich countries of the world. In Bhutan, for instance, environmental degradation is said to be mostly manifested in displacement of soil material through water erosion and internal biophysical and chemical deterioration. These processes are reported to be triggered by human induced activities in the mountainous terrain of the country (UNEP, 2007). Another major cause of environmental degradation in the world today is the loss of vegetation due to pressure on forests resulting from increased demand for construction material by both the domestic and industrial sectors. Similarly, firewood extraction from forest environmental in poorly developed countries of the world also exerts pressure to forests and increases the rate of deforestation thus causing environmental degradation (WMO, 2005). Population can be defined as the total of individuals of a species in a given geographical area over a period of time. Population is a concept of numbers which is not only used for human living in an area. It is a scientific term that can also be used in the study of all kind living species such as trees, animals, birds, ocean and seas living creatures at large. As of 2019, the estimated population of the country is over 200.96 million, ranking 7th in the world. Last collected in 2012 by the Nigeria National Bureau of Statistics, the total population of citizens in Nigeria was around 166.2 million people.

The term human overpopulation also refers to the relationship between the entire human population and its environment the Earth, or to smaller geographical areas such as countries. Overpopulation can result from an increase in births, a decline in mortality rate against the background of high fertility rates, an increase in immigration, or an unsustainable biome and depletion of resources.

2. MATERIALS AND METHODS

Vector Autoregressive (VAR) model is an extension of univariate autoregressive model to multivariate time series data. It is a multi-equation system where all the variables are treated as endogenous (dependent). There is one equation for each variable as dependent variable. In its reduced form, the right hand side of each equation includes lagged values of all dependent variables in the system, no contemporaneous variables. The VAR (p) model is given as:

$$Y_t = b + B_1 Y_{t-1} + B_2 Y_{t-2} + \cdots + B_p Y_{t-p} + u_t \quad (1)$$

where

$Y_t = (y_{1t}, y_{2t}, \cdots, y_{nt})'$ which is an $(n \times 1)$vector of time series variables, b is an $(n \times 1)$ vector of the intercepts, B_i is an $(n \times n)$ coefficient matrices and $u_t$is an $(n \times 1)$vector of unobservable i.i.d zero mean error term (white noise).

2.1 Stable Vector Autoregressive Processes

The vector autoregressive model of order p (VAR (p)) is given in (1). Considering the vector autoregressive model of order 1 (VAR (1))

$$y_t = b + B_1 y_{t-1} + u_t \quad (2)$$

Assumed generation of mechanism starts at some time t = 1

That is;

$$y_1 = b + B_1 y_0 + u_1$$

$$y_2 = b + B_1 y_1 + u_2 = b + B_1(b + B_1 y_0 + u_1) + u_2 \quad (3)$$

$$= (I_k + B_1)u + {B_1}^2 y_0 + B_1 u_1 + u_2 \quad (4)$$

Hence, the vector $y_1, \cdots, y_t$are uniquely determined by y_0, $u_1, \cdots, u_t$. To examine the consistent of the mechanism, the equation in (2) is considered.

$$y_t = b + B_1 y_{t-1} + u_t \quad (5)$$

$$= (I_k + B_1 + \cdots + {B_1}^j)b + {B_1}^{j+1} y_{t-j-1} + \sum_{i=0}^{j} {B_1}^i u_{t-i} \quad (6)$$

If all eigenvalues of B_1 have modulus less than 1, the sequence ${B_1}^i, i = 0,1,\cdots$ is absolutely summable.

