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POPULATION CHANGES AND ENVIRONMENTAL QUALITY IN NIGERIA: A PARSIMONIOUS ECM APPROACH

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ABSTRACT

This study examined population changes and environmental quality in Nigeria. The study basically covered a period of 32years (1986 – 2019). The study made use of annual time series data collected from various issues of the Central Bank of Nigeria (CBN) statistical bulletin and the World Development Indicators (WDI). Stationarity of the series was determined using the Augmented Dickey Fuller (ADF), unit root, long-run relationship was determined with the Johansen-Cointegration while the short run model estimation was carried out with the use of the Parsimonious Error Correction Mechanism (ECM). The result showed that a long run relationship exist among the variables while the ECM showed that the speed of adjustment in event of a perturbation or disequilibrium for air, sanitation and water quality was approximately 147percent, 84.6percnt and 63.9 percent respectively. The result showed that the coefficients of both current and past period values of rate of urbanization (RUB), urban population (UPOP), rural population (RPOP), and working population (WOKP) all had inverse and significant impact on air quality (AIQ), sanitation quality (SANQ) and water quality (WAQ). On the other hand, both current and past period values of industrial growth (ING) and net export (NEXP) had direct relationship with AIQ, SANQ and WAQ. It was concluded that increase in the rate of urbanization, working age population, urban and rural population can bring about depletion in air, sanitation and water quality in Nigeria. It was recommended that the Ministry of Environment (MoE) should endeavour to increase the awareness of citizens on population check and the dangers of various human activities that could be injurious or harmful to air, water and environmental resources. This can be achieved by increasing public campaign in local languages to make communication effective to both the educated and uneducated.

Keywords: Population, Environmental Quality, Air Quality, Water Quality.

1. INTRODUCTION

The relationship between population and economic growth has a long history in Economics. With the publishing of the ground-breaking paper titled "An essay on the principle of population" by Thomas Malthus of the classical school of thought in 1798 followed by numerous other publications by notable Economics scholars including Pigou, Marshal and Keynes, the entire world became more aware of the need to understand the dynamics of population as a prerequisite to efficient economic planning as well as achieving sustainable growth (Tartiyus, Dauda & Peter, 2015). It was believed that more people imply greater productivity and security since more workers or laborers working efficiently would be expected to immensely improve productivity and the overall output of a nation.

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The word population referred to the total number of inhabitants constituting a particular race, class or group in a specified area. It is a term that describes all the organisms of the same group or species that live in the same geographical area and are capable of interbreeding. Todaro and Smith (2013) defined population growth as the change in the size of population, depending on the balance of birth and death, which are measured both in absolute and relative terms. Population growth rate according to Mundi Index (2017) is the average annual percentage change in population, which is affected by birth and death as well as the balance of the number of people that are coming and leaving a particular country within a specified period of time. The global population growth rate for the period of 2000, 2001, and 2002 were 1.30%, 1.25% and 1.23% respectively. On the average, the world population growth rate between 2000 and 2017 stood at 1.27%, this means that the total human beings inhabiting this planet are increasing by 1.27% yearly (United Nations Development Programme, 2016; 2017).

Population of Nigeria increased rapidly, from 20.06 million in 1931 to 140.3 (140) million in 2016. The growth in population tends to retard per capita income in three ways: a) it increases the pressure of population on land, b) it leads to rise in cost of consumable goods because of the scarcity of the factors to increase their supplies, and c) it leads to a decline in the accumulation of capital because with increase in family members, expenses increase. In addition to this, is the adverse effect that population growth has on standard of living, employment, capital formation, social infrastructure, agricultural development and environmental quality (Jhingan, 2005; Azuh, Matthew & Fasina, 2016; Aidi, Emecheta & Ikenna, 2016).

The quality of the environment is central to the existence of life, be it that of humans, animals or plants (Streimikiene, 2015). When the environment in a country is of high quality, human beings as well as plants and animals will live longer, enjoy a life of improved quality, and hence sustainable development may be achieved. However, over the past couple of years, the quality of environment in many countries of the world (Nigeria inclusive), have been receiving increased attention on account of the awareness of the adverse implications of a degenerate environment that may result if the environment continues to be neglected by the society (Awan, 2013).

Population explosion may be one of the factors affecting environmental quality in Nigeria. This is because, when population increases, there may be corresponding rise in productivity at the expense of environmental sustainability. For instance, population explosion in a given city may increase demand for housing and further give rise to air and noise pollution among others. Similarly, increased housing demand increases urbanization, congestions and deforestation activities. These losses are at the expense of forest faunas that are becoming extinct or endangered as a result of land encroachment and deforestation. Hence, poor environmental quality results from various factors including fossil fuels combustion, carbon emissions from factories and vehicle exhausts, oil spills, deforestation, greenhouse gas emissions, soil degradation and so on (Atubi, 2015; Abdulah, Azam, & Zakariya, 2016).

Contributing to poor environment quality in addition to the aforementioned, are poor access to clean water, poor access to sanitation, poor access to electricity, carbon emissions in densely populated cities in states like Lagos, Port Harcourt and others. For Nigeria, World Bank data suggests that between 1981 and 2014, CO_2 emissions rose by about 41.3% (i.e., from 65,958.33 kilotonnes (kt) to 96,280.75 kt). The Federal Environmental Protection Agency (FEPA) reported that energy consumption per capita increased from 676.38kg of oil equivalent in 1981 to 763.39kg in 2014 (World Development Indicators, 2017)

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In addition to this, the total greenhouse gas (GHG) emissions (in CO_2 equivalent) for the three main greenhouse gases (CO_2, CH_2 and N_2O) and from the five main sectors (energy, industry, agriculture, land use change and forestry - LUCF – and waste) was about 330,946 Gg CO_2e in 2000 (Mesagan, 2015). The GHG emissions were distributed unevenly between the three main gases, i.e. net CO_2 was 214,523 Gg, representing 65% of the National GHG emissions, methane (CH_2) was 109,319 Gg CO_2e or 33%; and nitrous oxide (N_2O) totalled 7,104 Gg (CO_2e) or 2%. Total CO_2 emissions in the energy sector amounted to about 108,000 Gg CO_2 in 1995, and this is expected to rise to 186,000 Gg CO_2 in 2020, 232,000 Gg CO2 by year 2030 in the baseline scenario and 359,000 Gg CO_2 in 2050, at an average annual growth rate of 2.2%. Cumulative reduction from baseline till 2030 is 887,000 Gg CO_2 (Federal Ministry of Environment, 2016). These environmental challenges could be emanating from population growth and increase in the rate of urbanization.

