# Multicriteria Decision Approach to Budgetary Analysis in Taraba State, North East Nigeria

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## ABSTRACT
This study proposes a two-stage process of multi-criteria decision making approach to budgeting for efficient sectoral allocation. The two approaches of Multi-Criteria Decision Analysis (MCDA) used are Analytical Hierarchy Process (AHP) and Goal Programming (GP). The former takes care of an important aspect known as participatory budgeting while the latter handles the optimization aspect which outlines the areas of differences (also known as deviation) when compromise between the two parties is needed. Findings based on analyzing model outcomes, showed that the priorities of stake holders and that of government vary in terms of budget allocation. In other to reach a compromise, the study revealed that Education sector needed the greatest attention, closely followed by General Administration, Health and lastly Forestry.

**General Terms**: Two-stage multi-criteria decision analysis

**Keywords**: Analytical Hierarchy Process, Budget, Goal Programming

## 1. INTRODUCTION
One of the principal objectives of developing countries is to accelerate the pace of social and economic development. But the overall effort to achieve this development objective has remained an elusive and difficult task. This is partly due to lack of financial resources, problems of resource allocation and inefficient utilization of resources in the public sector. Financial resources are in scarce supply to meet ever-increasing social needs and population growth.

A budget reflects the choices that government has to make, and is the tool it uses to achieve its economic and development goals. Government has to balance a wide range of legitimate demands with limited resources at its disposal. In the budget, government sets out what it is going to spend (expenditure) and the income it shall collect through taxes (revenue), which it needs to finance expenditure.

Prominent budgeting scholars have been very explicit on the significance of budgeting to governance. Schick [22] documented that the capacity to govern depends on the capacity to budget. Hou [8] reported that if you can't budget, you can not govern.

Throughout the world, the processes for determining how to raise, allocate and spend public resources constitute the foundations of government. The way public resources are used is a major determinant of the achievement of public policy objectives. Public budgets enable governments to manage finances in accordance with political and economic policy priorities. A budget constitutes a type of map that traces the fundamentals for decision making in relation to the resources generated by society, and that have to return to society as supplies and services (Bloj, [2]).

Getachew [6] stressed that in developing countries, it has become increasingly complex to manage public expenditure allocation because the roles of the government have been expanded and financial resources are in scarce supply to meet this ever-increasing social needs and population growth. He also pointed out that there are no criteria for determining inter-sectoral resource allocation. And that significant part of budget is not only treated as an annual budgeting exercise, but also it lacks standardized preparation to estimate recurrent and project costs. These conditions indicate that budget is decided on the basis of inadequate information, often without sufficient knowledge of programs and performances.

Budget analysis is a thorough and detailed review of the budget. It involves the collection, study and interpretation of budget data, the correlation of budget data to other relevant information such as state policies and programs, and the establishment of findings and results. Its aim is to provide information that is credible and accessible to a wide range of audience. It makes a timely contribution to policy debates, with the purpose of affecting the way budget issues are decided (Iris, [9]).

Due to inadequate financial resources as opposed to an increasing demand for public service, there is a need to improve resource allocation through proper economic policy and expenditure planning.

This study attempts to analyze the budgetary allocation of Taraba State in North East Nigeria, so as to develop a methodological framework for scientific modeling in the budget process. Since budgeting involves tackling multiple objectives simultaneously, the study utilizes AHP and GP tools of MCDA.

## 2. PROBLEM STATEMENT
Information about public sector performance can satisfy the public's need to know and could also be a useful tool for governments to evaluate their performance (OECD Observer, [15]).

In Nigeria, fiscal policy is the most important instrument of macroeconomic management. Therefore, reforms at this level are critical for overall macro-economic consistency. The problems of fiscal policy in Nigeria include inefficiency in resource use, waste and misplaced priorities in government expendi-ture, high fiscal deficits at all tiers of government, weak institutional structure, a fiscal federalism structure that places little or no premium on inter-temporal fiscal solvency, and poor institutional mechanisms for regulating actions of the different tiers of government and their agencies. These have led to a high debt burden, huge recurrent expenditure burdens at all tiers of government, inefficient public delivery of services and distortion in the incentive structure for both the private and public sectors (USAID, [26]).

In this paper, we propose an integrated approach for establishing an optimal allocation process in budget planning among competing sectors which does not require arbitrary manipulations of the data. The proposed approach allows input from stakeholders and government in line with globalize clamour for all inclusive governance. The budget of Taraba State in North East Nigeria is used as a case study.

# 3. MODEL

## 3.1 Goal Programming

Goal programming is a modification and extension of linear programming, developed originally by Charnes and Cooper [3]. It solves the continuous MCDA choice problems in linear programming by a search for a solution at minimal distance from a multicriterion goal, generally non-achievable, set by the Decision Maker (DM). It arrives at an alternative closest to the DM's ideal goal by minimizing the distance from the goal.

