IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 3, Issue 4, Aug-Sept, 2015
ISSN: 2320 – 8791 (Impact Factor: 2.317)
www.ijreat.org

A New Decision Making Tool for Budgeting Based on the Analytical Hierarchy Process

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Abstract
Making a decision in today's environment is getting more and more complicated as there are a lot of criteria affecting the decision making process, the Analytical Hierarchy Process (AHP) has been used in this research to insure that the criterias are selected in the right way. And by using the AHP technique, we aim to bring benefit and reduce cost in the areas of finance and budgeting decision making, by doing so we presents the AHP as a computerized decision making tool for budgetary planning and control. Through pairwise comparisons the tool evaluates the priorities of the decision maker and proposes the most suitable plan for making a budget. The improved tool will be a new step in budgeting and AHP development in general.
Keywords: *Analytical Hierarchy Process, Decision making, budgeting, AHP, pairwise comparisons.*

1. Introduction

Every organization requires budgeting for its success, and budgeting is a process which involves decision making and the kind of decisions made may affect the organizations positively or negatively. Regarding the success of organizations in today's dynamic business world, each organization, decision maker as well as managers at all administrative levels require technical or high level decision support systems and data analytical technologies such as data warehousing and OLAP [18] to assist them in the day to day implementation of critical decisions such as those made in budgeting.
Choosing the right budget and using effective criteria will not only bring the organization's success, but will increase and develop the ability of the organizations to expand their environment and investment in the market [10]. But determining the best budget plan and solution is not always easily approached. Therefore AHP algorithm will hopefully be the best tool to solve this kind of structured problems.
Although AHP has been found suitable for a lot of decision making problems, there hasn't been much work done in budgeting with respect to the implementation of AHP therein therefor the main goal is to determine the most appropriate financial decision criterion and alternatives for institutions through the use of decision support technologies and techniques such as AHP.

2. The Analytical Hierarchy Process

In 1980 Dr. Thomas Saaty introduced the analytical hierarchy process as decision making technique. A technique is based on capturing all kind of factors that effects and helps in making the right decision in a specific domain [1][2][9] [11]. AHP is categorized as a multi-criteria decision making technique that uses pairwise comparison to solve structured problems by providing percentage priorities for all parts of the AHP model. The model consists of three main parts the goal, criteria and alternatives see (**FIG. 1**).

How AHP works?
AHP is based on multi-criteria comparison. Its starts with comparing all the criteria in the second level (**FIG. 1**) between each other and then comparing the alternatives in the third level with respect to all criteria in the model.
The goal of the problem and the appropriateness of the AHP to solve the problem should be determined. Then the problem is decomposed into levels until no more classification is required. However it should be kept in mind that the less the number of levels the problem's complexity decreases.