The most promising mitigation options to maintaining environmental sustainability in the Nigeria's energy system are: (a) introduction of compact fluorescent light (CFL) bulbs at a negative incremental cost of $58/ton CO2, with 5.155m ton CO2 reduction capacity; (b) introduction of improved kerosene stoves in households, at a cost of $21/ton of CO2 reduced (6.122 m ton CO2 reduction capacity); (c) fuel-oil to natural gas fuel substitution in the cement industry at $18/ton (7.49m ton CO2 reduction capacity); (d) improved electrical appliances ($16/ton) and wood-stoves ($3/ton) in the residential sector (9.566m ton CO2 reduction capacity); and (e) introduction of efficient motors in industry at $15/ton (10.738m ton CO2 reduction capacity) (Federal Ministry of Environment, 2016).

Despite the number of environmental laws that have been put forward to protect the environment from quality loss; oil spillage, pollution, and gas flaring in Nigeria, continues to worsen (Eregha & Mesagan, 2017). Nigeria is the focus of this study because it is the largest African economy in terms of population and output, and it depends significantly on fossil fuels for generating its electricity. Nigeria's population according to the National Population commission as at 2016 was 140.3million with an estimated population of about 180million persons (Ogunleye, Owolabi & Mubarak, 2018). The country is Africa's largest producer of crude oil and records the highest amount of gas flaring in Africa. Indeed, by the end of December 2015, Nigeria ranked 6th globally behind only Russia, Iraq, Iran, the United States, and Venezuela, with gas flaring of 8 billion cubic meters (bcm) (World Bank, 2016). It is thus pertinent to focus on Nigeria because of its size and for the fact that it can provide a template for other African countries to follow in the quest to improve environmental quality on the continent. Based on the preceding, this study sought to examine the nexus between population changes and environmental quality in Nigeria.

Studies on environmental quality have been carried out in literature. For instance, Saibu and Mesagan (2019) examined the growth effects of foreign direct investment on environmental quality in Nigeria between 1970 and 2013. Variables like per capita income, environmental degradation, foreign direct investment, human capital, inflation, trade openness, interest rate, and the interaction term between foreign direct investment and carbon emission were employed in the study. A long-run relationship was observed among the variables and foreign direct investment and environmental degradation negatively enhanced growth individually while the interaction variable positively enhance economic growth.

Owolabi, Aderounmu and Ogunbiyi (2019) explored the effect of environment quality on poverty reduction in Nigeria using data from the World Bank Development indicators over the period of 1990 to 2015. The study employed Augmented Dickey Fuller (ADF) unit root test, and

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Autoregressive Distributed Lag (ARDL) estimation in analyzing data and the findings of the study revealed that improved environment quality as measured by improved access to sanitation and access to electricity positively and significantly increase poverty level in Nigeria, possibly on account of the increased financial and social costs of gaining access to sanitation and electricity.

Agbebaku (2015) examined the impact of environmental imbalance, environmental challenges and climate change in Nigeria. The methodology adopted was purely on content analysis of secondary data and observed information from field survey. The study showed the cause of environmental imbalance, environmental challenges and climate change. However, atmospheric variables (positive and negative) are responsible of the gradual process and destruction of the ecosystem. The finding showed that human influences such as pollutants, chemicals, wastes, fertilizer, and deforestation among other interventions of the ecosystem are major determinants of environmental imbalance, environmental challenges and climate change.

In Nigeria, the problems of environmental pollution range from poor urban planning and lack of essential waste management facilities to inefficient industrial practices which put the environment into so much harm. A combination of related factors such as poverty, population growth and rapid urbanization and, the inability of governments to provide effective housing schemes has given rise to cities with high number of slums in which there are no waste management systems (Ezeabasili, 2009). Under such conditions, citizens especially people living in poverty (PLP) have become increasingly exposed to communicable diseases and other health endangering circumstances (Akinola, Ekpo & Haruna, 2012).

Several studies have been carried out to investigate the impact of population dynamics on macroeconomic variables in Nigeria. Ogunleye, Owolabi and Mubarak (2018) appraised the relationship between population and economic growth in Nigeria using Ordinary Least Squares (OLS) and found that population growth rate promoted economic growth. Onwuka (2004) examined the impact of Nigeria's growing population on the country's development and found that population growth rate had adverse effect on Nigeria's capital resources. Nwosu, Dike, and Okwara (2014) and Aidi, Emecheta and Ikenna (2016) found a two way causation running from population growth rate to economic growth rate and vice versa.

From the foregoing, many studies on population-growth nexus used average population growth rate, birth rate, total population and death rate as proxy for population dynamics in relation to economic growth. Although, there is lack of consensus on their findings, majority found that population changes affected economic growth. In regards to environmental quality, many of the studies investigated the effect of poverty, foreign direct investment and financial development on environmental quality in Nigeria. Furthermore, many of the studies on environmental quality often used CO_2 emission as indicator for environmental quality or air pollution (Owolabi, Aderounmu & Ogunbiyi, 2019; Saibu & Mesagan, 2019; Alege & Ogundipe, 2019). According to Oyeshola (2008), the use of the CO_2 emission as the only indicator could be weak because it measures more of air quality; and ignores other aspects of the environment like water quality, and sanitation depth. The inclusion of these other aspects; is the knowledge gap this study intends to fill.

