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Population Growth, Available Resources and Quality of Life: A Goal Programming Model Approach

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Abstract: The study examined population growth, available resources, and quality of life using an optimization tool of goal programming. The decision variable of the goal programming analysis was generated from the 4-year average of key variables of interest, namely population growth, available resource proxied by energy consumption, and quality of life proxied by the human development index, ranging from 2000 to 2023. The optimization technique of simplex goal programming analysis was adopted for the analysis. Based on the decision variables obtained from the averages of the relevant variables, the goal programming solutions could not satisfy any of the aspirational targets; hence, the non-optimization of the objective function after substituting the respective deviations into the objective function. The study, therefore, highlights the endemic flashpoint of the Nigerian economy wherein potentials and resource endowment are not sufficiently harnessed, hence the poor quality of life. The study therefore recommends urgent government intervention in the form of a broad-based master plan on how to harness our resource endowment, both human and material, for the sole aim of promoting increased and sustainable improvement in the quality of life.

Keywords: *Goal programming, Human Development Index, Resource Endowment, Decision Variable, Optimization.*

1. Introduction and Background

Sustainable improvement in the quality of life has become the ultimate preoccupation of governments in both developed and developing economies of the world. This agenda is brought about through deliberate government monetary cum fiscal policies program primarily orchestrated with the ultimate improvement of the welfare of the citizen in mind (Malhotra, 2023). These programs cannot be realized in the absence of human and material resources that are naturally or artificially domiciled within the geographical space of a given economy. Quality of life could be seen as a highly subjective measure of happiness, but strongly associated with financial factors beyond the necessities of food and shelter. According to the 2024 world population review analysis, countries with the best quality of life include Norway, Denmark, Finland, Switzerland, and the Netherlands etc. These countries were carefully selected based on safety, health care, economic factors, and education. These metrics and indices bring to bear clearly what characterizes quality of life, which in most cases is determined by the natural endowment/available resources of a given economy.

Available resource, as a matter of fact, forms the lynching pad and economic catalyst upon which a given economy depends to address its numerous challenges and equally solve its problems through its policies and programs. While some economies are richly endowed with mineral resources/deposits, others have to create strategic means of sustaining their people and achieving their macroeconomic goals. Several theories have tried to explain resource endowment and its relation with the welfare of its people, namely the Demographic transition theory, Malthusian population theory, Dutch disease hypothesis, the rentier state theory, etc. These theories bring to the fore the possible distortions, mostly artificially created, that largely hamper the ability of a given economy to explore maximally its productive potentials. Several studies have been conducted aimed at seeing how the quality of life of citizens has fared, given the resource endowment that a given economy is endowed with. Interestingly, studies by Mohammed (2021) on quality of life and its association with natural endowment found an inverse relationship between population growth and development, even as both variables significantly impact but differently on quality of life. In sharp contrast with the finding of Mohammed (2021) is the study by Jordan (2009) who found that quality of life together with low productivity boost metropolitan population growth even as the studies failed to mention whether the increase in population is associated with migration or entirely a function of government proactiveness in creating a sustainable city plan and amenities that are peoples' friendly. The divergence of opinion based on studies and also on theoretical review tends to compound the argument of the direction effect and possible way of guaranteeing improved quality of life, thus prompting a mathematical evaluation of the optimization of the quality of life, given the population growth and the natural endowment that a given economy is endowed with.

2. Literature Review

Several studies have been reviewed, with each adopting a different approach and consequently concluding differently based on the technique employed in its analysis. Yufeng Chen, Adnan Khurshid, Abdur Rauf, Hanyao Yang, and Adrian Cantemir Calin (2023) in their studies found that good governance, in the light of human and material endowment, guarantees sustained improvement in the standard of living and quality of life. This presupposes that the endowment of resources does not automatically translate to improvement in the quality of life of citizens. The study suggested a suitable policy for the better utilization of resource rents, which, together with good governance, will engender inclusive growth and development.