Hence, the infinite sum $\sum_{i=1}^{\infty} B_1{}^i u_{t-i}$ exists in mean square. Moreover,

$$= (I_k + B_1 + \cdots + B_1{}^j)b \overrightarrow{\,j \to \infty\,} (I_k - B_1)^{-1}b \quad (7)$$

Furthermore, $B_1{}^{j+1}$ converges to zero rapidly as $j \to \infty$ and thus, we ignore the term $B_1{}^{j+1}y_{t-j-1}$ in the limit. Hence if all eigenvalues of B_1 have modulus less than 1, by saying that $y_t$is the VAR(1) process, we mean that y_t is the well-defined stochastic process.

$$y_t = \mu + \sum_{i=0}^{\infty} B_1{}^i u_{t-i}, \ t = 0, \pm 1, \pm 2, \cdots, \quad (8)$$

Where

$$\mu = (I_k - A_1)^{-1}b \quad (9)$$

The distribution and joint distributions of the $y_t{}^{'s}$are uniquely determined by the distributions of the u_t process.

$$E(y_t) = \mu \text{ for all t} \quad (10)$$

and

$$= \lim_{n\to\infty} \sum_{i=0}^{n} \sum_{j=0}^{n} B_1{}^i E(u_{t-i}u_{t-h-j}{}') (B_1{}^j)' \quad (11)$$

Because $E(u_t u_s{}') = 0$ for s ≠ t and $E(u_t u_t{}') = \Sigma_u$for all t. The condition for the eigenvalues of the matrix B_1 is of importance, we call a VAR(1) process stable if all eigenvalues of B_1 have modulus less than 1.

2.1.1 Autocovariance of a VAR (1) Process

In order to illustrate the computation of the autocovariances when the process coefficients are given, suppose that y_t stationary the VAR (1) process.

$$y_t = b + B_1 y_{t-1} + u_t \quad (12)$$

With white noise covariance matrix $E(u_t u_t{}') = \Sigma_u$. Alternatively, the process may be written in mean adjusted form as:

$$y_t - \mu = B_1(y_{t-1} - \mu) + u_t \quad (13)$$

Where $\mu = E(y_t)$. Post-multiplying by $(y_{t-h} - \mu)'$ and taking the expectation gives:

$$E[(y_t - \mu)(y_{t-h} - \mu)'] = B_1 E[(y_{t-1} - \mu)(y_{t-h} - \mu)'] + E[u_t(y_{t-h} - \mu)'] \quad (14)$$

Thus, for h = 0

$$\Gamma_y(0) = B_1\Gamma_y(-1) + \Sigma_u = B_1\Gamma_y(1)' + \Sigma_u \quad (15)$$

and for $h \succ 0$

$$\Gamma_y(h) = B_1\Gamma_y(h-1) \quad (16)$$

The equations above are usually referred to as Yule-Walker equations.

2.1.2 Autocovariances of a Stable VAR (p) Process

For VAR(p) process,

$$y_t - \mu = B_1(y_{t-1} - \mu) + \cdots + B_p(y_{t-p} - \mu) + u_t \quad (17)$$

The Yule-Walker equations are also obtained by post multiplying with $(y_{t-h} - \mu)'$and taking expectation. For h = 0, using $\Gamma_y(i) = \Gamma_y(-i)'$

$$\Gamma_y(0) = B_1\Gamma_y(-1) + \cdots + B_p\Gamma_y(-p) + \Sigma_u \quad (18)$$

$$= B_1\Gamma_y(1)' + \cdots + B_p\Gamma_y(p)' + \Sigma_u \quad (19)$$

and for $h \succ 0$

$$\Gamma_y(h) = B_1\Gamma_y(h-1) + \cdots + B_p\Gamma_y(h-p) \quad (20)$$

2.2 Autocorrelation of a Stable VAR (p) Process

The autocorrelation:

$$R_y(h) = D^{-1}\Gamma_y(h)D^{-1} \quad (21)$$

given in equation (21) is convenient to work with as they are scale invariant measures of the linear dependencies among the variables of the system. D is a diagonal matrix with the standard deviations of the components of y_t on the main diagonal. That is; the diagonal elements of D are the square roots of the diagonal elements of$\Gamma_y(0)$. Denoting the covariance between $y_{it}$and $y_{j,t-h}$by $\gamma_{ij}(h)$ the diagonal elements $\gamma_{11}(0), \cdots, \gamma_{kk}(0)$ of $\gamma_y(0)$ are the variances of$y_{1t}, \cdots, y_{kt}$.