Hypotheses

The following hypotheses were tested in the study:

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a) Population changes has no significant relationship with air quality in Nigeria
b) Population changes has no significant effect on sanitation quality in Nigeria
c) Population changes has no significant relationship with water quality in Nigeria

Theoretical Framework

The Malthusian theory of population was used as the theoretical framework of this work. Thomas Robert enunciated his views about population in his famous book, "essay on the principle of populations and how it affects the future improvement of society", published in 1798. Malthus (1798) objected that the pressure of increasing population on the food supply would destroy perfection and there would be misery in the world. Malthus was severely criticized for these pessimistic views which led him to travel on the continent of Europe to gather data in support of his thesis. The Malthusian doctrine is stated as follows:

a. There is a natural sex instinct in human beings to increase at fast rate. As a result population increases in geometrical progression and if unchecked doubles itself every 25 years. Thus, starting from 1, population in successive periods of 25years will be 1, 2, 7, 8, 16, 32, 64, 128, 126 (after 200 years);
b. On the other hand, the food supply increases in a slow arithmetical progression due to the operation of the law of diminishing returns based on the supposition that the supply of land is constant, thus the food supply in successive similar periods will be 1, 2, 3, 4, 5, 6, 7, 8 and 9 (after 200 years).
c. Since population increases in geometrical progression and the food supply in arithmetical progression, population tends to outrun food supply. Thus, an imbalance is created which leads to over-population. The exponential growth of population and it effect on food, growth and environmental quality are explained in the equation [3.1]:

The differential equation describing exponential growth is

$$\frac{dN}{dr} = rN - (1)$$

Integrate equation 3.1 directly to get equation 3.2

$$\int_{50}^{t} \frac{dN}{N} = \int_{0}^{t} r dt - (2)$$

$$\text{In}\left(\frac{N}{Na}\right) = rt_t - (3)$$

Where No = N (t=0) exponentiating

$$N(t) = JN_{se}{}^{1t}{}_{t} - \quad - \quad - \quad - \quad - \quad - \quad - \quad - (4)$$

This equation [3.4] is called the low of growth and, in a much more antiquated fashion, the Malthusian equation; the quantity in this equation is sometimes known as the Malthusian parameter. The Malthusian parameter explains the implications of exponential growth rate of population on various economic and environmental parameters such as food production and environmental quality in a given economy or society.

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Model Specification

The empirical model of Mesagan and Nwachukwu (2018) was adapted for the study. The mother model as used by Mesagan and Nwachukwu (2018) is given below in equation 5:

$ENV = \beta_0 + \beta_1 POD_t + \beta_2 PGR_t + \beta_3 FER_t + \beta_4 CDR_t + \beta_5 NEXR_t + u_t$……… [5]

Where: ENV is Environmental quality proxied with CO_2 emission, POD is population density, PGR is Population growth rate, FER is Fertility Rate, CDR is Crude Death Rate and NEXR is Net Export Growth Rate.

Before using the model in the current study, some variables were included to examine the effect of rural-urban population growth and working population dynamics on environmental quality. The modifications are as follows. First, urban and rural population was included separately as against the total population growth rate used in the mother model. Second, working age population (16-69years) which captures the stock of productive labour force was included to examine dependency on the working population. Third, industrial growth was included to show the effect of productive activities on environmental quality. Lastly, environmental quality (ENV) was proxied with three indicators. These indicators are: a) air quality (CO_2 emission from residential buildings, commercial and public services); b) sanitation quality (percentage of population with access to improved sanitized facilities for residence) and; c) water quality (percentage of population with access to portable water supply). Following these modifications, the functional form of the equations to be estimated is given below.

AIQ = RUB, UPOP, RPOP, WOKP, ING, NEXP [6]

SANQ = RUB, UPOP, RPOP, WOKP, ING, NEXP [7]

WAQ = RUB, UPOP, RPOP, WOKP, ING, NEXP [8]

In econometric form, the equations are stated thus:

$AIQ = \alpha_0 + \alpha_1 RUB + \alpha_2 UPOP_t + \alpha_3 RPOP_t + \alpha_4 WOKP_t + \alpha_5 ING_t + \alpha_6 NEXP_t + u_t$… [9]

$SANQ = \beta_0 + \beta_1 RUB + \beta_2 UPOP_t + \beta_3 RPOP_t + \beta_4 WOKP_t + \beta_5 ING_t + \beta_6 NEXP_t + u_t$… [10]

$WAQ = \lambda_0 + \lambda_1 RUB + \lambda_2 UPOP_t + \lambda_3 RPOP_t + \lambda_4 WOKP_t + \lambda_5 ING_t + \lambda_6 NEXP_t + u_t$… [11]

To linearise the equations, a natural log transformation was introduced to equations [3.8] to [3.10]. The transformed form of the equations is given thus:

$AIQ = \alpha_0 + \alpha_1 RUB + \alpha_2 UPOP_t + \alpha_3 LnRPOP_t + \alpha_4 LnWOKP_t + \alpha_5 LnING_t + \alpha_6 LnNEXP_t + u_t$

$\alpha_1 - \alpha_6 < 0$ [12]

$SANQ = \beta_0 + \beta_1 RUB + \beta_2 UPOP_t + \beta_3 LnRPOP_t + \beta_4 LnWOKP_t + \beta_5 LnING_t + \beta_6 LnNEXP_t + u_t$

$\beta_1 - \beta_6 < 0$ [13]

$WAQ = \lambda_0 + \lambda_1 RUB + \lambda_2 UPOP_t + \lambda_3 LnRPOP_t + \lambda_4 LnWOKP_t + \lambda_5 LnING_t + \lambda_6 LnNEXP_t + u_t$

$\lambda_1 - \lambda_6 < 0$ [14]

Where:

AIQ = Air quality (proxied with CO_2 emission)

SANQ = Sanitation quality (percentage of population with access to improved sanitized facilities for residence)

WAQ = Water quality (percentage of population with access to portable water supply)

RUB = Rate of urbanization (proxied with people per square kilometre of land area)

RPOP = Rural population (rural people in agglomeration of more than 1million)

UPOP = Urban population (urban people in agglomeration of more than 1million)

WOKP = Working age population (aged 16-69years)

ING = Industrial output growth (Nbillion)

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NEXP = Net export (₦billion)
α_{0}, β_{0} and λ = Constants
α_1 - α_6, β_1 - β_6, λ_1 - λ_6 are coefficients to be estimated
Ln = Natural logarithm
U = Error term
t = time (yearly trend)

2. METHOD OF DATA ANALYSIS

The econometric methods used include: Ordinary Least Squares (OLS) method, Augmented Dickey Fuller (ADF) Unit-root test, Johansen Cointegration test, Lag order Selection Criteria and the Parsimonious Error Correction Model (ECM). The econometric view package (Eviews 7) was used to analyse data.