Habeeb [7] reported that conventional mathematical programming models are unable to allocate resources effectively in a conflicting environment. He proposed a goal programming model for allocating a country's scarce resources among competing sectors during a planned period.

The goal-programming approach is extensively applied in decision analysis, such as, production planning, financial decisions (Kvanli, [12]), marketing decisions, corporate planning, academic planning, and decision in government (Lin, [13]; Taylor *et al*., [25]).

The steps needed to structure a GP model are three fold:

1. Goals are identified and expressed as constraints
2. Goals are analyzed to determine the correct deviational variables needed for them, $d^+$, $d^-$, or both.
3. A hierarchy of importance among goals is established by assigning to each of them a pre-emptive factor, $P_k$. These pre-emptive priority factors reflect the hierarchy relationships in such a way that $P_1$ represent the highest priority, $P_2$ the second highest, and so on.

Once the above steps are completed, the problem can be quantified as a GP model as follows:

Minimize: $$\sum_{i=1}^{n} w_{ik} P_k \left(d_i^+ + d_i^-\right)$$

Subject to $$\sum_{j=1}^{n} a_{ij} x_j - d^+ + d^- = b_i \qquad (1)$$

where

i = 1, 2, 3, …, m

j = 1, 2, 3, …, n

m = number of constraints

n = number of variables

k = pre-emptive priorities

$w_{ik}$ = the differential weighting factor for the deviational variables within a single k priority level

$P_k$ = the pre-emptive priority level k such that

$$P_1 > P_2 > \ldots > P_k .$$

[Meaning first goal is more important than the second goal that is more important than the third goal and so on. This ensures the achievement of higher-priority objectives before lower-priority ones. In other words, the $P$'s indicate a simple ordinal ordering of the goals].

$d_i^-$ = the under – achievement

$d_i^+$ = the over – achievement

$b_i$ = total amount of resource available

$a_{ij}$ = coefficients associated with decision variables

$x_j$ = decision variables

The main objective of goal programming model is to minimize the deviations from the multiple objectives defined in the budget after their weights have been determined and prioritized.

For its simplicity and other advantages highlighted by Sarkis and Surrandaj [21], the AHP has been used to determine the weights that are incorporated into the GP model above.

## 3.2 The Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) developed and reported in Saaty [18] is based on sets of pair wise comparison of the decision elements. In using the AHP, the decision maker structures his perceptions hierarchically, compare pairs of similar things against a given criteria or a common property and judge the intensity of the importance of one thing over the other.

In order to obtain an AHP ranking (i.e. overall relative weighting of the elements), the AHP synthesizes all the judgments using the framework given by the hierarchy. Estimate of relative priority weights for the single decision elements on each hierarchy level of decision problems are obtained. There are several procedures for estimating the relative priority weights. These includes eigenvector method, logarithmic least square method and linear programming (Saaty, [19]; Saaty, [20]; Korhonen and Wallenius, [11]).

The AHP is a multi-attribute evaluation method that involves three phases: decomposition, comparative judgments and synthesis of priorities (Saaty, [19]). In the decomposition phase, the project team can explicitly develop the AHP hierarchy model from the fundamental-objective hierarchy as mentioned above. In the second phase, each decision maker utilizes paired comparisons for the attributes and alternative to extract judgment matrices with a nine-point scale at each level. In the third phase, the paired comparison process is repeated for each attribute in the alternatives prioritization problem based on the largest eigen-value method. Finally, the relative importance of attributes and the global priority of alternatives can be obtained by aggregating the weights over the hierarchy. Hence, AHP can accelerate the development of a consensus amongst multiple decision makers (Chun-Chin *et al*., [5]).

## 3.3 Integration of AHP and GP

The basic approach of Mathematical Programming Models is to optimize the objective function while simultaneously satisfying all the constraints equations that limit the activities of the decision-maker. The current trends of research is to formulate integrated models, as the justification of problems become more complex (Chen and Everett, [4]).

Schniederjans and Wilson [23] utilized the AHP method to determine the relative weights of attributes and applied these weights to a GP model for Information System (IS) selection. Suresh *et al*. [24] developed a procedure that combines a general mixed integer GP formulation with AHP to utilize both optimization and evaluation capabilities. A similar attempt has been made by Myint and Tabucanon [14] who effectively combined the GP and AHP methodologies for the machine selection problem. As a possible extension to these works on the combination of AHP and GP methodologies, an integrated AHP-GP model has been formulated for selection of software architecture design alternative (Rama *et al*., [16]). It formally treats the priorities in the decision hierarchy of AHP as penalty weights of the goal constraints. The following are some of the works that have also used integrated AHP-GP models: Ramanathan and Genesh [17] for energy resource allocation to urban households; Benjamin *et al* [1] for planning facilities at the University of Missouri-Rolla and Khorramshahgoy *et al* [10] for project evaluation and selection.