Timur Madreimov and Leiming Li (2019), in their study on the natural resource dependence and life expectancy using fixed effect and panel corrected standard error regression estimator, found that natural resource dependence hampers human development; an observation that grossly corroborates the two leading resource curse theories. In what appears to be a twist in the direction of the effect of the key contending variables is the discovery from the study "Increasing Importance of Quality of Life" by Rappaport (2009). The study found that quality of life, together with low productivity, boosts metropolitan population growth by several percentage points. The study stressed that a region with amenities for which individuals would initially pay 5% (a small fraction) of their income grows slightly faster than an otherwise identical place. Badiora & Abiola (2017) in their study on the quality of life of rural dwellers in Nigeria found that the majority of the residents were living below the poverty line. The study further revealed that residents were less satisfied with key qualities of life indicators, especially availability of portable water, electricity, quality of recreational facilities, cleanliness of the area, and access to waste disposal facilities, among others. What appears obvious is the fact that the indicators of quality of life in the study do not in any shape or form coincide with the indices of quality of life as put forward by the 2024 World Population Review, which includes safety, health care, economic factors, and education. This brings into question the uncertainty of indices that constitute the presence or absence of quality of life in any locality.

Onah (2022) in his study on the incidence of population explosion in Nigeria and its implication on the quality of life highlighted the challenges of high population growth without visible sustainable provision to includes low per capita income, shortage of food, unemployment, kidnapping, general insecurity, etc. The study pointed out the bleak condition of the welfare of the masses owing to the visible fact that rapid population growth appears not to be consistent with national development, thus evidently hampering the quality of life of city dwellers. The study inferred (in the light of evidence from the UN report that depicts rising population at the expense of declining growth rate) that the culture and religion of the people have rekindled the population increase in Nigeria. This evidence casts doubt on the sustainability of the efficiency of resource use and consequent declining quality of life.

year	Population	Growth rate	Unemployment rate	Human Development Index
1990	94,398,550	2.63%	10.20	0.39
2000	121,351,477	2.54%	13.60	0.41
2010	157,315,944	2.71%	21.10	0.47
2019	199,805,437	2.67%	25.40	0.53

Source: United Nations Department of Economic and Social Affairs: Population Division (2019).

It is also important to state that further empirical discovery shows that other socio-economic indicators like the human development index, which is integrally composed of per capita income, literacy rate, and life expectancy, the unemployment rate, etc. within this period under review did not show sign of robust improvement as they were consistent in reflecting the declining growth rate following the rise in population. Extrapolating the findings and comparative assessment of key socio-economic indicators of countries relatively at par with Nigeria, like India, China, Malaysia, and South Africa, shows some astonishing empirical patterns that point to weaknesses of institutions and a lack of a broad-based master plan that keeps the economy on the growth path despite population upsurge. For instance, these economies have sustained an upward trajectory (within the limit of their respective endowed resources) with respective HDI indices of 0.685, 0.788, 0.81, and

0.717, not withstanding their population surge within the period under review. This empirical position yields to the view of Yufeng Chen, *et al* (2023) that highlights the importance of goods governance even with an abundance of human and material resources.

Mohammed (2021) in his study on the population and development vs Quality of life found that while population and development are inversely related, both impact on the quality of life. Appraising the strength and content of Mohammed's (2021) study, the researchers failed to categorically state the exact measure of development, or rather, the type of development that is being referred to. Secondly, the proxy for the quality of life was not stated. The study, just like the Malthusian theory, recommended control of population (which can also be controlled through an increase in literacy and education) to achieve development, and, in its conclusion, could guarantee improvement in quality of life.

Theoretical literature

Demographic transition theory: The theory of demographic transition (initially introduced by Warren Thompson in 1929 and later expanded by Frank W. Notestein) describes the historical shift in population trends that occurs as societies progress from pre-modern to modern conditions, characterized by societal transformations from high birth and death rates to low birth and death rates. The demographic transition theory is relevant to this study as it provides a framework for understanding the relationship between population dynamics and socio-economic development. The theory, when sufficiently x-rayed, highlights that there is always a socio-economic dimension to increasing population in satellite cities, as pointed out (even though loosely) by Mohammed (2021). Despite its application, the theory has been criticized on several fronts. Firstly, Critics argue that the theory has a Eurocentric bias, as it was originally formulated based on demographic changes observed in European countries. This limits its applicability to European contexts even as its assumptions may not hold universally. Secondly, the theory overly emphasizes the role of economic development in driving demographic changes. Critics contend that socio-cultural factors, government policies, and other non–economic derivatives are equally significant in shaping population dynamics.