Thus;

$$D^{-1} = \begin{bmatrix} 1/\sqrt{\gamma_{11}(0)} & 0 \\ 0 & 1/\sqrt{\gamma_{kk}(0)} \end{bmatrix} \quad (22)$$

and the correlation between y_{it} and $y_{j,t-h}$ is;

$$\rho_{ij}(h) = \frac{\gamma_{ij}(h)}{\sqrt{\gamma_{ii}(0)}\sqrt{\gamma_{jj}(0)}} \quad (23)$$

Which is just the ijth element of $R_j(h)$

2.3 Information Criteria

Akaike Information Criteria (AIC) suggested using the LS estimator with degrees of freedom adjustment:

$$\hat{\Sigma}_u(P) = \frac{T}{T-kp-1}\tilde{\Sigma}_u(P) \quad (24)$$

For $\Sigma_u$and taking the determinant of the resulting expression $\tilde{\Sigma}_u(P)$ is the ML estimator of $\Sigma_u$obtained by fitting a VAR (P) model. The resulting criterion is called the final prediction error (FPE) criterion, that is;

$$FPE(P) = det\left[\frac{T+kp+1}{T} \times \frac{T}{T-kp-1}\tilde{\Sigma}_u(P)\right] = \left[\frac{T+kp+1}{T-kp-1}\right]^k \widetilde{det\,\Sigma_u}\,(P) \quad (25)$$

Akaike (1973, 1974) derived a very similar criterion usually abbreviated by AIC.For a VAR (P) process the criterion is defined as;

$AIC(P) = ln\left|\tilde{\Sigma}_u(P)\right|' + \frac{2}{T}$ (Number of freely estimated parameters)

$$= ln\left|\tilde{\Sigma}_u(P)\right| + \frac{2mk^2}{T} \quad (26)$$

The estimated $\hat{P}(AIC)$ for P is chosen so that this criterion is minimized. The similarity of the criteria AIC and FPE can be seen by noting that, for a constant N.

$$\frac{T+N}{T-N} = 1 + \frac{2N}{T} + 0(T^{-2}) \quad (27)$$

The quantity $0(T^{-2})$ denotes a sequence of order T^{-2} that is, a sequence indexed by T that remains bounded if multiplied by T^2. Thus, the sequence goes rapidly when $T \to \infty$.

Hence,

$$InFPE(P) = ln\left|\tilde{\Sigma}_u(P)\right| + kln\left[\frac{(T+kp+1)}{(T-kp-1)}\right]$$
$$= ln\tilde{\Sigma}_u(P) + kln\left[1 + 2\frac{(kp+1)}{T+0(T^{-2})}\right]$$
$$= ln\left|\tilde{\Sigma}_u(P)\right| + k\frac{2(kp+1)}{T} + 0(T^{-2})$$
$$= AIC(P) + \frac{2k}{T} + 0(T^{-2}) \quad (28)$$

2.4 Estimation of Vector Autoregressive Processes

The Vector Autoregressive (VAR) model superficially resembles simultaneous equation modelling in which several endogenous variables are considered together. However, each endogenous variable is explained by its lagged past values, and the lagged of all other endogenous variables in the model. The VAR will be used to determine the inter-relationship between population rate, family planning and environmental degradation, agriculture area and unemployment. The VAR approach sidesteps the need for structural modelling by treating every endogenous variable in the system as a function of the lagged values of all the endogenous variables in the system. The VAR process is defined as:

$$y_t = B_1 y_{t-1} + \cdots + B_p y_{t-p} + Ax_t + u_t \quad (29)$$

where $y_t$is a k vector of endogenous variables, $x_t$is a vector of exogenous variables. $B_1, \cdots, B_p$and A are matrices of coefficients to be estimated, $u_t$is a vector that may be contemporaneously correlated but are uncorrelated with their own lagged values. The parameter of a vector autoregressive model (VAR) can be estimated using the Least square method and Maximum Likelihood Method which are asymptotically equivalent. This study adopt the OLS method of parameter estimation.

