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PYTHON-BASED POPULATION FORECASTING FOR DELTA STATE: TRAPEZOIDAL AND INTEGRATION METHOD

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ABSTRACT
The paper focuses on the development of Population Forecasting of Using Population Exponential Model Python with case Study of Delta State Population Census 2006. The focus is to generate manual estimation using the Population Exponential Model; to compare the result estimation with python library. Also, to formulate of an algorithm for area of population of Delta State; visualize the result of prediction of Population with graph and bar chart to see the trend of prediction population trend of Delta State. Population Area under curve of Integration Method and Trapezoidal Method for Delta State for 20 years is obtained. The performance accuracy of 99.9 percent of the population model of Exponential Model of Python with Trapezoidal and Integration Method. Moreover, the calculated sensitivity of the adopted models are in alignment.

Keywords: Forecasting of Population, Trapezoidal method of Numerical Analysis of Python, Integration Method, Population Exponential Model and Algorithm

INTRODUCTION
Forecasting defined as to prediction of a given population as result of child birth, death rate of animal and human in a given community, state and country as a whole. The area of Population forecasting under the curve is done to know the real total number of population of female and male in order to distribute social amenities and infrastructure accordance with the resources available at period of time.
Population estimation under a curve is a great concern and must be surmounted by opting for established model. There exist three methods for predicting demographic processes: extrapolation, expectation (birth expectations at the individual or expert opinions at the population level. The theory-based on structural modeling using exogenous factors. Three parameters in the models are: age, period, and cohort. Multistate models, such as macro-simulation and micro-simulation, also employ decomposition and disaggregation. It is challenging to predict changes in the demographics; accuracy of area under curve using of Integration Method, Trapezoidal Method and Simpson rule. The area under curve has many diverse application especially to calculate the population of human and animals. The velocity of time graph, Work done in a spring in Physics while in engineering field for length of coastline and the volume of water in reservoir. It can also be used to estimate the strength of a material and efficiency of a machine. This is unlisted in Population estimation of area of Delta State. The germane features of a good population as stipulated in 2006 census as reported by National Population Commission are listed as follows: it must be carried by the government or its agents and not private individuals or organizations; It must divulge population of a specific territory at particular point in time; it must be a periodic or regular count that should be taking place at regular interval of say 5, 10, 20 years etc. This become necessary to determine the population growth of the female and male and in order to know where there is inadequate social amenities and to provide basic necessities. This is also to determine the density of the thickly and sparsely populated. Several researches abounds where data were collected, analyzed and modelled to obtain valuable and valid predictions (Solomon M.K. et al., 2024; Awariefe C. & Ogumeyo S.A., 2023).
In Hare et al. (2010) state that the mechanistic hypothesis underlying their model is that juvenile mortality in their estuarine habitats throughout the winter is driven by temperature. This results in recruitment. Fourteen general circulation models that simulated three CO_2 emission scenarios were used to forecast temperatures. To predict the population's response, an ensemble-based method was employed, wherein a multimodel average was computed for a specific CO_2 Manual Trapezoidal Method 22 emission scenario. The linked model shows that the number and distribution of Atlantic croakers are severely impacted by both climate change and exploitation. The average spawning biomass of the population is predicted to increase by 60–100% between 2010 and 2100 at present fishing levels. In a similar vein, it is predicted that the population center will move 50–100 kilometers northward. According to a yield study, which sets benchmarks for fishery management, there will be a 30-to 100% rise in the maximum sustainable production. The authors' findings showed that in order to achieve sustainable exploitation in a changing climate, managers need to be aware of, comprehend, and take into account the consequences of climate change on fisheries.
Using population models and connected AOPs parameterized using long-term white sucker (Catostomus commersoni) monitoring data gathered from a study site at Jackfish Bay, Lake Superior, Canada, the authors illustrated their approach. The ability of the framework to predict changes in population status, both in terms of ongoing impact and subsequent recovery after stressor mitigation associated with process changes at the mill, was demonstrated by the individual responses of fish exposed to pulp mill effluent (Miller et al., 2015). The authors compiled 2379 time series of vertebrate population indices from real surveys in order to examine the