Malthusian population theory: The Malthusian population theory, as proposed by Reverend Thomas Robert Malthus in 1798 in his well-known work titled "An Essay on the Principle of Population could also find significant expression in this study. The theory posits that population growth tends to outpace the growth of resource endowment, leading to a condition of overpopulation and consequent impact on economic development. Malthus argued that while population increases geometrically (exponentially), the production of food and resources increases arithmetically (linearly). According to this theory, if left unchecked, population growth will eventually exceed the capacity of the resource endowment, which will eventually have a far-reaching effect on the standard of living. The Malthusian population theory, even though it offers a historical perspective on how population dynamics may influence resource availability and economic development, fails to acknowledge the importance of technological advancement in boosting means of sustenance, a weakness that calls into question the veracity of the Malthusian theory.

The dependency theory: The dependency theory is the theory of underdevelopment proposed by a group of scholars referred to in literature as dependency theorists, namely Frank, Sunkel, Furtado, Santos, Emmanuel, and Amin (Jhingan, 2007). The theory explores the relationship between the number of dependents (children and the elderly) and the working-age population in a given society. It posits that the ratio of dependents to the working-age population has significant implications for economic well-being. The theory suggests that a high dependency ratio can significantly strain economic resources and potential, thus stifling economic development. However, critics have argued that the theory succeeded in oversimplifying the relationship between the dependency ratio and economic productivity, thus neglecting factors such as technological advancements and workforce skill levels, which have the tendency to advance the course of development.

Resource curse theory: Resource curse theory demonstrates how countries underperform economically despite benefitting from valuable natural resources. The theory could be attributed to Richard Auty, who wrote about the concept in his 1993 book titled Sustaining Development in the Mineral Economies: The Resource Curse Thesis. The theory could be seen as a paradoxical situation in which countries with an abundance of non-renewable natural resources experience stagnant economic growth as a result of deliberate neglect of investment in other major sectors of the economy. The relevance of the theory in explaining the present study

cannot be overemphasized. This presupposes that, following the argument put forward by Mohammed (2021) in his study, underperformance or neglect of other major sectors of the economy has the tendency to hamper the quality of life of the citizen.

Neoclassical Growth Theory: The neoclassical growth theory, also known as the exogenous growth model, was postulated independently by Solow (1956). The centre piece of the standard neoclassical growth model is an aggregate production function of the form;
$Y_t = F(K_t, L_t, A_t)$

Where: Y is output, K is capital, L is labor, and A is an index of technology or efficiency. The model posits that F has the usual neo-classical properties, that is, characterized by constant returns to scale, decreasing returns to each input, and a positive and constant elasticity of substitution. Technological change replaced investment (growth of K) as the primary factor explaining long-term growth, and its level was assumed by Solow and other growth theorists to be determined exogenously, that is, independently of all other factors, including inflation.

Neo–classical economists believe that to raise an economy's long-term trend rate of growth requires an increase in the labor supply and an improvement in the productivity of labor and capital. This model assumes that countries use their resources efficiently and that there are diminishing returns to capital as labor increases. Thus, technological knowledge brought about by human capital, such as education, training, and skill acquisition, is capable of raising the productivity of individuals, which leads to improvement in overall productivity and hence economic development. The neo-classical theories find their relevance in explaining a sequence of effects between the key variables (namely population growth, resource availability, and quality of life) as partially enunciated by Mohammed (2021). The theoretical framework of this study lies on the template of the neo-classical theories, even as it remains to be seen the effect the two key variables will have on the quality of life proxied by the human development index.

Goal programming hypothesis

The concept of goal programming was introduced by Charnes and Cooper (1961). The model was informed by the need to solve complex programming problems arising from conflicting resource constraints. Lee (1972), cited in Ekezie and Onuoha (2013), affirmed that the distinguishing feature of goal programming is that it allows for an ordinal solution. Ignizio (1976) holds that the goal programming technique often represents a substantial improvement in modelling and analysis of multi-objective problems. Many researchers, such as Kwak et al (1991), Ignizio (1985, 1989), Hallefjord and Jornsten (1988), Hemaida and Kwak (1994), Bryson (1995), Easton and Rossin (1996), etc., concentrated more on the techniques for solving multiple objective mathematical programming problems. The distinguishing feature of the preemptive goal programming approach as used by Ekezie and Onuoha (2013) is that the goal is arranged in order of priority. This means that the solution of the goal programming problem following the preemptive approach involves achieving the higher goal first before the lower goals are considered. Distinguishing between the weighted GP and the pre-emptive GP technique holds that although both methods convert the multiple goals into a single objective function, they do not generally produce the same solution. Thus, none of the methods is superior to the other because each technique is designed to satisfy certain decision-making preferences. Notable writers share different views and opinions about the novelty of the goal programming approach. Chowdary and Slomp (2003) considered the goal programming technique as an appropriate, powerful, and flexible technique for decision analysis of the troubled modern decision maker who is burdened with achieving multiple conflicting objectives under complex environmental and operational constraints. Tipparate (2005) stated that Goal programming extended itself by re-engineering many of the prior single objective linear programming with multiple and/or trade-off. Wikipedia (2006) described the goal programming technique as a generalization of the Linear Programming approach with a specific interest in handling multiple conflicting objective measures.