2.5 Least Squares Method

Suppose that

$$y_t = \varphi_0 + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + u_t \quad (30)$$

Then VAR (p) model can be written as:

$$y_t{}' = y_t{}'\beta + u_t{}' \quad (31)$$

Where $y_t = (1, y_{t-1}{}', y_{t-2}{}', \cdots, y_{t-p}{}')$ is $(kp+1)$ dimensional vector matrix and $\beta' = (\varphi_0, \varphi_1, \cdots, \varphi_p)$ is $k \times (kp+1)$ matrix

The least square of β is:

$$\hat{\beta} = [\textstyle\sum_{t=p+1}^{p} z_t z_t{}']^{-1} [\textstyle\sum_{t=p+1}^{p} z_t{}^p z_t] \quad (32)$$

The least square residual is;

$$\hat{u}_t = y_t - \textstyle\sum_{t=1}^{p} \hat{\varphi}_i y_{t-1}, \text{t = p+1, } \cdots\text{, n} \quad (33)$$

and the least square estimate of $\Sigma_u$is;

$$\hat{\Sigma}_u = \frac{1}{n-(k+1)(p-1)} \textstyle\sum_{t=p+1}^{n} \hat{u}_t\, \hat{u}_t{}' \quad (34)$$

3. NORMALITY

Jarque – Bera is a test statistic used for testing whether the series is normally distributed. The test measures the difference of the skewness and kurtosis of the series with those from normal distribution. The test statistic is computed as;

$$Jarque - Bera = \frac{N-K}{6}\left(S^2 + \frac{(K-3)^2}{6}\right) \quad (35)$$

Where S is the skewness, K is the kurtosis, and N is the number of estimated coefficients used to create the series.

Structural Analysis by Granger Causality

To investigate the causal relationship between variables of the system, the linear Granger Causality test should be applied by using the following steps. Compare the unrestricted models;

$$\Delta y_t = a_1 + \textstyle\sum_{i=1}^{m_1} \beta_{1i}\Delta y_{t-i} + \textstyle\sum_{j=1}^{m_2} \theta_{1i}\Delta y_{j-i} + e_{1t} \quad (36)$$

$$\Delta x_t = a_2 + \textstyle\sum_{i=1}^{m_1} \beta_{2i}\Delta x_{t-i} + \textstyle\sum_{j=1}^{m_2} \theta_{2i}\Delta x_{j-i} + e_{2t} \quad (37)$$

With the restricted models,

$$\Delta y_t = a_1 + \sum_{i=1}^{m_1} \beta_{1i} \Delta y_{t-i} + e_{1t} \quad (38)$$

$$\Delta y_t = a_2 + \sum_{i=1}^{m_1} \beta_{2i} \Delta x_{t-i} + e_{1t} \quad (39)$$

where $\Delta x_t$and $\Delta y_t$are the first order forward difference of the variables $\alpha, \beta, \theta$are the parameters to be estimated and $e_1, e_2$are standard random errors. The lag order m are the optimal lag orders chosen by information criteria, if $\theta_1$is statistically significant and $\theta_2$is not, then it can be said that changes in variable y Granger cause changes in variable x or vice versa. If both are statistically significant there is a variable caused relationship between the variable.

4. RESULTS AND DATA ANALYSIS

The descriptive analysis was used to summarize the characteristics of the variables used in this study with a view to be showing the features of each of the population rate, forest area, family planning, agriculture area and unemployment rate.

Table 1: Descriptive Analysis and Correlation Matrix

Measures	Population rate	Forest area rate	Family planning	Unemployment rate	Agriculture land rate
Mean	2.577	12.63	45.48	4.361	75.80
Median	2.580	12.63	46.88	3.767	77.52
1st Quarter	2.500	9.48	46.11	3.735	75.10
3rd Quarter	2.650	15.77	50.33	3.817	78.29
Minimum	2.490	6.33	13.40	3.539	66.74
Maximum	2.680	18.92	52.11	8.389	80.92
Standard dev	0.072	3.827	9.126	1.486	4.025
Skewness	0.1231	-0.000137	-2.51249	2.10073	-1.01869
Kurtosis	1.4664	1.79851	8.36333	5.62928	2.95368
Correlation Matrix					
	Population	**Forest area**	**Family planning**	**Unemployment**	**Agriculture**
Population	1	-0.7793	0.0687	0.2635	0.5436
Forest area	-0.7793	1	0.3008	-0.6326	-0.7865
Family planning	0.0697	0.3008	1	-0.8175	0.0046
Unemployment	0.2635	-0.6326	-0.8175	1	0.2162
Agriculture	0.5436	-0.7865	0.0046	0.2162	1