effectiveness of time-series forecasting models for wild animal population data. Their data were of three very distinct types: small variance but long memory (bird and animal counts), strongly cyclic (adult salmon counts), and extremely variable (marine fish production). Autoregressive time-series models, non-linear regression-type models, and non-parametric time-series models are the three main kinds of forecasting models that the researchers assessed for predictive performance. Over a broad variety of taxa, low-dimensional parametric autoregressive models produced the most accurate forecasts; the most accurate model was one that merely used the most recent observation as the forecast (Ward et al, 2014). In Stefano Parodi etal(2022) termed as the clinical meaning of the area under a receiving operating characteristic curve for the evaluation performance of disease markers. This is to estimate number ofv disease diagnose and the performance accuracy subjected to number of sample collected from patients.

Zylstra & Zipkin. (2021) said forecasts of how populations will react to climate change are becoming more and more important to conservation plans for threatened species. In order for these projections to be correct, they need to take into consideration a variety of sources of uncertainty, such as those related to future climatic scenario projections and those related to population dynamics models. The majority of population predictions ignore the significance of assessing uncertainty in the population model's structural design, even if many of them take parameter uncertainty in abiotic effects and process variance related to unexplained temporal variation into account. Jaatinen et al. (2021) showed that density-dependent mechanisms are anticipated to worsen negative effects of climate change and diminish population viability of this keystone species by accounting for structural uncertainty in a model of blue mussel population expansion. The aforementioned results underscore the significance of integrating structural unknowns into population projections and the worth of methodologies that consider various origins of climate and model uncertainties.

To actualize the population in China, this research develops a BP neural network model that exhibits good prediction accuracy and can be applied to population forecasting in the future. MATLAB software is used to train and simulate the model, which is based on demographic data from China from 1961 to 2021. The population of China in 2022 is predicted by the trained model, which serves as a useful guide for relevant departments' decision-making (Xianfang et al, 2022). It was discovered that the Time Independent Fourier Amplitude Model Approach was a good model for population prediction when it came to projecting the US population from 1790 to 2020 and beyond. The outcomes from various models, including the Malthusian, Logistics, and Logistics (Least Squares) Models, were compared with the findings from the Time Independent Fourier Amplitude Model Approach. The sum of square error (SSE) and the coefficient of determination (R) were used to assess the models' quality of fit.

However, Atajeromavwo et al (2021) in Population forecasting of Nigeria Population census use natural growth model and geometric model method was estimated using visual basic programming approach which lead to delay of time of obtaining desirable result. Due to these fact, this research paper uses Python programming language that is robust and resilient that give fast result in computation will be utilized for the estimation area under the curve of the Population of Delta State based on Trapezoidal method of numerical Integration and Integration method with the development of algorithm for the area under the curve.

MATERIALS AND METHODS

The main objective of this research is the development of Population Forecasting of Delta State using Trapezoidal method of numerical analysis of Python and Integration method of area under curve of Population exponential model. The specific objectives are: to formulate an algorithm for area of population under a curve to generate manual estimation using the Trapezoidal method of numerical Integration and Integration method; to compare the result of Integration estimation with Trapezoidal Python library; to visualize the predicted population trends using graphs and bar charts; to evaluate the population area under curve of performance accuracy of result obtained**.**

Data Collection.

The data for the models of the population were collected from National Population Commission of Nigeria, Abuja based on 2006 census data of various States. The initial Delta State Population Census of 2006 is 4112445.

$$P = \int_0^{20} P_o e^{rt} \quad (1)$$

r is the rate of population Delta State of birth and death rate of 3.8 percent, that is 0.038

Where P_0 is initial Population of Delta State Population Census of 2006 and equation (1) becomes equation (2).

$$P = \int_0^{20} 4112{,}445 e^{0.038t}\, dt \quad (2)$$

The Flow Chart of Trapezoidal Rule

Flow chart refers to pictorial diagram of description or expression of mathematical formula in step by step in order to accomplish desirable results. A flowchart is a visual representation of a process or algorithm, showing the steps and decisions involved in a specific order. It is a diagram that uses boxes, arrows, and other symbols to illustrate the flow of a process, making it easier to understand and follow.