Model formation of the General Goal Programming Equation

Charnes and Cooper (1977) presented the general goal programming model, which can be expressed mathematically as:

$$\text{Minimize Z} = \sum_{j=1}^{m} d_i^{+}\, d_i^{-1}$$

Subject to the linear constraint
Goal constraint

$$\sum_{j=1}^{n} a_{ij}x_j - d_i^+ \, d_i^{-1} = b_{i,} \text{ for } i=1,....m$$

System constraint

$$Sum \sum_{j=1}^{n} a_{ij}x_j \begin{bmatrix} \leq \\ = \\ \geq \end{bmatrix} = b_{i,} \text{ for } i=m+1,....m+p$$

With $d_i^+, d_i^{-1}, x_i \geq 0$, for i =1, …, m; for j = 1,…, n.
Where there are m goals, p constraints and n decision variables
Z = objective function or achievement function (summation of all deviations from the goals)
a_{ij} = the coefficient associated with the variable in the jth Goal.
x_j = The jth decision variable
b_j = the associated right-hand side value.
d_i^- = negative deviation variable from the ith goal (underachievement)
d_i^+= positive deviation variable from the ith goal (overachievement)
Both overachievement and underachievement of a goal cannot occur simultaneously. Hence, either one or both of these variables must have a zero value; that is
$d_i^+ . d_i^- = 0$

Category of goal programming technique

a. Lexicographic goal programming (Preemptive goal programming)

The lexicographic goal programming model is a form of goal programming where the goal at the upper priority level is given the utmost attention, more than other goals. Ignizio (1985) re-echoed that preemptive goal programming or the lexicographic goal programming model should be employed. There exists a clear priority ordering among the goals to be achieved. Other presumption of the preemptive goal programming model is that it is assumed that no two goals have equal priority and are absolute. More so, the goals have equal ordinal ranking and are called preemptive priority factors with a relationship stated thus; $P_1 >> P_2 >>> P_i >>> P_{i+1} >>> P_m$. The priority relationship implies that multiplication n However larger it may be cannot make the lower-level goal as the higher goal ($P_n > P_{n+1}$).
The proposed pre-emptive model is given as. $Minimize\ Z = \sum_{i=1}^{n} p_i\{(d_i^+ + d_i^-)\}$
$Subject\ to$

$$\sum_{(i=1)}^{m} (a_{ij}\, x_j + d_i^- - d_i^+) = g_i$$

$(i, k = 1,2, \ldots\ldots, n)$
$(j = 1,2, \ldots, m)$
$d_i^-, d_i^+, x_j \geq 0$
Where d_i^+ and d_i^- are deviational variables;
x_j = decision variables;
a_{ij} = decision variables coefficients;
Where w_i^+ and w_i^- Are non-negative constraints representing relative weights;
p_i = The preemptive factor/priority level assigned to each relative goal in rank order (that is $p_i > p_2 > \ldots > p_n$).

b. Weighted goal programming model

The weight goal programming approach is deployed when the decision maker is more interested in the indirect comparison of the goals. The weighting of deviational variables at the same priority level shows the relative importance of each deviation. Charnes and Cooper (1977) stated that the weighted goal programming model can be specified thus.
In the weights method, the single objective function is the weighted sum of the functions representing the goals of the problem.
The weights goal programming model is of the form:$CapCapMinimize\ Z = \sum_{i=1}^{n}\{(w_i^+ + w_i^-)d_i)\}$
$Subject\ to$

$$\sum_{(i=1)}^{m} (a_{ij}\, x_j + d_i^- - d_i^+) = g_i$$
$(i = 1,2, \ldots\ldots, n)$
$(j = 1,2, \ldots, m)$
$d_i^-\ , d_i^+, x_j \geq 0$

