**Introduction**

Accurate population census of any country is very important because it enables the government and her institutions to plan effectively for her citizens with regards to their well-being. Virtually, all planning by the government begins with population structure and forecasts. It is imperative that any responsible government should have current and reliable population forecast for better economic planning. Over the years, there have been concerns about the appreciation of governments on the need for reliable and accurate population census on budgeting and planning for the welfare of her citizens.

Adele (2006) explained the controversy surrounding the recently concluded population census in Nigeria arguing that the 2006 population census was no way different from the past falsified ones held in Nigeria. Onwuka (2006) in his study used regression techniques to test the association from 1980 to 2003 to ascertain the validity of the assumed inverse association between population’s growth and the development in Nigeria which has also been emphasized by Anthony et al (2011). He used the observed result to assess the impact of demographic change on government’s social obligation to its people and observed that the population size is relevant to the development aspiration of Nigeria.

The issues variously thrown up were on accuracy and reliability of our population census exercises over the years. These issues led to the outright cancellations of some past exercises (1962 and 1973) and in some cases due dates were postponed (1983 and 2001), Nduka (2007). In other to draw our attention to some of these issues, particularly as another census year, 2016 approaches, it is imperative to draw a comparison between the World Bank figures with that of Nigeria and Ghana respectively. This will help to appreciate any possible inadequacies of the past and to address such in the proposed exercise of 2016.

These recurring issues motivated this study on Nigeria population census using four different growth models (Arithmetic, Geometric, Logistic and Exponential) in comparison with Ghana’s population census while the World Bank data serves as a standard.

The use of mathematical models to analyze population census was emphasized by Islam (2009), where he stated that Mathematical model is very important for the estimation of population projections. He stated further that, mathematical model is essentially an endeavour to find out structural relationships and their dynamic behaviour among various elements in demography.

In a related development, Pearl and Reed (1920) and Meyer et al (1999) demonstrated that simple mathematical models account for growth-increase or decline-in human population.

Many authors have proposed several models for forecasting population census.

In Logistic growth model, Pearl and Reed (1920), showed how changes in mortality , fertility and agricultural productivity actually have distinct effects on the population growth rate and equilibrium.

Meyer (2004), applied Logistic models in combination with the Fisher-Pry transform technique (1971) to provide clear and suggestive outputs for supporting medium and long-term forecasting of technology changes.

Ofori et al (2013) , used Exponential and Logistic growth model to model the population growth of Ghana using data from 1960 to 2011. The Exponential model predicted a growth rate of 3.15% per annum and also predicted the population to be114.8207million in 2050 while the Logistic model predicted a growth rate of 5.23% per annum and the population of Ghana to be 341.2443million in 2050.

Similarly, Eguasa et al (2013), applied Logistic model and Exponential growth model to make projections for three States in Nigeria. A transformation was done on the models to linearize them. It was observed that the estimates got from the models were close to the figures got from the National Population Commission (NPC) of Nigeria data set.

Kucharavy and Rowland (2007) stated the usefulness of Exponential model for population growth and also asserted that it would be appropriate for modeling the effect of natural disasters or the lack of resources in a country.

Turchin (2003) supported the usefulness of the Exponential Growth agreeing that the model describes the initial phase of growth when population is far from its limits. They argued that the accuracy of the exponential model drops at a later stage due to saturation of other nonlinear effect such as high population density.

The aim of the present study is to examine the population growth of Nigeria and Ghana population census using Logistic growth, Exponential growth, Arithmetic growth and Geometric growth models. These will be compared for closeness with the World Bank population figures. To the best of our knowledge, there has not been any reported study of this nature in the literature.

**Methods**

We employ four population growth models namely Arithmetic, Geometric, Logistic and Exponential. The data were obtained from World Bank Development Indicator (Nigeria and Ghana) and the Nigeria census data (National Bureau of Statistics, (2015)) and Ghana census data(Ghana Statistical Service,(2015)). The growth rates were obtained using the different models and subsequently used to compute and forecast the population values for the year 2020.

The four growth models are as follows:

**1. Arithmetic**

; (1)

**2. Geometric**

; (2)

**3. Logistic**

(3)

(3a)

(3b)

(3c)

**4. Exponential**

; r = (4)

From eq. (1) to eq. (4),

population at saturation level.

= population at some time t.

= the initial population

r = population growth rate

t = period of the projection

n = time interval between succeeding censuses.

= number of years after base year.

**Table 1 :** World Bank Indicator on Nigeria and Ghana with Data on Nigeria and Ghana census population ( **Population in millions** )

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | | |
|  | **World Bank Figures** | | | **Country’s Population Census** | | | | |
|  | 1990 | 2000 | 2010 | 1984 | 1991 | 2000 | 2006 | 2010 |
| **Nigeria** | 97.34 | 123.69 | 158.42 | NA | 88.99 | NA | 140.31 | NA |
| **Ghana** | 14.97 | 19.17 | 24.39 | 12.30 | NA | 18.91 | NA | 24.66 |
| **NA** : Not Applicable (but estimable)  **Source:** National Bureau of Statistics, Nigeria and Ghana Statistical Service (2015). | | | | | | | | |

**Results and Discussion**

To estimate the forecast population of Nigeria and Ghana, firstly, we estimate the growth rates of Nigeria and Ghana using the Growth models given in equations (1 to 4),see Table 2. Using the four different growth models, we forecast the population of Nigeria and Ghana in 2020 using the World Bank Data and the census data from the two countries. The results of the forecast using the four different models are summarized in Table 4 below. The differences between World Bank versus Nigeria/Ghana in the Year 2020 using the four Population Growth Models are shown on Table 5. A plot of the results using the four different models is also given in figures 1 to 3 for a clearer picture of the estimated figures.