A flowchart typically includes:

i. Boxes or nodes: Representing actions, decisions, or inputs.
ii. Arrows: Showing the direction of the process flow.
iii. Decision diamonds: Representing decisions or conditional statements.
iv. Connectors: Linking boxes and arrows to show the process flow.

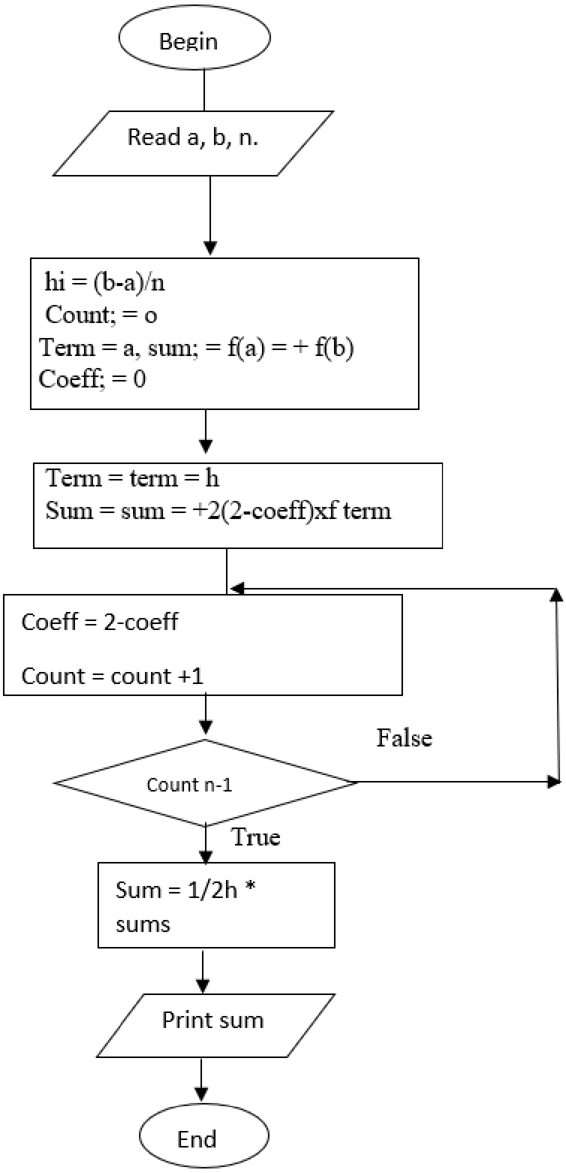

Figure 1 Flow Chart of Trapezoidal's Rule

By using flowcharts, you can:

i. Visualize complex processes.
ii. Identify bottlenecks and inefficiencies
iii. Improve communication and understanding
iv. Simplify decision-making
v. Enhance problem-solving

In short, flowcharts are a powerful tool for mapping out processes and making them easier to understand and follow.

Where: a represent the lower limit, b is the upper limit and n is the number of intervals or ordinates.
Thus, the Trapezoidal rule can be stated that the first and last term should be added and 2 to multiply as their ones. Mathematically, it is written as $\int_a^b f(x)\,dx$ => h/2 [(f(x) +2[f(x_1) + (x_1)+ f(x_2) +f [(x_2) + f(x3) + -------- +f(x_n)] = h/2[(f(x_0) + 2 f(x_1) +2 f(x_2) + --- + 2 f(x_{n-1}) +f(x_n)]