Where w_i^+ and w_i^{-1} These are non-negative constraints representing the relative weight to be assigned to the respective positive and negative deviation variables. The relative weights may be any real number, where the greater the weight, the greater the assigned importance to minimize the respective deviation variable to which the relative weight is attached. This model is a non-preemptive model that seeks to minimize the total weighted deviation from all goals stated in the model. While Ijiri (1955) had introduced the idea of combining preemptive priorities and weighing, Charnes and Cooper (1977) suggested the tool programming model as;
The proposed pre-emptive model is given as

$$..Minimize\ Ƶ = \sum_{i=1}^{n} P \sum_{i=1}^{n} \{w_{ik}^+ d_i^+ +\ w_{ik}^- d_i^-\}$$
$Subject\ to$
$$\sum_{(i=1)}^{m} (a_{ij}\, x_j + d_i^- - d_i^+) = g_i$$
$(i, k = 1,2, \ldots\ldots, n)$
$(j = 1,2, \ldots, m)$
$d_i^-\ , d_i^+, x_j \geq 0$
Where d_i^+ and d_i^- are deviational variables;
x_j = decision variables;
a_{ij} = decision variables coefficients;
Where w_i^+ and w_i^- are non-negative constraints representing relative weights;
$p_i =$ The preemptive factor/priority level assigned to each relative goal in rank order (that is $p_i > p_2 > \ldots > p_n$).

Research Gap
Based on the reviewed study, it appears mixed the results from different studies. While some studies are looking at population growth and development, others were dealing with population growth and quality of life or resource dependence and life expectancy (which is identical close proxy of quality of life). The present study discovered a topic gap by deviating from previous studies and looking at population growth, available resources and quality of life, i.e., integrating the two contending variables into one equation. While population growth proxied by the population growth rate is critical in these studies because of how uncontrolled population rise can create pressure on available infrastructural facility which consequently will affect standard of living and welfare of the populace, the choice of energy consumption as measure of is influenced by paucity of data and also the believe that energy consumption will offer a good measure of the available resources of a given economy. Finally, the Quality of life is proxied by the human development index (developed by Mahbub Haq, a Pakistani Economist, in 1990)- a composite measure of the standard of living, life expectancy and literacy rate, which together and respectively are outcomes for GDP per capita income, health and education investment outcomes.

Technique gap was equally discovered as the present study adopted a mathematical approach of goal programming to ascertain the optimization of quality-of-life given population growth and available resources, which, based on the study by Mohammed (2021), were found to be inversely related with both impacting concurrently on quality of life.

3. Research Methodology

The study adopts an *ex post facto* design. In specific terms, while the general model of the goal programming model will guide the actualization of the objective of the study, the neo-classical growth framework depicted as $Y_t\ =\ F\ (K_t, L_t, A_t)$, Offers a mechanism and theoretical anchor of the study wherein the human development

index, as a measure of quality of life, is affected by population growth and available resources (proxied by energy consumption). The leeway to this choice of methodology was rightly informed by Ekezie & Onuoha (2013).

Model Specification: Goal programming optimization model
The general form of the goal programming model is given as;

$$Minimize\ Z = \sum_{m=1}^{M}\sum_{n-1}^{N} P_m^n \left[\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{T}\left(d_{ijt}^{+} - d_{ijt}^{-}\right)\right]$$

Subject to:
System constraint

$$X_{it} - \sum_{k} a_{ikt}X_{kt} + d_{it}^{+} + d_{it}^{-}: \quad \begin{array}{lcl} i & = & 1,2 \ldots\ldots I \\ k & = & 1,2 \ldots\ldots K \\ t & = & 1,2 \ldots\ldots T \end{array}$$

Goal constraint

$$\sum_{I} a_{ijt}\, X_{it} + d_{jt}^{-} + d_{jt}^{-} = C_{jt} : \begin{array}{lcl} j & = & 1,2 \ldots\ldots J \\ t & = & 1,2 \ldots\ldots T \end{array}$$