The results presented in Table 1 showed the descriptive analysis of the variables selected in the study and the correlation matrix. The population rate showed an average value of 2.577, forest area is 12.63, family planning is 5.48, unemployment rate is 4.361 and agriculture area is 75.80. The correlation matrix showed that the correlation value between forest area and population rate, unemployment rate and agriculture area are -0.7793, -0.6326 and -0.7865, respectively. This indicates that there exist a strong negative relationship between rate of forest area, population, unemployment and agriculture area while a positive relationship exists between family planning and forest area of Nigeria. The time series plots of the population, forest area, family planning, unemployment and agriculture are given in Figure 1 through Figure 5, respectively.

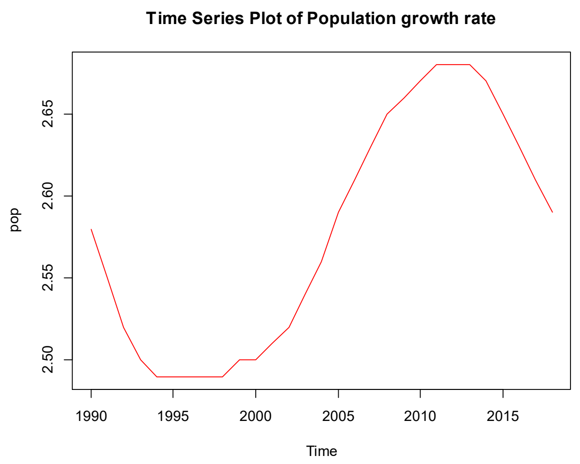

Fig 1: Population Rate of Nigeria Time Series Plot

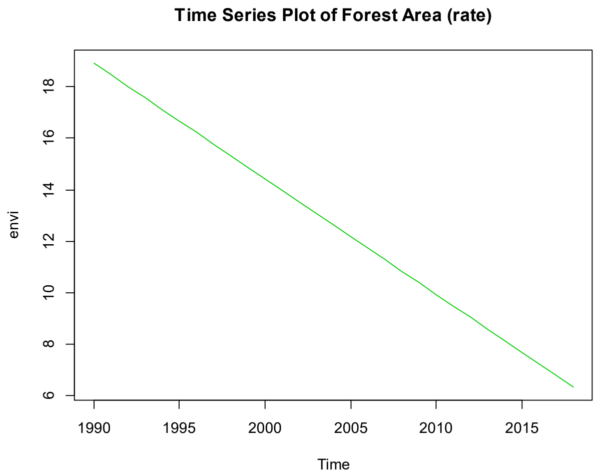

Fig 2: Nigeria Forest Area Rate Time Series Plot

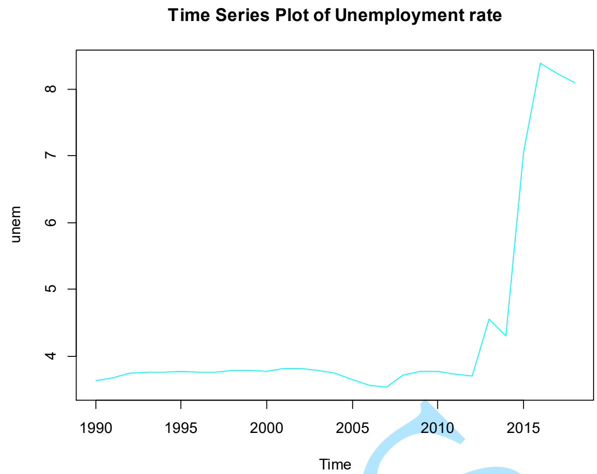

Fig 4: Time Series Plot of Unemployment Rate of Nigeria

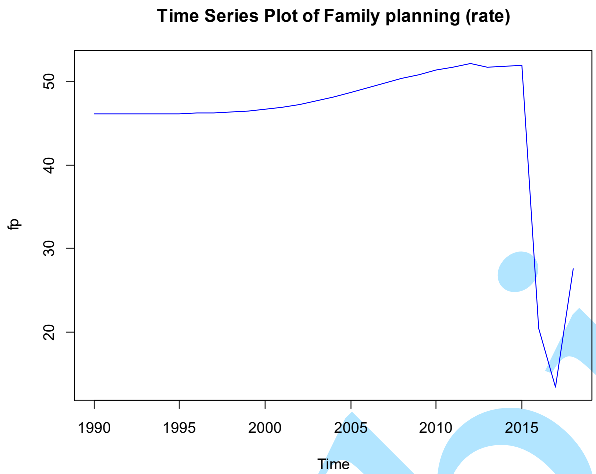

Fig 3: Nigeria Family Planning Rate Time Series Plot