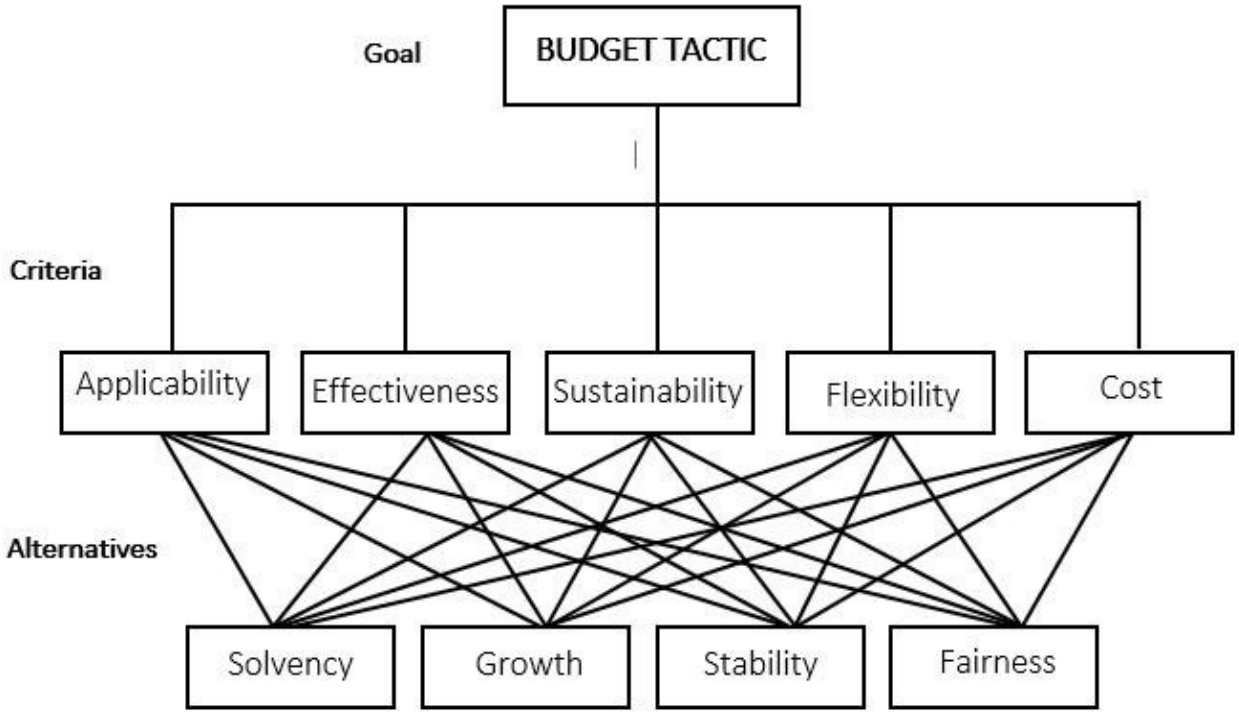

FIG. 1 AHP Model

Finally the pairwise comparison matrix is generated according to Saaty's instructions for scaling (**TABLE 1**) according to which the weights of different criteria and the score of the final solution is calculated [3] [4] [9].

The instruction of Saaty for the scaling of alternatives is used to make pairwise comparisons in multi-level hierarchic models. These comparisons reveal the relative strengths of the criteria, the preferences or feelings of the decision maker. These scales proposed by Saaty for the comparisons are given in the table below.

Table 1: Comparison scales

Explanation	*Numeric Values*
If Option A and Option B are equally important	1
If Option A is moderately more important than Option B	3
If Option A is strongly more important than Option B	5
If Option A is very strongly more important than Option B	7
If Option A is extremely more important than Option B	9

The table (Table 1) is used while comparing the criteria. The user of this method will tell the computer the relative importance of the criteria presented him/her, saying whether it is more important, equally likely or less important [5].

We can summaries the AHP in the following steps:

1. Determining the goal and identifying the criteria.
2. Using pairwise comparison and evaluating comparison matrix at each level.
3. Ranking the criteria through eigenvectors.
4. Obtaining the alternatives priorities through the Weights of the criteria [6] [7] [8].

3. Aim and Objectives

The purpose of this paper is to examine the Analytic hierarchy process technique in budgetary decision making and study its impact in choosing the right financial decisions. This can be done by determining the most appropriate financial decision criterion and alternatives for institutions through the use of decision making technologies and techniques such as AHP. Therefore the aim is to design a decision making tool using the AHP technique in the finance and budgetary fields.

Research objectives are as followed:

1. Studying the technologies that help in the process of decision making.
2. Implementing the techniques of decisions support on a budget and representing the results interactively for easy and quick understanding of the user.
3. Assess the output accuracy and alternatives results.

3. Research Methodology

An experimental research methodology was used for this study. Both qualitative and quantitative research methods have been used to create a convincing model that contains the most required components used in budgeting that helps in making a proper plan for both understanding the requirement and weaknesses of budgets. Therefore it included:

1. AHP (Analytical Hierarchy process): The use of pair wise comparisons and eigenvector normalization.
2. Survey and interviews: Surveys and personal interviews were carried out in which the decision makers were asked about the appropriate criterion and alternatives used in budgetary decision making, which also included at least 33 questionnaires.

The criteria used in the AHP model (FIG. 1) were extracted from the evaluated survey results. The survey addressed one purpose, which is to find out the most important criterias that are used in budgeting.

The survey restricted many budgeting terminologies that were taken from interviews done with a specific population identified by the researchers from the necessary decision makers in the fields of budgeting and finance. The questionnaire was developed from the AHP technique to express the importance of one criterion over another. The chosen criteria were Applicability, Effectiveness, Sustainability, Flexibility and cost of Measure.