$X_{i,j,k,t};\ d_{i,j,t}^{-};\ d_{i,j,t}^{-} \geq 0\ \forall\ \ i, j, k\ and\ t\ non - negativity\ constraint$
Where:
$P_m^n = priority\ level\ m\ attached\ to\ goal\ or\ objective\ n$
$d_{jt}^{+}\left(d_{jt}^{-}\right) = positive\ (negative) deviational\ variable\ denoting\ overachivement$
$(underachievement\ of\ goal\ n\ representing\ system\ or\ non\ goal\ constraint$
$X_{it}(X_{kt}) = endogenous\ (decisions)\ and\ exogenous\ variables\ respectively\ at\ time\ t$
$I\ =\ \ number\ of\ endogenous\ (decision)\ variables$
$K =\ \ number\ of\ exogenous\ variable\ in\ each\ system\ constraints$
$N\ =\ number\ of\ goal\ and\ non\ goal\ (system)\ constraints.$
$M\ =\ number\ of\ priority\ level$
$J\ =\ number\ of\ goals$
$T\ = time\ period$
$B_{it} = right\ hand\ side\ value\ of\ system\ constraint\ i\ at\ time\ t$
$C_{jt} = right\ hand\ value\ of\ goal\ constraints\ j\ representing\ the$
$aspiration\ level\ of\ target\ at\ time\ t$
$a_{ik} = regression\ coefficient\ of\ exogenous\ variable, X_k, in\ the\ system$
$constrant\ representing\ decision\ variable\ X\ at\ time\ t$
$a_{ijt} = technological\ coefficient\ of\ the\ decision\ variable\ , X_I\ corresponding$
$to\ goal\ constraint\ j\ at\ time\ t$

The major policy goals that the goal programming technique seeks to achieve as clearly stated in the objective, clearly incorporated in the objective function/achievement function of the general goal programming framework, which entails minimizing the underachievement of the desired quality of life, minimizing the overachievement recorded in the population growth rate and minimizing the underachievement of available resources. These goals are clearly stated according to priority based on the tenets of the adopted weighted-preemptive goal programming framework.

4. Results

Goal programming formulation for population growth, available resources and quality of life
Using four data points from 2000 to 2024, the decision variable as well as the aspirational target were determined. The functional coefficient of the decision variables will be based on the average of the decision variables. Recall that the aspirational target goal to be achieved would be set based on these data points. The decision variable can be determined as follows.

Table 1: Average of core variable

ITEM(GOAL)	MEAN (2000 - 2005)	MEAN (2006 - 2011)	MEAN (2012 - 2017)	MEAN (2018 - 2023)	TOTAL
ARES	84.0	84.3	84.5	86.1	338.9
POPG	2.67	2.73	2.61	2.43	10.4
HDI	0.44	0.48	0.51	0.54	1.96
Total	87.1	87.2	87.6	89.1	351.3

Table 1 is an outline of the data for Available resources, Population Growth rate and Human development index (proxy for Quality of life) over the period of twenty-three years (2000 - 2023), represented as means for four-year intervals each.

Table 2: Coded data over the period of twenty-three years (2000 -2023)

ITEM(GOAL)	MEAN 1	MEAN 2	MEAN 3	MEAN 4	TOTAL
ARES	8.4	8.43	8.5	8.6	33.9
POPG	0.267	0.273	0.261	0.243	1.04
HDI	0.044	0.048	0.051	0.054	0.197
Total	11.1	11.2	11.16	8.90	35.2

Table 2 gives the coded data of the Available resources, Population Growth rate and Quality of life (proxied by human development index). The reason for the coding is to enable one to work with small figures in the analysis.

Assignment of weights to the goals

The objective function coefficient for the variables associated with the goal is called the weight for the goal. Justification of Weight of these weight could be deduced from early theorist like the Warren Thompson of the demographic transition theory of 1929 (and further expanded by Frank W. Notestein) who highlighted the importance of resources endowment in its analysis of the demographic transition- a premise and discovery that formed the basis for assigning a higher weight of 6 to available resources, then followed by the population growth rate (significantly influenced by the socio-economic activities around available resource which in political economy balance is referred to as the super structure) which weights 4 and finally the consequent outcome of these socio-economic activities of the demographics- quality of life, taking the weight of 2 in the goal programming weight assignment. Therefore, let w_i Be the weights for goals, ranging from 6,4 and 2 in a descending order of importance of these weights.

Table 3: Coded data with weights

ITEM(GOAL)	MEAN 1	MEAN 2	MEAN 3	MEAN 4	TOTAL	w_i
ARES	8.4	8.43	8.5	8.6	33.9	6
POPG	0.267	0.273	0.261	0.243	1.04	4
HDI	0.044	0.048	0.051	0.054	0.197	2

The table above gives the coded data and the assigned weights to the goals.