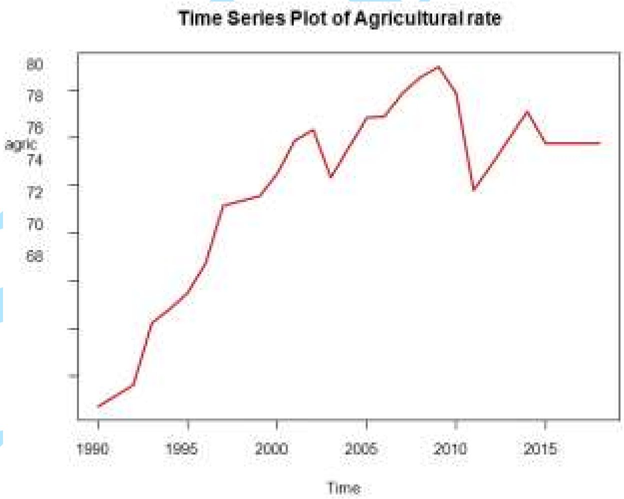

Fig 5: Time Series Plot of Agriculture Area

Table 2: Augmented Dickey Fuller Test

Order of Integration	Series	ADF test statistic	P-value	Remarks
I(0)	Population	-1.33	0.828	Not stationary
	Forest area	-1.93	0.585	Not stationary
	Family Planning	0.745	0.990	Not stationary
	Unemployment rate	-2.132	0.504	Not stationary
	Agricultural area	-1.21	0.874	Not stationary
I(1)	Population	-1.19	0.882	Not stationary
	Forest area	-2.39	0.4088	Not stationary
	Family Planning	0.356	0.990	Not stationary
	Unemployment rate	-2.99	0.1901	Not stationary
	Agricultural area	-2.90	0.2244	Not stationary
I(2)	Population	-2.55	0.3506	Not stationary
	Forest area	-4.38	0.01	Stationary
	Family Planning	-7.89	0.01	Stationary
	Unemployment rate	-4.79	0.01	Stationary
	Agricultural area	-5.80	0.01	Stationary
I(3)	Population	-4.67	0.01	Stationary

The results in Table 2 presented the Augmented Dickey Fuller test which indicated that all the variables were non stationary at d = 0, but the forest area, family planning, unemployment rate and agricultural area were stationary after second difference while population rate was stationary after third difference. The results obtained from Vector Autoregressive Model (VAR) are given in Table 3 and Table 4.