Unit Root test

Prior to estimation, data were subject to unit root test to establish their adequacy as regards stationarity. The need to determine whether time series are stationary overtime underscores the importance of unit root test; that is, the test in which the order of integration of each series employed is determined. The determination of each series is necessary for co-integration and error correction modelling, simply because each series involved in the estimation of a model must be integrated of the same order (Engle & Granger 1987). A time – series is said to be stationary if it exhibits white noise. It implies that the series is integrated of order zero.

Co-integration test

In econometric terms, two or more variables are co-integrated if they have a long-run or an equilibrium relationship between or among them (Gujarati, 2004). This implies that the variables or series are associated and have the tendency to move together over a long time. The Johansen (1991) likelihood ratio test statistics; the trace and maximum eigenvalue test statistic, were utilized to determine the number of cointegrating vectors. The decision rule is to reject the null hypothesis if the probability (p-value) is less than 5% (0.05), otherwise, we do not reject.

Error Correlation Mechanism (ECM)

The error correlation mechanism is employed to tie the short–run dynamic behaviours of a variable to its long–run values. The error correlation mechanism (ECM) was first used by Sargen and later popularized by Engle and Granger (1981) to correct disequilibrium. Given these dynamics, Engle and Granger suggested that adjustment should be involved through the iterative process to obtain a more parsimonious model. The ECM is stated as:

$$\Delta Y_t = \alpha_1 \Delta X_t + \alpha_2 u_{t-1} + \sum_t \qquad [15]$$

Where Δ denotes the first difference operator, $\sum_t$ the random error term and $U_{t-1} = \{Y_{t-1} - \beta_1 - \beta_2 - X_{t-1}\}$ is the one period lagged values of the error from the co-integrating regression. In this regard, the equations [9] to [11] are rewritten in the ECM form as equations [16] to [18]:

$$\Delta AIQ = \delta_0 + \sum_{i=1}^{a} \sigma_1 \Delta RUB_{t-1} + \sum_{i=1}^{a} \varphi_1 \Delta UPOP_{t-1} + \sum_{i=1}^{a} \tau_1 \Delta Ln\mathrm{RPOP}_{t-1} + \sum_{i=1}^{a} \omega_1 \Delta Ln\mathrm{WOKP}_{t-1} + \sum_{i=1}^{a} \Omega_1 \Delta Ln\mathrm{ING}_{t-1} + \sum_{i=1}^{a} \mho_1 \Delta Ln\mathrm{NEXP}_{t-1} + \varepsilon_{t-1} \qquad [16]$$

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$$\Delta SANQ = \delta_0 + \sum_{i=1}^{a} \sigma_1\, \Delta RUB_{t-1} + \sum_{i=1}^{a} \varphi_1\, \Delta UPOP_{t-1} + \sum_{i=1}^{a} \tau_1\, \Delta Ln\text{RPOP}_{t-1} + \sum_{i=1}^{a} \omega_1\, \Delta Ln\text{WOKP}_{t-1} + \sum_{i=1}^{a} \Omega_1\, \Delta Ln\text{ING}_{t-1} + \sum_{i=1}^{a} \mho_1\, \Delta Ln\text{NEXP}_{t-1} + \varepsilon_{t-1} \quad [17]$$

$$\Delta WAQ = \delta_0 + \sum_{i=1}^{a} \sigma_1\, \Delta RUB_{t-1} + \sum_{i=1}^{a} \varphi_1\, \Delta UPOP_{t-1} + \sum_{i=1}^{a} \tau_1\, \Delta Ln\text{RPOP}_{t-1} + \sum_{i=1}^{a} \omega_1\, \Delta Ln\text{WOKP}_{t-1} + \sum_{i=1}^{a} \Omega_1\, \Delta Ln\text{ING}_{t-1} + \sum_{i=1}^{a} \mho_1\, \Delta Ln\text{NEXP}_{t-1} + \varepsilon_{t-1} \quad [18]$$

Where, δ_0 is the drift component, Δ is first-difference operator while a represents the optimal lag lengths for each incorporated series. The error correction term is ε_{t-1}. In the second part of the equation $\sigma_1,\ \varphi_1,\ \tau_1,\ \omega_1,\ \Omega_1 and\ \mho_1$ represents the estimated coefficient of the variables in the model. Note that the terms with summation sings are used to model the total number of lags for each variable. Appropriate lag length is selected based on the Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn Information Criterion (HQ) before the error correction model in equation [16] to [18] were estimated.

Sources of Data

This study made use of secondary data. The study employed annual time series data for the period 1986 – 2019. Secondary data needed for the study were obtained from various issues of the World Development Indicators (WDI) of the United Nations database and CBN statistical bulletin.

3. RESULTS

The econometric methods employed in this study include: Augmented Dickey Fuller (ADF) unit-root test, Johansen Cointegration test, lag order selection criteria and the Parsimonious Error Correction Model (ECM). The results of these various analysis are presented in this section.