In addition, it is necessary to normalize the objective functions so that the deviations ($d_i^+$, $d_i^-$) from the goals are directly comparable. There is a need to use AHP in conjunction with GP so as to increase the applicability of both methodologies to problems that are both qualitative and quantitative.

## 4. DATA SOURCES

This study uses both primary and secondary data. Primary data was collected from a structured questionnaire which solicit stake-holders' preference on the goals or priorities government sets for itself in the annual appropriation bill. The stakeholders in this case includes government officials (especially those in the budget departments of various ministries).

About 100 questionnaires were administered to various offices/ministries in the state, out of which 75 were returned. It was observed that 60 were correctly completed and 15 were invalid. The questionnaire has four compare-son matrix, the first with eight decision alternatives, second and third with four decision alternatives each and the last with three decision alternatives.

The secondary data utilized, includes budget reports presented to the House of Assembly by the State Government and passed into law for the period 2006–2010. Information has been provided on a total of 19 sectors of the budget which are listed together with their percentage allocation in Table 1.

**Table 1. Budget Allocation (2006-2010)**

| S/N | Sectors | Percentage (%) |
|---|---|---|
| 1 | Transport | 26.55 |
| 2 | Education | 16.65 |
| 3 | General Administration | 12.99 |
| 4 | Health | 8.15 |
| 5 | Social Development | 5.61 |
| 6 | Housing | 5.3 |
| 7 | Agriculture | 4.84 |
| 8 | Town Planning | 3.32 |
| 9 | Water | 3.21 |
| 10 | Industry | 2.42 |
| 11 | Legislature | 2.32 |
| 12 | Poverty Alleviation | 2.28 |
| 13 | Information | 1.86 |
| 14 | Energy | 1.74 |
| 15 | Judiciary | 1.31 |
| 16 | Sewages & Drainages | 0.62 |
| 17 | Livestock | 0.47 |
| 18 | Forestry | 0.28 |
| 19 | Fishery | 0.06 |

## 5. DATA ANALYSIS AND RESULTS

This study adopts two multicriteria decision tools – AHP and GP.

To carry out the AHP analysis for this study, an Excel Solver Program is designed to help capture the data extracted from questionnaire easily and automatically calculate all the parameters needed. The designed solver helps in inverting the entries gotten directly from the questionnaire, it normalizes the matrix and calculates the weights. Other parameters that are automatically obtained from these procedure are λmax value, Consistency Index (CI), Random Consistency Index (RI), Consistency Ratio (CR) and it also tells us whether the matrix is consistent or not as it displays 'CONSISTENT' or 'INCONSIS-TENT' depend-ing on whether CR satisfy the condition of CR < 0.1.

The summarized result of AHP analysis carried out on the questionnaires using the Excel program developed for this study is shown in Table 2 below.

## 5.1 Results of AHP Analysis

**Table 2. Weights derived from AHP Analysis**

| Sector | Ranked normalized consistent mean weight |
|---|---|
| Water | 0.1061 |
| General Administration | 0.09185 |
| Judiciary | 0.09157 |
| Health | 0.07844 |
| Education | 0.07675 |
| Legislature | 0.06658 |
| Information | 0.06595 |
| Housing | 0.06097 |
| Agriculture | 0.05761 |
| Town Planning | 0.0547 |
| Livestock | 0.04144 |
| Forestry | 0.03487 |
| Social Development | 0.02887 |
| Sewages & Drainages | 0.02823 |

| | |
|---|---|
| Industry | 0.02624 |
| Fishery | 0.02514 |
| Transport | 0.02356 |
| Poverty Alleviation | 0.02238 |
| Energy | 0.01876 |

The results of AHP analysis are treated as weights in the objective function in the GP analysis.

## 5.2 Results of GP Analysis

Introducing the weights from Table 2 and total amount of resource available for each sector from Table 1 into the goal programming model defined in equation (1), we have the following:

$$\begin{aligned}\text{Min Z: } & P_1\{0.1061(d_1^+ + d_1^-) + 0.09185(d_2^+ + d_2^-) + 0.09157(d_3^+ + d_3^-)\} + P_2\{0.07844(d_4^+ + d_4^-) + \\ & 0.07675(d_5^+ + d_5^-) + 0.06658(d_6^+ + d_6^-)\} + P_3\{0.0659(d_7^+ + d_7^-) + 0.06097(d_8^+ + d_8^-) + \\ & 0.05761(d_9^+ + d_9^-)\} + P_4\{0.0547(d_{10}^+ + d_{10}^-) + 0.04144(d_{11}^+ + d_{11}^-) + 0.03487(d_{12}^+ + d_{12}^-) + \\ & 0.02887(d_{13}^+ + d_{13}^-)\} + P_5\{0.022823(d_{14}^+ + d_{14}^-) + 0.02624(d_{15}^+ + d_{15}^-) + 0.02514(d_{16}^+ + d_{16}^-) + \\ & 0.02356(d_{17}^+ + d_{17}^-) + 0.02238(d_{18}^+ + d_{18}^-) + 0.01876(d_{19}^+ + d_{19}^-)\} \qquad (2)\end{aligned}$$