Table 1 Population of Delta State Population Census of 2006 to 2026, that is, for 20 years

t	$P = \int_0^{20} 4112{,}445e^{0.038t}$	Y_i
O	4112, 445	Y_o
2	4, 437,174, 24	Y_1
4	4, 787, 544.94	Y_2
6	5, 165, 581.82	Y_3
8	5, 573, 469.95	Y_4
10	6, 013, 564.95	Y_5
12	6, 488, 411.52	Y_6
14	7, 000, 753.19	Y_7

16	7, 553,550.69	Y_8
18	8, 149, 998.49	Y_9
20	8, 793, 543.35	Y_{10}

Trapezoidal rule: Area $\approx \frac{h}{2}\left[(Y_0 + Y) + 2\sum_{i=1}^{n-1} Y_i\right]$ (3)

Trapezoidal rule Area = $\frac{h}{2}$ [(Sum of the first and last ordinate) + 2 (other ordinates)] (4)

h = (upper limit- lower limit)/number of ordinates or intervals
h = (20-0)/10
h = 2

Trapezoidal rule Area = $\frac{h}{2}$ $(Y_0 + Y_{10}) + 2((Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6 + Y_7 + Y_8 + Y_9\})]$ (5)

Substitute for h and Y_i values in equation (5) as reflected in Table 1
Trapezoidal rule Area = **123246086.58**
The Total Population of Delta State for 20 years is **123246086.58**

Integration Method of Area under Curve of Delta State Population For 20 Years

$P = \int_0^{20} 4112{,}445e^{0.038t}$ dt (2)

The data set obtained were fitted into the adopted models of Integration Method of Area of Delta State Population for 20 Years, in equation (2) to yield area of population of Delta State of Trapezoidal Area Method. The upper limit is 20 and the lower limit is 0.
The area under of curve of Population of Delta State originate from range of zero to 20 years.
= $(4112445e^{0.038X20} - 4112445e^{0.038\ X\ 0})$/0.0038
= **123186798.73**
The Area of Population of Delta State under the Curve is
$Population\ of\ Delta\ State$= The Area of Population of Delta State under the Curve.
Population of Delta State=**123186798.73**

Trapezoidal Method Algorithm of Population of Delta State for 20 Years

1. Start
2. Define function f(x)
3. Read Lower Limit of integration, upper Limit of integration of Population of Delta State and number of Sub interval Population of Delta State
4. Calculate step size=(upper Limit Population of Delta State - lower Limit Population of Delta State } divided by number of sub interval
5. Set: Integration value=f(lower limit Population of Delta State)+f(upper limit Population of Delta State)
6. Set: i=1
7. If i>number of sub interval then goto
8. Calculate: K=lower limit +i*h
9. Calculate: Integration value=Integration Value Population of Delta State +2*f(k)
10. Increment I by 1, that is, i=i+1 and goto step 7
11. Calculate: Integration value=Integration value Population of Delta State *step size/2
12. Display integration value Population of Delta State as required answer
13. Stop

Python implementation of Trapezoidal Method of The Total Population of Delta State for 20 Years.

This is based on the implementation of the Trapezoidal Method Algorithm for the Total Population of Delta State for 20 Years.

```
import math
def trapezoidal_rule_formula(y):
   h = 2
   n = len(y) - 1 #Number of interval
   #sum of the first and last and multiply by the area
   integral = (h/2) * (y[0] + y[-1])
   #sum all y_values except the first and last
   sum_y_values = sum(y[1:-1])
   #Multiply the sum by 2 and addb to integral
   integral += 2 * sum_y_values
      return integral
#list containing y values
y_values=
[4112445,4437174.24,4787544.94,5165581.82,5573469.95,6013564.95,6488411.52,7000753.19,7553550.69,8149998.49,87
93543.35]
result = trapezoidal rule formula (y_values)
print(round(result,2))
123246087.93
```

RESULTS AND DISCUSSION

Results obtained from the various adopted models are depicted in Tables 1, 2 and 3, and, the nature of interaction between population growths with respect to year is presented in plots of Figures 2 and 3.