Unit Root Test

Table 1: Unit Root test result on the Variables

Series	ADF statistics	Critical values			Order of Integration
		1%	5%	10%	
AIQ	-6.2581	-3.6537	-2.9571	-2.6174	$I(1)$
SANG	-6.5287	-3.6537	-2.9571	-2.6174	$I(1)$
WAQ	-5.3512	-3.6537	-2.9571	-2.6174	$I(1)$
RUB	-6.7497	-3.6537	-2.9571	-2.6174	$I(1)$
RPOP	-10.3785	-3.6537	-2.9571	-2.6174	$I(1)$
UPOP	-3.3332	-3.6537	-2.9571	-2.6174	$I(1)$
WOKP	-3.4299	-3.6537	-2.9571	-2.6174	$I(1)$

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ING	-5.6026	-3.6537	-2.9571	-2.6174	*I*(1)
NEXP	-5.7645	-3.6537	-2.9571	-2.6174	*I*(1)

Source: Author's computation from Eviews

From Table 1, the results on the ADF statistics indicated that none of the series were stationary at level i.e integrated at order zero *I*(0) but rather all – AIQ, SANQ, WAQ, RUB, RPOP, UPOP, WOKP, ING and NEXP were stationary at first difference i.e or integrated at same order one *I*(1). Hence, the null hypothesis of no unit root exist was rejected for the rest of the entire series. This outcome provides sufficient reason for the researcher to proceed with further estimation as the trend or unit root that could result in a spurious estimate has been successfully eliminated by detrending the series. Also, the order of integration is the same and the Johansen Co-integration test is applicable. Before proceeding with estimating the ECM equation, the long run relationship among the series was determined using the Johansen Co-integration test.

Cointegration test

The result of the cointegration is summarized in Table 4.4 below.

Table: Cointegration Rank Test (Trace and Maximum Eigenvalue) on the Series in Model 1

Series: AIQ RUB UPOP RPOP WOKP ING NEXP
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.953220	234.7565	125.6154	0.0000
At most 1 *	0.867204	136.7630	95.75366	0.0000
At most 2 *	0.650235	72.15683	69.81889	0.0322
At most 3	0.394531	38.54102	47.85613	0.2789
At most 4	0.323584	22.48496	29.79707	0.2723
At most 5	0.164608	9.974633	15.49471	0.2827
At most 6	0.123531	4.219317	4.841466	0.2400

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.953220	97.99344	46.23142	0.0000
At most 1 *	0.867204	64.60620	40.07757	0.0000
At most 2 *	0.123531	4.219317	3.841466	0.0400
At most 3	0.394531	16.05606	27.58434	0.6610
At most 4	0.323584	12.51033	21.13162	0.4982
At most 5	0.164608	5.755316	14.26460	0.6448
At most 6	0.650235	33.61581	33.87687	0.0637

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

From the trace and maximum eigenvalue statistics in Table 4.4, the first and second null hypotheses were rejected at 5% level of significance based on our decision rule that the probability value(s) is less than 5% (0.05). The trace and maximum eigenvalue statistics revealed that there are at least three cointegrating equations or vectors among the variables respectively. Therefore, there exist a long run relationship among the series in model one

Table Cointegration Rank Test (Trace and Maximum Eigenvalue) on the Series in Model 2
Series: SANQ RUB UPOP RPOP WOKP ING NEXP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value
None *	0.982669	388.9583	125.6154
At most 1 *	0.969444	259.1904	95.75366
At most 2 *	0.876243	147.5682	69.81889
At most 3 *	0.742322	80.70636	47.85613
At most 4	0.482957	37.31294	39.79707
At most 5	0.314105	16.20480	25.49471
At most 6	0.121351	4.139821	4.841466

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Eigen	0.05

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No. of CE(s)	Eigenvalue	Statistic	Critical Value
None *	0.982669	129.7679	46.23142
At most 1 *	0.969444	111.6222	40.07757
At most 2 *	0.876243	66.86184	33.87687
At most 3 *	0.742322	43.39342	27.58434
At most 4	0.482957	21.10814	21.83162
At most 5	0.314105	12.06498	14.26460
At most 6	0.121351	3.139821	3.841466

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The result of the trace and maximum eigenvalue statistics in Table 4.5 produced satisfactory evidence for the first and second null hypotheses to be rejected at 5% level of significance. This is based on our decision rule that the probability value(s) is less than 5% (0.05). The trace and maximum eigenvalue statistics revealed that there are at least four cointegrating equations or vectors among the variables respectively. Therefore, there exists a long run relationship among the series in model two.

Table: Cointegration Rank Test (Trace and Maximum Eigenvalue) on the Series in Model 3

Series: WAQ RUB UPOP RPOP WOKP ING NEXP
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value
None *	0.967627	316.4905	125.6154
At most 1 *	0.905718	206.7172	95.75366
At most 2 *	0.798701	131.1505	69.81889
At most 3 *	0.711443	79.85563	47.85613
At most 4	0.474203	40.08400	49.79707
At most 5	0.304974	19.51313	25.49471
At most 6	0.218062	7.871341	13.81466

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value
None *	0.967627	109.7733	46.23142

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At most 1 *	0.905718	75.56673	40.07757
At most 2 *	0.798701	51.29483	33.87687
At most 3 *	0.711443	39.77163	27.58434
At most 4	0.474203	20.57087	21.13162
At most 5	0.304974	11.64179	14.26460
At most 6	0.218062	7.871341	9.841466

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The result of the trace and maximum eigenvalue statistics in Table 4.6 indicated that the first and second null hypotheses were rejected at 5percent level of significance. This is based on the decision rule that the probability value(s) should be less than 5percent. The trace and maximum eigenvalue statistics revealed that there are at least four cointegrating equations or vectors among the variables respectively. Therefore, there exist long run relationships among the series in the third model. The result of the long-run estimates is presented in the following section.