1. Applicability: It refers to legal, institutional, technical, human, social and political resources that should exist to implement the actions.
2. Effectiveness: It means the capability to produce a desired solution to problems arising from miss budgeting.
3. Sustainability: It describes the processes, actions, decisions and strategies by stakeholders which should not actually add to Budget impacts or limit the ability of other parts of the finances to carry out operations elsewhere.
4. Flexibility: It refers to phased adaptation approach to cope with possible changes in financial conditions, e.g. Market drop. Adaptation action is taken over time as required, based on more information as it becomes available on the present and future financial conditions.
5. Cost of Measure: It refers to the cost of designing, implementing and maintaining an adaption action. The action should be economically feasible.

4. Survey Analysis and Results

A special software package used for statistical analysis called SPSS was used for the analysis of the statistical results that were collected from the AHP questionnaire tool. The minimum and maximum results from the analysis are as followed:

4.1 The Maximum Results

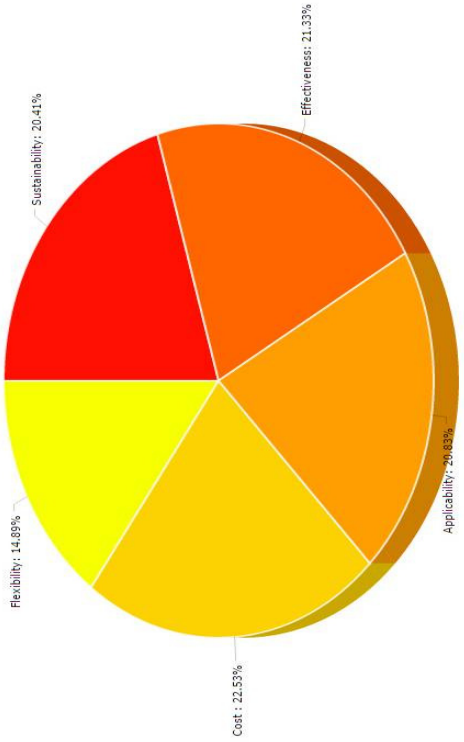

FIG. 2 Survey Maximum Results

- Applicability: 20.03%
- Effectiveness: 21.33%
- Sustainability: 20.41%
- Flexibility: 14.89%
- Cost: 22.53%

4.2 The Minimum Results

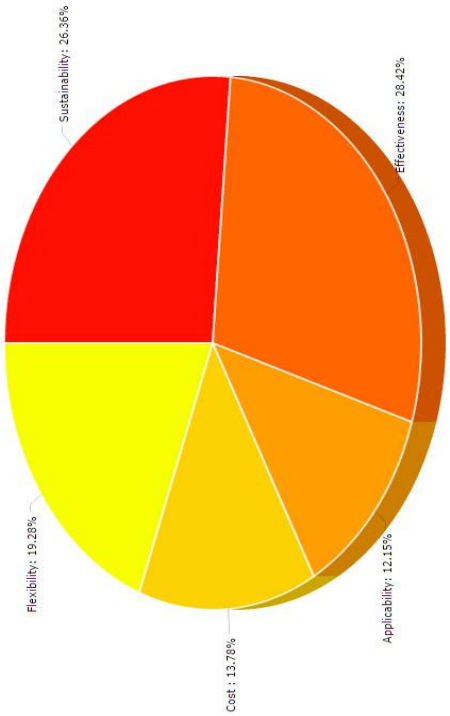

FIG. 3 Survey Minimum Results

- Applicability: 12.15%
- Effectiveness: 28.42%
- Sustainability: 26.36%
- Flexibility: 19.28%
- Cost: 13.78%

4.3 The Average Results

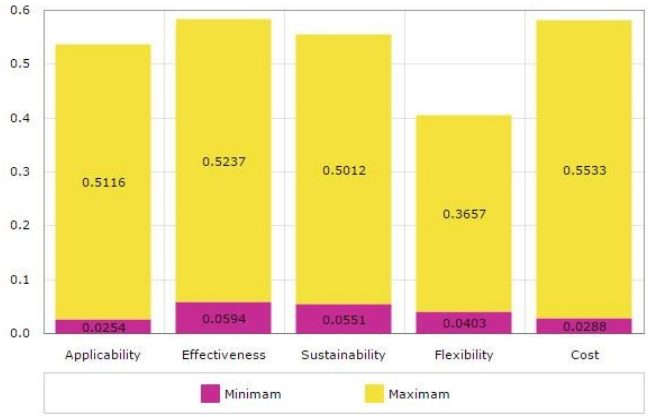

FIG. 4 Survey Summarized Results

From the above figure the minimum values mean that the criteria has minimum side effects with respect to negativity in the budget results, while the maximum values mean that the criteria has maximum side effects with respect to positivity in the budget result. Therefore, the above results show that applicability, effectiveness and cost were highly favored by decision makers and these criterion were considered critical in general budgets.