Aspiration level (Target value) of the Goals

The aspirational target of each of the weighted goals is influenced by the data point averages and the prevailing stance of these variables in Nigeria. For instance, the HDI of Nigeria currently stands at a little above 0.50; a figures that validate the chosen aspirational target used in the study. The same applies to the population growth target of 2 percent and the Energy consumption target of .80 as a measure of available resources. The goal statements are given as follows.

Goal 1: Raise the Energy consumption measure by at least 80 percent

Goal 2: Reduce population growth rate by at most 2 percent

Goal 3: Raise the quality-of-life measure by at least 0.50

The goal formulation

Let X_i = mean of data for Available resources, Population growth and economic development for the years 2000 – 2023

Let x_1 = mean of data for Available resources, Population growth and economic development for the year 2000 – 2005

x_2 = mean of data for Available resources, Population growth and economic development for years 2006 – 2011

x_3 = mean of data for Available resources, Population growth and economic development for the years 2012 – 2017

x_4 = mean of data for Available resources, Population growth and economic development for the year 2018 – 2023

Where x_1, x_2, x_3, x_4 These are decision variables.

The goals can be stated mathematically as follows:

$8.4x_1 + 8.4x_2 + 8.5x_3 + 8.6x_4 >= 8$ (Available resource constraint)

$0.27x_1 + 0.27x_2 + 0.26x_3 + 0.24x_4 =< 0.2$ (Population growth rate constraint)

$0.04x_1 + 0.05x_2 + 0.05x_3 + 0.05x_4 >= 0.5$ (Quality of life constraint)

$X_1, X_2, X_3, X_4 >= 0$.

The goal programming formulation

Let d_i^+ = the amount by which the aspirational target exceeds the ith goal.

Di^- = amount by which the aspirational target is less than the ith goal.

Let ~~Z~~ = be the weighted sum of the objective function.

Using the weighted goal programming model, the goal formulation can be mathematically stated as follows:

Min ~~Z~~ $= 6d_1^+ + 4d_2^- + 2d_3^+$ (objective function)

Subject to:

$8.4x_1 + 8.4x_2 + 8.5x_3 + 8.6x_4 + d_1^- - d_1^+ = 8$

$0.27x_1 + 0.27x_2 + 0.26x_3 + 0.24x_4 + d_2^- - d_2^+ = 0.2$

$0.04x_1 + 0.05x_2 + 0.05x_3 + 0.05x_4 + d_3^- - d_3^+ = 0.5$

$x_1, x_2, x_3, x_4, d_1^+, d_2^+, d_3^+, d_1^-, d_2^-, d_3^- >= 0$

The input data

Table 4:

Basic variables Name of variables	x_1	x_2	x_3	x_4	x_5 d^{1+}	x_6 d^{2+}	x_7 d^{3+}	x_8 d^{1-}	x_9 d^{2-}	x_{10} d^{3-}		RHS
Minimize Z	0	0	0	0	6	0	2	0	4	0		
Constraint 1	8.4	8.4	8.5	8.6	-1	0	0	1	0	0	=	8
Constraint 2	0.27	0.27	0.26	0.24	0	-1	0	0	1	0	=	0.2
Constraint 3	0.04	0.05	0.05	0.05	0	0	-1	0	0	1	=	0.5

In the above table, let:

$x_5 = d^{1+}, x_6 = d^{2+}, x_7 = d^{3+}$.

$x_8 = d^{1-}, x_9 = d^{2-}, x_{10} = d^{3-}$

Excel Solver was applied to the table above to obtain the table below:

0	0	0	0.930	0	0	0.023	0	0	0.453	Solution	Min Z	0
x_1	x_2	x_3	x_4	ued^{1+}	ued^{1-}	$dued^{2+}$	$dued^{2-}$	ued^{3+}	$dued^{3-}$			
0	0	0	0	6	0	0	4	2	0	Coefficients		
Constraints												
8.4	8.4	8.5	8.6	-1	1	0	0	0	0	8	>=	8
0.27	0.27	0.26	0.24	0	0	-1	1	0	0	0.2	<=	0.2
0.04	0.05	0.05	0.05	0	0	0	0	-1	1	0.5	>=	0.5

The Excel solver application gives the optimum solution as follows:
Z = 0, x_1 = 0, x_2= 0, x_3 = 0, x_4 = 0.93
d^{1+} = 0, d^{2+} = 0.023, d^{3+} = 0
d^{1-} = 0, d^{2-} = 0, d^{3-}= 0.453.