Log-run estimate on the Regression Results

The result obtained from the Ordinary Least Squares (OLS) regression analysis for Models 1, 2 and 3 are given below respectively:

Table 4.7: Long-run Regression Output for the models

	Model 1	**Model 2**	**Model 3**
Variable	**AIQ**	**SANQ**	**WAQ**
C	-8.3508 (-1.1115)	-169.8047 (-3.4048)	-148.3512 (-5.6954)
RUB	-2.3192 (-0.9225)	-21.7496 (-1.3033)	-113.7364** (-13.048)
UPOP	-0.3209* (-2.6787)	-0.6170 (-0.7757)	0.6653 (1.6014)
RPOP	-0.1413** (-3.5907)	-0.8848** (-3.3876)	0.2079 (1.5245)
WOKP	-0.12151** (-3.6603)	0.4592 (0.9449)	-0.6929* (-2.7303)
ING	1.1629 (1.1726)	-21.512** (-3.2676)	-6.7043 (-1.9498)
NEXP	0.0465 (0.6684)	1.7457** (3.7819)	1.1507** (4.7730)
R-squared	0.2994	0.9326	0.7986
Adjusted R-squared	0.1437	0.9177	0.7984
F-statistic	19.231	62.323	33.422
Prob(F-statistic)	0.0000	0.0000	0.0000
Durbin-Watson Stat.	1.9585	0.7824	1.9535

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Source: Author's computation **(**Eviews 7)
** Coefficient is significant at 0.05 alpha level*
*** Coefficient is significant at 0.01 alpha level*

From model 1 in Table 4.7, the coefficient of RUB is -2.3192. This implies that there is an indirect relationship between rate of urbanisation (RUB) and air quality (AIQ). Hence, rate of urbanization has indirect impact on air quality in Nigeria. The t-ratio value for the estimate (α_2) is -0.9225 was not significant at 5% level of significance. The regression estimate for UPOP is -0.3209. This explains that there is an inverse relationship between urban population (UPOP) and air quality (AIQ). Hence, urban population has inverse impact on air quality in Nigeria. This implies that a unit increase in urban population will bring about 0.3209 unit decrease in air quality. The t-ratio for the estimate of UPOP was significant. The coefficient of RPOP is -0.1413. This denotes that there is an inverse relationship between rural population (RPOP) and air quality (AIQ). Hence, rural population has an indirect impact on air quality in Nigeria. The t-ratio for the estimate of -3.5907 for RPOP is significant.

The coefficient of WOKP is -0.1215. This shows that there is an inverse relationship between working age population (WOKP) and air quality (AIQ). Hence, working age population has an inverse impact on air quality in Nigeria. This implies that a unit increase in working age population will bring about -0.1215 units decrease in air quality. The t-ratio for the estimate (-3.6603) was statistically significant. The coefficient of ING is 1.1629. This indicates that there is a direct relationship between industrial growth (ING) and air quality (AIQ). Hence, industrial growth has direct impact on air quality in Nigeria. This implies that a unit increase in industrial growth will bring about 1.1629 unit increase in air quality. The t-ratio for the coefficient (α_6) is not statistically significant. The coefficient for NEXP (0.0465) shows that there is a direct relationship between net export (NEXP) and air quality (AIQ). Hence, net export has direct impact on air quality in Nigeria. This implies that a unit decrease in net export will bring about 0.6684 increases in air quality. However, the value of the coefficient was not statistically significant.

The coefficient of determination (R^2) is 0.2994. This explains that the independent variables are able to explain 29.94% of any systematic change in the dependent variable while the unexplained residue of 70.6% is attributed to values in the error term or other randomized variables not captured in the model that have prominent impact on the dependent variable. Similarly, the value of the adjusted coefficient of determination (R^{-2}) is 0.1437. This value measures the reduced explanatory power of the model. It further explains that the independent variables are able to explain 14.37% of any systematic change in dependent variable while the unexplained residue of 85.63% is attributed to values in the error term or other randomized variables not captured in the model that have prominent impact on the dependent variable.

The f-statistic of 19.231 is significant at 5% level (prob<0.05). Therefore, the overall parameter estimates for the model is jointly significant. The Durbin Watson (D.W) statistics of the model is 1.9585. Since the value is approximately equal to 2. It explains that there is no presence of serial auto-correlation between the dependent and independent variables.

From model 2 in Table 4.7, the coefficient of RUP is -21.7496. This implies that there is an inverse relationship between rate of urbanisation (RUP) and sanitation quality (SANQ). Hence, rate of urbanization has an indirect impact on sanitation quality in Nigeria. The t-ratio showed that the coefficient is not statistically significant. The coefficient of UPOP (-0.6170) shows that there is an inverse and significant relationship between urban population (UPOP) and sanitation quality

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(SANQ). Hence, a unit increase in urban population will bring about 0.6170 units decrease in sanitation quality. An inverse relationship was found between rural population (RPOP) and sanitation quality (SANQ) as the coefficient of RPOP was -0.8848. Hence, rural population has indirect and significant impact on sanitation quality in Nigeria ($p<0.05$).
The coefficient for WOKP (0.4592) shows that there is a direct relationship between working age population (WOKP) and sanitation quality (SANQ) indicates that a unit increase in working age population will bring about 0.4592 units increase in sanitation quality. The t-ratio for estimate however showed that the coefficient was not statistically significant. The estimated coefficient of -21.5115 for ING explains that there is an inverse relationship between industrial growth (ING) and sanitation quality (SANQ). Hence, industrial growth has indirect impact on sanitation quality in Nigeria. This implies that a unit increase in industrial growth will significantly bring about 21.5115 units decrease in sanitation quality ($p<0.05$). The coefficient of NEXP is -1.7457. This result shows that there is a direct relationship between net export (NEXP) and sanitation quality (SANQ). This implies that a unit increase in net export will bring about 1.7457 increases in sanitation quality.
The coefficient of determination (R^2) is 0.9326. This explains that the independent variables are able to explain 93.26% of any systematic change in the dependent variable while the unexplained residue of 6.74% is attributed to values in the error term or other randomized variables not captured in the model that have prominent impact on the dependent variable.The value of the adjusted coefficient of determination($\bar{R}^2$) is 0.9177. This value measures the reduced explanatory power of the model. It further explains that the independent variables are able to explain 91.77% of any systematic change in dependent variable while the unexplained residue of 8.23% is attributed to values in the error term or other randomized variables not captured in the model that have prominent impact on the dependent variable.

The f-statistic is 62.323 at 5% level of significance. Since, the probability value is less than the 0.05 level of significance, calculated F-ratio (62.323) shows that the estimated coefficients are jointly significant. The Durbin Watson (D.W) statistic of model 2 (SANR model) is 0.7824. Since the value is not approximately equal to 2. It explains that there is presence of serial auto-correlation between the dependent and independent variables.