Table 3: Lag Length

Information Criteria	Lag value				Lag Length
	1	2	3	4	n
AIC	-1.905058e+01	-2.116394e+01	-2.606734e+01	NAN	3
HQ	-1.870010e+01	-2.052139e+01	-2.513273e+01	NAN	3
SC	-1.756279e+01	-1.843633e+01	-2.209991e+01	NAN	3
FPE	5.717290e-09	1.053789e-09	3.378737e-11	-6.597133e-75	4

The VAR lag selection criterion in Table 3 for the maximum lag length selected for the purpose of VAR estimation was lag order 8. The optimal lag length was lag order 3, because it has the lowest values of AIC, HQC, SC and FPE. Thus, it is the most preferred and is used in the VAR estimation presented in Table 4.

Table 4: Coefficient of Vector Autoregressive Model Dependent Variable

	Population	Forest area	Family planning	Agriculture	Unemployment
Pop.11	-0.6416 (0.4491)	1.635e-01 (1.727e-01)	135.6132 (83.4825)	-104.6941 (66.2547)	-2.7471 (23.8225)
Forest Area.11	1.4769 (0.8316)	-5.786e-01 (3.197e-01)	73.9094 (154.5713)	-45.0288* (122.6732)	-39.2146 (44.1082)
FP.11	-0.0065* (0.0029)	2.844e-04 (1.138e-03)	-0.5892 (0.5502)	1.1724* (0.4367)	0.16273 (0.15701)
Agric.11	0.0019 (0.0017)	-6.669e-04 (6.714e-04)	0.2256 (0.3246)	-1.1852* (0.2576)	0.08982 (0.09262)
Unemploy.11	-0.0396 (0.0215)	-3.945e-04 (8.276e-01)	-7.0280 (4.0013)	8.0793* (3.1755)	-1.03511 (1.14179)
Pop.12	0.4990 (0.7491)	2.405e-01 (2.880e-01)	163.6596 (139.2358)	-147.3152 (110.5024)	-5.03429 (39.73213)
Forest Area.12	-1.5078 (1.2744)	-8.379e-01 (4.899e-01)	-490.7897 (236.8726)	188.3489 187.9904	-10.6571 (67.5936)
FP.12	0.00196 (0.0021)	9.216e-04 (7.988e-04)	-1.1246* (0.3862)	-1.2616* (0.3065)	0.16031 (0.11021)
Agric.12	0.0067 (0.0037)	-3.182e-05 (1.430e-03)	0.8829 (0.6915)	-1.6645 (0.5488)	-0.04565 (0.19733)
Unemploy.12	-0.0639 (0.0342)	5.965e-03 (1.316-02)	-5.4289 (6.3637)	10.5095 (5.0505)	1.39062 (1.81592)
Pop.13	0.4081 (0.4371)	2.585e-01 (1.681e-01)	93.5163 (81.2504)	-23.4231 (64.4832)	-7.5589 (23.1855)
Forest area.13	-2.2500* (1.0823)	-2.294e-01 (4.161e-01)	-186.2452 (201.1780)	364.5721 (159.6619)	-2.9389 (57.4079)
FP.13	-0.0525 (0.0466)	3.069e-03 (1.793e-02)	10.1821 (8.6681)	2.9966 (6.8793)	-3.50785 (2.47352)
Agric.13	0.00161 (0.0019)	-7.648e-04 (7.301e-04)	-0.4508 (0.3530)	-0.7865* (0.2802)	0.02857 (0.100073)
Unemploy.13	0.0183 (0.02289)	8.629e-03 (8.802e-03)	-6.9818 (4.2554)	-12.9009 (3.3772)	0.40600 (1.21432)
Constant	0.00269	2.010e-04	0.1900	-0.8476	0.13044
R^2	0.8733	0.7663	0.9946	0.9041	0.9418
Adjusted R^2	0.6018	0.2655	0.9831	0.6985	0.8172
Residual	0.006721	0.002584	1.249	0.9915	0.3565
F statistic	3.216 (0.062)	1.53 (0.2932)	86.43 (1.841e-06)	4.398 (0.0277)	7.558 (0.0058)