Subject to:

$$\begin{aligned}
a_1x_1 &- d_1^+ + d_1^- = 3.21 \\
a_2x_2 &- d_2^+ + d_2^- = 12.99 \\
a_3x_3 &- d_3^+ + d_3^- = 1.31 \\
a_4x_4 &- d_4^+ + d_4^- = 8.15 \\
a_5x_5 &- d_5^+ + d_5^- = 16.65 \\
a_6x_6 &- d_6^+ + d_6^- = 2.32 \\
a_7x_7 &- d_7^+ + d_7^- = 1.86 \\
a_8x_8 &- d_8^+ + d_8^- = 5.3 \\
a_9x_9 &- d_9^+ + d_9^- = 4.84 \\
a_{10}x_{10} &- d_{10}^+ + d_{10}^- = 3.32 \\
a_{11}x_{11} &- d_{11}^+ + d_{11}^- = 0.47 \\
a_{12}x_{12} &- d_{12}^+ + d_{12}^- = 0.28 \\
a_{13}x_{13} &- d_{13}^+ + d_{13}^- = 5.61 \\
a_{14}x_{14} &- d_{14}^+ + d_{14}^- = 0.62 \\
a_{15}x_{15} &- d_{15}^+ + d_{15}^- = 2.42 \\
a_{16}x_{16} &- d_{16}^+ + d_{16}^- = 0.06 \\
a_{17}x_{17} &- d_{17}^+ + d_{17}^- = 26.55 \\
a_{18}x_{18} &- d_{18}^+ + d_{18}^- = 2.28 \\
a_{19}x_{19} &- d_{19}^+ + d_{19}^- = 1.74
\end{aligned}$$

A GP analysis using TORA software was carried out. The results of deviations obtained are shown in Table 3 below.

**Table 3. Deviations obtained from GP Analysis**

| **Sector** | **Ranked Deviations** |
|---|---|
| Education | 1.33 |
| General Administration | 1.17 |
| Health | 0.65 |
| Transport | 0.53 |
| Water | 0.35 |
| Housing | 0.32 |
| Agriculture | 0.29 |
| Town Planning | 0.17 |
| Social Development | 0.17 |
| Legislature | 0.16 |
| Information | 0.13 |
| Judiciary | 0.12 |
| Industry | 0.07 |
| Poverty Alleviation | 0.05 |
| Energy | 0.03 |
| Livestock | 0.02 |
| Sewage & Drainage | 0.02 |
| Forestry | 0.01 |
| Fishery | 0 |

# 6. DISCUSSION

The approach used throughout this study has been to integrate the AHP method to a GP model for optimal allocation of resources to different sectors. This is a feature that is particularly important in situations where the decision maker has to choose between different objectives subject to several constraint conditions.

Over the years, budgeting in Taraba State North East Nigeria, is by arbitrary allocation of resources, otherwise known as incremental allocation based on previous year allocation.

It is shown in Table 1 that government gives highest priority to transport sector. This is followed by education and lastly fishery. The AHP analysis (stakeholders' views) in Table 2 however, places water sector highest in scale of importance, followed by general administration and lastly energy sector.

The arrive at a compromise position, a GP analysis was carried out. The result reported in Table 3 showed that the education sector needed the most attention, followed by general administration and lastly forestry. In the GP analysis, government and stakeholder's views which varied regarding budgetary allocation to the 19 sectors were combined in other to minimize deviation from the goal.

Furthermore, the study revealed that the views of government and stakeholder's on fishery sector is the same since the deviation from goal is zero as shown in Table 3. All the other 18 sectors showed discrepancy in government and stakeholder's goal preferences. This integrated approach can also be applied to each sector for planning of resources and manpower allocations.

# 7. CONCLUSION

In preparing a budget, the efficient allocation of resources is an important ingredient of success. Budget planning involves active participation of different groups of stake-holders. Therefore, it is absolutely necessary to have their preferences incorporated in the decision making process.

In this study, an integrated AHP-GP model for establishing an optimal allocation process in budget planning among competing sectors is suggested. The integrated approach proved to be a flexible tool in budgetary analysis.

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