From model 3 in Table 4.7, the coefficient of RUB is -113.7364. This implies that there is a direct relationship between rate of urbanisation (RUB) and water quality (WAQ). Hence, rate of urbanization has inverse relationship with water quality in Nigeria. The t-ratio (-13.048) of the coefficient shows that RUB is statistically significant ($p<0.05$). The estimated coefficient of UPOP (0.6653) shows that urban population has direct relationship with water quality in Nigeria. This implies that a unit increase in urban population will bring about 0.6653 units increase in water quality. The t-ratio for the estimated coefficient of UPOP (1.6014) is not significant at 5% level of significance.
The value of RPOP coefficient (0.2079) shows that rural population has direct but insignificant impact on water quality in Nigeria, while the coefficient of WOKP (-0.6929) indicates the existence of an inverse relationship between working age population (WOKP) and water quality (WAQ). Hence, working age population has inverse relationship with water quality in Nigeria. This implies that a unit increase in working age population will bring about 0.6929 units decrease in water quality and related resources. The t-ratio for the estimated coefficient (-2.7303) further

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showed that working age population has significant effect on water quality. The coefficient of -6.7043 shows that there is an inverse but insignificant relationship between industrial growth (ING) and water quality (WAQ) while the regression coefficient of NEXP shows that there is a direct relationship between net export (NEXP) and water quality (WAQ); implies that a unit increase in net export will significantly bring about 1.1507 units increase in water quality.
The coefficient of determination (R^2) explains that the independent variables are able to explain 79.86% of any systematic change in the dependent variable while the unexplained residue of 20.14% is attributed to values in the error term. In the same vein, the adjusted coefficient of determination (R^{-2}) which measures the reduced explanatory power of the model (i.e goodness of fit of the model) further explains that the independent variables are able to explain 79.84% of any systematic change in dependent variable while the unexplained residue of 20.16% is attributed to values in the error term.
The f-statistic of 33.422 is statistically significant at 5% level of significance (prob<0.05). Therefore, the overall parameter estimates for the model is jointly significant. The Durbin Watson (D.W) statistic of the model (1.9535) is approximately equal to 2. Folowing the rule of thumb of an approximate value of 2, the model is considered satisfactory as there is no presence of serial auto-correlation between/among the independent variables.
The existence of a long run relationship among all the series in the models makes it possible for the researcher to determine how quickly the variables converge to equilibrium (i.e. the speed of adjustment back to long-run equilibrium after a perturbation, shock or a short-run disturbance). To determine this, the Parsimonious Error Correction Mechanism (ECM) was estimated. However, before estimation, it is pertinent to determine the optimum number of lags required for model estimation by using some relevant criteria. The results for the lag order selection criteria for model one to three are as follows.

Lag Order Selection Criteria

The result of the Lag Order Selection Criteria is presented in Table 4.8.

Table Lag Order Selection Criteria for Model 1

Endogenous variables: D(AIQ)
Exogenous variables: C D(RUB) D(UPOP) D(RPOP) D(WOKP) D(ING) D(NEXP)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	30.08076	NA	0.011383	-1.648626	**-1.315575***	-1.546809
1	30.11813	0.053385	0.012260	-1.579867	-1.199237	-1.463504
2	30.12009	0.002659	0.013262	-1.508578	-1.080369	-1.377670
3	34.31334	**5.391325***	**0.010656***	**-1.736667***	-1.260880	**-1.591214***
4	34.66608	0.428324	0.011292	-1.690434	-1.167068	-1.530436
5	34.69041	0.027806	0.012284	-1.620744	-1.049799	-1.446200

* indicates lag order selected by the criterion

Note: LR - Log ratio, FPE - Final prediction error, AIC - Akaike information criterion, SC - Schwarz information criterion, HQ - Hannan-Quinn information criterion

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The result in Table 4.8 showed that the coefficient of SC indicates zero lag while LR, FPE, AIC, and HQ indicated three optimum lag length. Since four of the five (5) lag length selection criteria indicated an optimum lag length of three; three (3) lag was considered the optimum lag orders needed for the estimation of model one.

Table Summary of the Order Selection Criteria for Model 2

Endogenous variables: D(SANQ)
Exogenous variables: C D(RUB) D(UPOP) D(RPOP) D(WOKP) D(ING) D(NEXP)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1.384620	NA	0.107728	0.598901	0.931953	0.700718
1	27.25530	0.000694	0.017642	-1.232522	-0.756734	-1.087069
2	27.25476	0.011370	0.016274	-1.303912	-0.875703	-1.173004
3	27.24639	**40.90144***	**0.015052***	**-1.374742***	**-0.994112***	**-1.258380***
4	27.51008	0.309374	0.018826	-1.179292	-0.655926	-1.019293
5	28.09797	0.671876	0.019671	-1.149855	-0.578910	-0.975312

* indicates lag order selected by the criterion
Note: LR - Log ratio, FPE - Final prediction error, AIC - Akaike information criterion, SC - Schwarz information criterion, HQ - Hannan-Quinn information criterion

Table 4.9 result showed that the coefficients of all the criteria LR, FPE, AIC, SC and HQ indicated three optimum lag length. Since all the five (5) lag length selection criteria indicated an optimum lag length of three; three (3) lag was considered the optimum lag orders needed for the estimation of model two.

Table Summary of the Order Selection Criteria for Model 3

Endogenous variables: D(WAQ)
Exogenous variables: C D(RUB) D(UPOP) D(RPOP) D(WOKP) D(ING) D(NEXP)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	21.08328	NA	0.021645	-1.005949	**-0.672898***	-0.904132
1	21.65813	0.821209	0.022436	-0.975581	-0.594951	-0.859218
2	21.68936	0.042381	0.024219	-0.906383	-0.478174	-0.775475
3	25.08122	**4.360972***	0.020606	-1.077230	-0.601443	-0.931777
4	26.45522	1.668422	**0.020299***	**-1.103944***	-0.580578	**-0.943946***
5	26.78813	0.380469	0.021601	-1.056295	-0.485350	-0.881751

* indicates lag order selected by the criterion
Note: LR - Log ratio, FPE - Final prediction error, AIC - Akaike information criterion, SC - Schwarz information criterion, HQ - Hannan-Quinn information criterion

The result in Table 4.10 showed that the coefficient of SC indicates zero lag, LR indicates three lags while FPE, AIC, and HQ indicated four optimum lag length. Due to the relatively small

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number of observations, four lags were too large for the model fit. Hence, three lags was considered the optimum lag length needed for the estimation of model three.