Available resource-constrained Evaluation
From the Excel solver, we have that;
$x_1 = 0; x_2 = 0\ ;\ x_3 = 0\ : x_4$ = 0.930
Substituting these values into constraint 1 (Resource constraint), we have;
$8.4x_1 + 8.4x_2 + 8.5x_3 + 8.6x_4 >= 8$
$8.4(0) + 8.4(0) + 8.5(0) + 8.6(0.930) \geq 8$
$7.998 \geq 8$ Constraint unsatisfied (approximately)
$\therefore\ d_1^- = 0.002;\ d_1^+ = 0$

2. Population growth-constraint Evaluation
From the Excel solver, we have that;
$x_1 = 0; x_2 = 0\ ;\ x_3 = 0\ : x_4$ = 0.930
Substituting these values into the population growth constraint, we have;
$x_1 = 0; x_2 = 0\ ;\ x_3 = 0\ : x_4$ = 0.930
$0.27(0) + 0.27(0) + 0.26(0) + 0.24(0.930) \leq 0.2$
$0.223 \leq 0.2$ Constraint unsatisfied
$\therefore\ d_2^- = 0.023;\ d_2^+ = 0$

3. Economic development (Quality of life) constraint evaluation
$0.04x_1 + 0.05x_2 + 0.05x_3 + 0.05x_4 \geq 0.50$
$0.04(0) + 0.05(0) + 0.05(0) + 0.05(0.930) \geq 0.5$
$0.047 \geq 0.50\ \ constraint\ unsatisfied$
$\therefore\ d_3^- = 0.453;\ d_3^+ = 0$
To check for the optimization of the objective function, we substitute the value of the respective deviation from the constraint into the weighted objective function and we have;
$Min\ Z = 6(0) + 4(0.023) + 2(0)$
Recall that Z is minimized when Z=0; otherwise, the objective function is not minimized.
$Min\ Z = 6(0) + 4(0.023) + 2(0)$
$Min\ Z = 0.092$

5. Discussion and Conclusion

We conclude that since Z. ≠ 0, therefore, the objective function is not satisfied.

Interpretation of the solution
The application of the simplex GP method by Excel Solver gives the optimum solution as follows:
$CapCapZ$ = 0.092, x_1 = 0, x_2 = 0, x_3 = 0.45, x_4= 0.930, d_1^+ = 0, d_2^+ = 0, d_3^+= 0, d_1^- = 0, d_2^-= 0.023, d_3^- = 0.453 Since the value of Z is not approximately equal to zero, it shows that the objective function of the goal programming formulation was not minimized (optimized). Based on the decision variables obtained from the averages of the relevant variables, the goal programming solutions could not satisfy any of the aspirational targets; hence, the

non-optimization of the objective function after the careful substitution of the respective deviations into the objective function. Recall the lingering argument of Malthusian population theories, which one could argue finds an explanation in the study area. Based on the outcome of the goal programming iteration, the aspirational target of a 2 percent population growth rate could not be met. An affirmation that the Nigerian population keeps growing with little or no intervention to curtail the surge; a development that could worsen the quality-of-life argument that was supported by Mohammed (2021) and also by the critics of demographic transition theory who strongly hold that non–economic derivatives are equally significant in shaping population dynamics. Furthermore, following the goal programming practice of assigning weight, one could equally observe that there is no way the goal three, which is the quality of life (measured by the human development index), target could be meet without first meeting the aspiration target of goal one (the available resource proxied by energy consumption) hence the non-optimization of the weighted objective function. It is also important to highlight that the problem of Nigeria, far from resource non-optimization, is the endemic problem of institutional failure (a non-economic factor), which finds expression in the inability of the Nigerian system to enjoy optimal resource allocation and consequently poor quality of life, proxied by the human development index. Therefore, it could be summarized that there is consistency in the constraint evaluation, where all the aspirational targets showed strong evidence of not being satisfied.

Policy Recommendations

However, the result portends great potential, but on the condition that the government needs to come up with a broad-based master plan on how to harness our resource endowment for the sole aim of promoting increased quality of life. Secondly, increased investment in research and development cannot be ignored, as the outcome of such investment will portend a far-reaching effect on the quality of life of an average Nigerian.

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