Table 2: Population of Delta State Estimated (Forecasted) with Relative Years

t=Years	$P = \int_0^{20} 4112{,}445e^{0.038t}$
2006	4112, 445
2008	4, 437,174, 24
2010	4, 787, 544.94
2012	5, 165, 581.82
2014	5, 573, 469.95
2016	6, 013, 564.95
2018	6, 488, 411.52
2020	7, 000, 753.19
2022	7, 553,550.69
2024	8, 149, 998.49
2026	8, 793, 543.35

Table 3: The Summary of Solution of Integration Method, Python of Trapezoidal and Manual Trapezoidal Method of Area of Delta State Population

Integration Method of Area of Delta State Population For 20 Years	Python of Trapezoidal Area Method of Delta State Population For 20 Years	Manual Trapezoidal Method of Area of Delta State Population For 20 Years
123186798.73	123246087.93	123246086.58

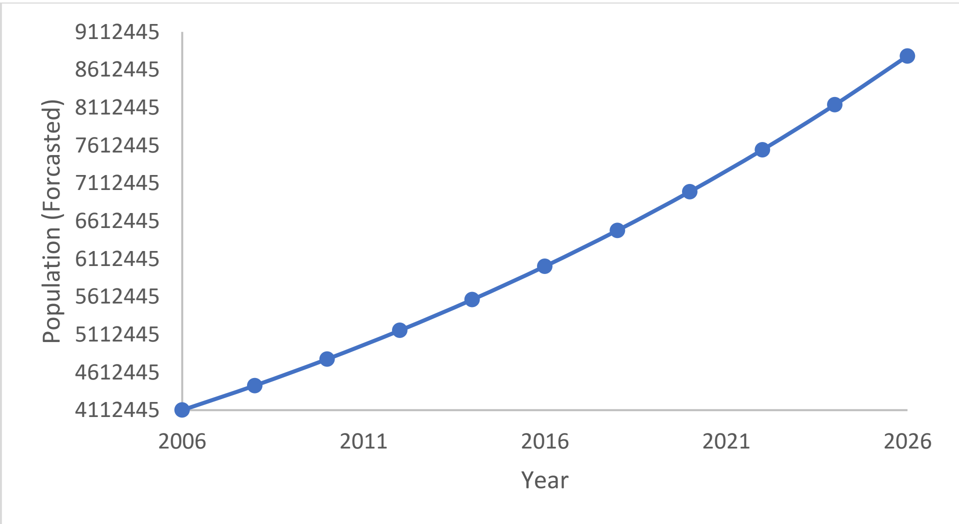

Figure 2 The Graph of Population of Delta State Estimated (Forecasted) with Relative Years Under the Curve