Parsimonious Error Correction Model

The result of the parsimonious error correction models (ECM) were generated from the overparametised equations (see appendix for tables). The results obtained from the regression analysis for Models 1, 2 and 3 are provided in the next table

Table Short-run Regression estimate for the models

Model 1		**Model 2**		**Model 3**	
Variable	**AIQ**	**Variable**	**SANQ**	**Variable**	**WAQ**
C	0.0356 (0.6349)	C	0.8030 (4.6887)	C	0.1476 (0.932)
D(RUB(-2))	-23.2115* (-2.5693)	D(RUB)	-111.1097** (-16.7199)	D(RUB)	-84.0983** (-10.3363)
D(UPOP)	-0.4444** (-4.4919)	D(RUB(-3))	-110.1463** (-4.8749)	D(RUB(-2))	-104.0323** (-4.5971)
D(UPOP(-2))	-0.2382* (-3.5693)	D(UPOP)	-1.8416** (-7.8538)	D(RUB(-3))	-76.5068* (-3.5262)
D(RPOP)	-0.2092** (-4.3714)	D(UPOP(-1))	-0.3489** (-3.9685)	D(UPOP(-2))	-0.2662* (-3.7882)
D(RPOP(-1))	-0.0942* (-2.5513)	D(UPOP(-2))	-0.2713** (-3.7677)	D(RPOP(-1))	-0.3499** (-6.8088)
D(RPOP(-3))	-0.2034* (-3.3334)	D(RPOP(-1))	-0.8021** (-18.0907)	D(RPOP(-2))	-1.0293** (-10.5472)
D(WOKP)	-0.5209* (-3.4441)	D(RPOP(-2))	-0.3808** (-9.8798)	D(RPOP(-3))	-0.2436* (-2.5385)
D(WOKP(-1))	-0.4044* (-2.1360)	D(RPOP(-3))	-0.2867* (-2.5208)	D(WOKP(-2))	-0.6482* (-2.8507)
D(WOKP(-2))	-0.7662** (-4.4835)	D(WOKP)	-1.4281** (-9.2064)	D(WOKP(-3))	-0.5170** (-7.4599)
D(ING(-2))	-2.1806* (-3.8167)	D(WOKP(-2))	0.7273** (4.4954)	D(ING(-1))	1.1545* (2.1576)
D(ING(-3))	1.0603* (2.5714)	D(WOKP(-3))	0.9029** (5.6793)	D(NEXP)	0.2327** (4.7057)
D(NEXP)	0.1790* (3.7266)	D(ING(-2))	2.1909** (3.9519)	D(NEXP(-2))	0.1524* (3.1300)
D(NEXP(-2))	0.3216** (5.5481)	D(NEXP(-2))	0.0923* (2.4478)	**ECM(-1)**	**-0.6396*** **(2.6871)**
ECM(-1)	**-1.4764**** **(-4.7966)**	**ECM(-1)**	**-0.8455*** **(-3.1978)**		

Source: Author's computation **(**Eviews 7)
** Coefficient is significant at 0.05 alpha level*
*** Coefficient is significant at 0.01 alpha level*

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Results in Table indicates that the Error Correction Term (ECM) of models 1, 2 and 3 are -1.4764, -0.8455 and -0.6396 are correctly signed and statistically significant at 0.05 level of significance ($p<0.05$). This shows that if there is disequilibrium, AIQ, SANQ and WAQ will restore itself back to equilibrium with a speed of adjustment of approximately 147percent, 84.5percent and 63.9percent. That is if there is disequilibrium in air quality, sanitation quality and water quality, there will be an adjustment speed of 147percent, 84.5percent and 63.9percent.

The coefficients of both current and past period values of RUB, UPOP, RPOP, and WOKP all had inverse and significant impact on AIQ, SANQ and WAQ. This implies that increase rate of urbanization (RUB), urban population (UPOP), rural population (RPOP), and working population (WOKP) will bring about decrease in air quality (AIQ), sanitation quality (SANQ) and water quality (WAQ) respectively. On the other hand, both current and past period values of industrial growth (ING) and net export (NEXP) had direct relationship with AIQ, SANQ and WAQ. This implies that increase in industrial growth and trade promotes air quality (AIQ), sanitation quality (SANQ) and water quality (WAQ).

4. CONCLUSION

Environmental quality depletion is fast becoming a topical issue of discuss among stakeholders - government, policy makers, researchers, international agencies and several others. Based on the results in this work, it is concluded that population growth has adverse effect on environmental quality in Nigeria. This clearly indicates that increase in the rate of urbanization, working age population, urban and rural population can bring about depletion in air, sanitation and water quality in Nigeria. This is because as the population in cities, villages and communities increases, congestions, pollution, forest reserve depletion becomes inevitable and when a check is not put to control it; more and more pressure is imposed on the environment; bringing about a loss in air, water and sanitation quality.

5. RECOMMENDATIONS

The following recommendations were made based on the empirical analysis:

1. The Ministry of Environment (MoE) should endeavour to increase the awareness of citizens on population check and the dangers of various human activities that could be injurious or harmful to air, water and environmental resources. This can be achieved by increasing public campaign in local languages to make communication effective to both the educated and uneducated.
2. The government should admonish industries and citizens living in slums and urban areas on the need to use environmental friendly materials such as compact fluorescent light, improved kerosene stoves, improved electrical appliances and wood-stoves for productive activities in their manufacturing plant and homes respectively. This will help to check the emission of greenhouse gases (GHGs) such as CO_2, so as to improve air quality.
3. Policy of periodic sanitation should be put in place, while industrial liquid waste capable of degrading water quality should be properly monitored and approximately disposed.

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