**Table 2** : Estimation of growth rates (r) using the four Population Growth Models.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year (2000/2010) | | | | |
| **Population Growth Model** | | Nigeria  Census | Ghana  Census | | W/Bank  Nigeria | W/Bank  Ghana |
| 1 | Arithmetic | 0.03/0.03 | | 0.03/0.08 | 3.05 | 0.47 |
| 2 | Geometric | 0.03/0.02 | | 0.03/0.02 | 0.02 | 0.02 |
| 3 | Logistic | NA | | NA | -0.05 | -0.02 |
| 4 | Exponential | 0.03/0.02 | | 0.03/0.08 | 0.03 | 0.03 |

**Table 3** : Estimated Nigeria’s Population Census figures (2000 and 2010) using the four Population Growth Models.

|  |  |
| --- | --- |
| YEAR | |
| Population Growth Model | | 2000 | 2010 |
| 1 | Arithmetic | 89.26 | 140.49 |
| 2 | Geometric | 116.11 | 138.64 |
| 3 | Logistic | NA | NA |
| 4 | Exponential | 116.57 | 139.56 |

Table 4 : Forecast on World Bank Data versus Country’s census figures for

the Year 2020.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Population Growth Model | | W/Bank/Nigeria census | | W/Bank/Ghana census |
| 1 | Arithmetic | | 161.47/141.29 | 24.36/24.96 |
| 2 | Geometric | | 212.90/169.00 | 29.73/33.14 |
| 3 | Logistic | | 200.70/158.78 | 29.89/29.42 |
| 4 | Exponential | | 213.84/170.46 | 32.92/33.29 |

Table 5: Differences between World Bank Data Versus Nigeria/Ghana Population censuses in the Year2020.

|  |  |  |
| --- | --- | --- |
| % Difference in the Year 2020 | | |
| Population Growth Model | | World Bank/ Nigeria | | World Bank/ Ghana |
| 1 | Arithmetic | | 12.62% | -2.46% |
| 2 | Geometric | | 20.62% | -11.47% |
| 3 | Logistic | | 20.87% | 1.41% |
| 4 | Exponential | | 20.29% | -0.67% |

**Figure 1**: A chart showing a forecast of Nigeria population census in 2020 with World Bank forecast in 2020.

**Figure 2:** A chart showing a forecast of Ghana population census in 2020 with World Bank forecast in 2020

**Conclusion**

Setting a tolerance limit of , and Preferably using Geometric, Logistic and Exponential Growth models, the Average Difference for Nigeria is 20.59%,and Ghana is -3.58%. This implies that Nigeria population is undercounted to an average of 20.59%, while that of Ghana is over counted to the average of

-3.58%. Compared to Nigeria, Ghana’s population census is more World Bank compliant than Nigeria’s since it is within the tolerance limit set. If World Bank data is anything to go by, Nigeria needs to address any distortions in the process of her population census exercise.

References

Anthony, T. Eniayejuni, 1.,Agoyi, M., (2011). A Biometrics Approach to Population Census and National Identification in Nigeria: A Prerequisite for Planning and Development, AsianTransactions on Basic & Applied Sciences, Vol.1 (5).

Adele, B.J.( 2009). Falsification of Population Census data in a heterogeneous Nigeria

state: The fourth Republic example. Political science and International Relations,

3,(8) pp. 311-319.

Eguasa O., Obahiagbon K. O. and Odion A. E.(2013). On The Performance of the Logistic Growth Population Projection Models, Mathematical Theory and Modeling Vol.3 (14).

Fisher, J.C, and Pry, R. (1971). A Simple Substitution Model for Technological Change,

Technology Forecasting and Social Change. Vol. 3 pp. 75-78.

Islam, R. (2009). Mathematical Modeling of Age Specific Marital Fertility Rates of Bangladesh; Maxwell Scientific Org. Rajshahi: Bangladesh.

Kucharavy, D. and Roland De Guio (2007). Application of S-Shaped Curves, 7th Etria Triz Future Conference, Kassel University Press GmbH, Kassel, Frankfurt, Germany.

Meyer, P., Yung, J., and Ausubel, J., (1999). “A Primer on Logistic Growth and Substitution. The Mathematics of the Loglet La b Software”, Technological Forecasting and Social Change. Vol. 61(3), pp. 247-271.

Nduka, E. C.(2007). Statistics has it that…., Inaugural Lecture Series, No.57,University of Port Harcourt, Pp.38-39.

Ofori, T.,Ephraim,L., and Nyarko , F., (2013). Mathematical Model of Ghana’s Population Growth International Journal of Modern Management Sciences, Florida, USA.Vol.2 (2) pp. 57- 66

Onwuka, E.C ., (2006). “Another Look at the Impact of Nigeria’s Growing Population on the Country’s Development.” African Population Studies, Vol.21 (1), pp. 1-18.

Pearl, R. and Reed, L. J.(1920). A further Note on the Mathematical Theory of Population Growth. National Academy of Science. Vol.8 (12), pp. 355-368.

Turchin, P. (2003). Historical Dynamics: Why States Rise and Fall. Princeton, NJ: Princeton University Press.