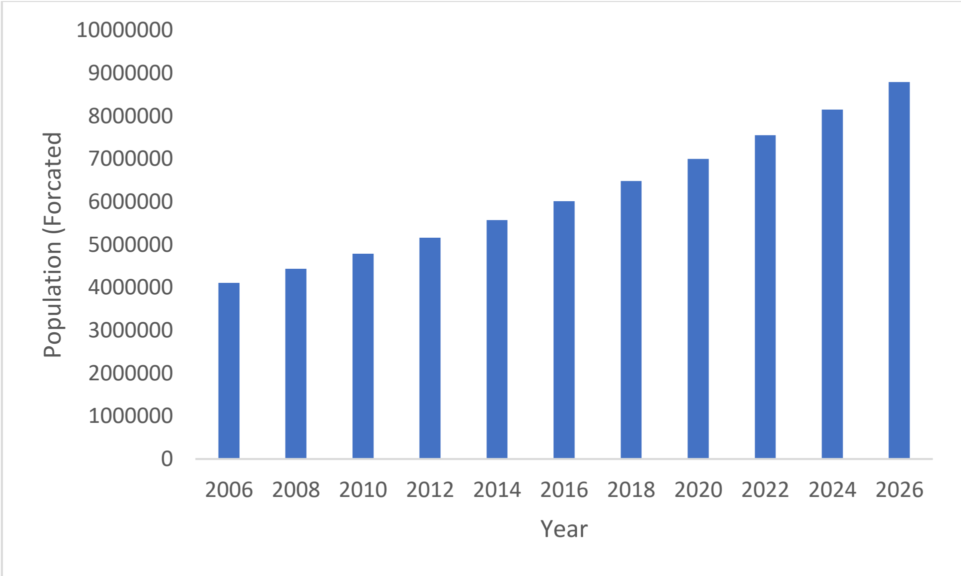

Figure 3: Bar Chart showing Population of Delta State Estimated (Forecasted) with Relative Years under the Curve.

The plots of Figure 2 and 3 above represent the pollution estimated with relative year covering a period of 20 years, that is, 2006 to 2026 with interval of two years. It can be visualized from the plots above that an exponential trend was attained. This connotes that over time, there is an upsurge in population with respect to the years under the curve.

From the Table 3 results, the Population of Integration Method, Python of Trapezoidal Area Method of Delta State and Manual Trapezoidal Method of Area of Delta State are in tandem. The result of Population of Delta State forecasted is shown from year 2006 to 2026 as in illustrated in Table 2 is in exponential progression.

Percentage error $=\frac{\text{integration value} - \text{Python of Tapezoidal}}{integratiion\ value}\ X\ 100$ (6)

$= \frac{/123186798.73-123246087.93/}{12318698.73}\ X\ 100$

=0.00000481 Percent

Percentage Performance Accuracy =100-0.0000481 percent (7)

=99.9 99percent

The percentage error is negligible, that is Performance Accuracy of the Python is almost 100 percent.

Sensitivity Calculation

To calculate the sensitivity analysis using the values previously calculated, we can use the following formula:

$Sensitivity = \left(\frac{\partial A}{\partial r}\right)\ A$ (8)

Where:

A = Area under the curve,

$\left(\frac{\partial A}{\partial r}\right) = partial\ derivative\ of\ the\ area\ with\ respect\ to\ growth\ rate\ (r)$

But $\left(\frac{\partial A}{\partial r}\right) = 114255t\ x\ \exp(rt)/\text{A}$ (9)

Mid-point of the time range, t = 10 (That is,$\frac{20}{2}$)

Therefore,

$Sensitivity\ for\ Python\ of\ Traprzoidal\ = (114255\ x\ 10\ x\ \exp\ (0.038\ x\ 10))/123246087.93$

= 0.5%

$Sensitivity\ for\ Integration\ of\ Traprzoidal\ = (114255\ x\ 10\ x\ \exp\ (0.038\ x\ 10))/123246086.58$

= 0.5%

Table 4: Summary of Sensitivity Analysis

Manual integration Sensitivity (%)	Python Trapezoidal Sensitivity (%)	Ratio
0.5	0.5	1

This connotes that a 1% change in the growth rate would result in approximately a 0.5% change in the area under the curve.
It is pertinent to note that the obtained value of sensitivity is an approximate value as the sensitivity analysis assumes a small change in the growth rate.

CONCLUSION

The paper has contributed to the body of knowledge in the sense that in field of Numerical Analysis and computing this act as basis for comparing the result of Manual estimation of Exponential Growth with python library. Also, the development of algorithm for area of population of Delta State; visualize the result of prediction of Population with graph and bar chart in figure 1 and 2 to see the trend of prediction population of Delta State; Population Area under curve of Integration Method and Trapezoidal Method for Delta State for 20 years is obtained. The performance accuracy of 99.9 percent of the population model of Exponential Model of Python with Trapezoidal and Integration Method, that mean that the Trapezoidal Method suitable for the estimation of area under the curve.
Further research should be geared towards comparing area of under the curve of Population of Delta State using Trapezoidal Method and Simpson's rule Method of integration.

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