* P-value significant

$$population_t = 0.00269 - 0.0065 family\_planning_{t-1} - 2.250 forest\_area_{t-3}$$

$$family\_planning = 0.1900 - 1.1246 family\_planning_{t-2}$$

$$agricultural\_area = -0.8476 - 45.0288 forest\_area_{t-1} + 1.1724 family\_planning_{t-1}$$
$$-1.1852 agricultural\_area_{t-1} + 8.0793 unemployment_{t-1} - 1.2616 family\_planning_{t-2} - 0.7865 agricultural\_area_{t-3}$$

The findings in Table 3 showed the vector autoregressive model of lag 3 for population rate, forest area, family planning, agricultural area and unemployment rate. The vector autoregressive model for population rate was explained and determined by the family planning at its first lag and forest area at the third lag. This implies that one and five year past values of family planning and forest area, respectively has an enormous implications and influence on the future value of population rate. The family planning of Nigeria was explained and determined by the family planning at its second lag, which indicates that the second year past value of family planning rate has an enormous implications and influence on the future value of family planning rate. The agriculture area was explained and determined by the forest area, family planning; agricultural area and unemployment at the first lag while family planning at its second lag with agricultural area at its third lag. This implies that one and three years past values of forest area, family planning, agricultural area and unemployment rate with second past value of family planning and third past value of agricultural area have an enormous implication and influence on the future value of agricultural area.

Table 5: Normality Test

	Chi Squared statistic	P - value	Remark
Portmanteau test	245.92	0.1614	No serial correlation
JB test	15.487	0.1153	Normally distributed
Skewness	10.475	0.06283	Normally distributed
Kurtosis	5.012	0.4144	Normally distributed

Table 6: Causality Test

Variable	Null hypothesis (H_0)	F-test	p-value
Population	Population do not Granger cause forest area, family planning, unemployment rate and agriculture area	3.387	0.00237
Forest Area	Forest area do not Granger cause population, family planning, unemployment rate and agriculture area	5.5852	3.123e-05
Family planning	Family planning do not Granger cause population, forest area, unemployment rate and agriculture area	16.286	6.526e-11
Agriculture area	Agriculture area do not Granger cause population, forest area, family planning and unemployment rate	2.2647	0.0298
Unemployment rate	Unemployment rate do not Granger cause population, forest area, family planning and agriculture rate	12.043	4.042e-09

The results in Table 5 showed the test of normality of the model in Table 4. The portmanteau test indicate that there is no serial correlation in the model while results findings of JB test, skewness and kurtosis identify that the model is normally distributed. Results in Table 6 showed the Granger Causality test results of the model in Table 4. The test result indicated that population rate granger cause the rate of forest area, family planning, agriculture area and unemployment rate of Nigeria. The forest areas Granger cause population rate, family planning, agriculture area and unemployment rate. More so family planning Granger cause population, forest area, unemployment rate and agriculture area. The agriculture areas Granger cause population, forest area, family planning and unemployment rate. Also the unemployment rate Granger cause population, forest area, family planning and agriculture rate. We therefore concluded that there is a causal relationship among the rate of forest area and population rate, family planning rates, agriculture area and unemployment rate of Nigeria.

5. CONCLUSIONS

This study has examined empirically the interrelationship among the population rate, forest area, family planning, agriculture area and unemployment rate of Nigeria. The study was conducted using vector autoregressive model approach. The results from correlation analysis provide evidence that there is a negative bidirectional relationship between forest area and population rate, agriculture area and unemployment rate inclusive while there is a positive bidirectional relationship between forest area and family planning. Evidence from the time series plot shows that Nigeria forest area experience a downward trend throughout the year of study. Evidence shows that the decline in forest area of Nigeria is influenced by the high rate of population rate, unemployment rate and low level embracement of family planning among married women in Nigeria, which could be as a result of religion belief, culture, et c. Results of findings indicated that if the unemployment rate reduces and the family planning rate increases, population rate of Nigeria will be stabilized which will in turn increases the forest area of Nigeria. This study recommends that family planning should be embraced by the masses to reduce population growth in order to curb environmental degradation. Government should create job to prevent people from finding life sustenance in forest and more importantly land use act should be strictly implemented on forest area and agricultural area as there must be specification on cultivated land from forest area.

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