5. Structure of the Proposed Model

Through the criteria used in the survey we can understand and acquire more significant information about budgets, we can focus on its weaknesses. Either it's a project or institution budget the financial plan must be highly accurate, and only by knowing all the flaws and lacks of the planed budget we can reduce the proportion of a deficit in some of the institution's budget parts and Increasing institution\s financial controls. Moreover providing a good distribution of institution's financial resources. Therefore using such terminologies like applicability or sustainability will increase the decision maker ability to identify new ways of thinking in the budget problems.

This led to ask an important question which is what is budgeting?

Budgeting starts with managing all financial resources in the best possible way to achieve the desired goals of the institution. Specifically budgeting is a process of planning for the future and trying to fulfill all the financial obligations and need without weakening the institution capabilities and duties, moreover increasing benefits and reducing cost [12].

The proposed model (FIG. 1) is a structure of three levels goal, criteria and alternatives which applies the same AHP standards. The goal as mentioned before is to solve budgeting problem through making the best possible financial plan. The criteria in the second level were taken from the survey results presented before. Finally the third level alternatives was the most challenging level because the decision maker favored alternative produced from the AHP analysis will be the highest priority for him.

The alternatives chosen were Solvency, Growth, Stability and Fairness [13].

1. Solvency: the institution strength possibility to pay its financial commitments.

2. Growth: Monetary policy that maintains economic development.
3. Stability: the institution strength possibility to fulfill its future commitments with the current tax liabilities.
4. Fairness: the institution strength possibility to pay existing commitments without delaying cost future years.

The decision made by the decision maker must be precise in an unharmed way. AHP provides a safe environment where the decision maker can take as long as he wants to choose the right decision. The multi criteria comparison made at each level is not just for statistical results elicitation it is also a part of creating a strong logical thinking strategy for the necessary needs and deficiencies [14].

Providing a strategic point of view will not only increase the decision maker interests put will brings quality, growth and sustain the ground for Futuristic decisions [15].

6. Mathematical Model

The AHP process was experimented manually using matrices calculation and algebra in order to give a clear example about how it works in general. Matrices are presented as follows:

5.1 Criteria Comparison

.	Applicability	Effectiveness	Sustainability	Flexibility	Cost
Applicability	1	7	5	1	3
Effectiveness	1/7	1	5	9	3
Sustainability	1/5	1/5	1	7	1
Flexibility	1	1/9	1/7	1	9
Cost	1/3	1/5	1	1/9	1

Criteria Final Result:

criteria	ranking
Applicablity	0.3940
Effectiveness	0.3211
Sustanability	0.1728
Flexibility	0.0859
Cost	0.02603

5.2 Alternatives Comparison

5.2.1 Alternatives comparisons with respect to applicability

.	Solvency	Growth	Stability	Fairness
Solvency	1	3	9	5
Growth	1/3	1	7	1
Stability	1/9	1/7	1	9
Fairness	1/5	1/1	1/9	1

5.2.2 Alternatives comparisons with respect to effectiveness

.	Solvency	Growth	Stability	Fairness
Solvency	1	1	7	9
Growth	1/1	1	3	5
Stability	1/7	1/3	1	1
Fairness	1/9	1/5	1/1	1

5.2.3 Alternatives comparisons with respect to sustainability

.	Solvency	Growth	Stability	Fairness
Solvency	1	5	1	3
Growth	1/5	1	1	9
Stability	1/1	1/1	1	7
Fairness	1/3	1/9	1/7	1

5.2.4 Alternatives comparisons with respect to flexibility

.	Solvency	Growth	Stability	Fairness
Solvency	1	7	9	1
Growth	1/7	1	3	3
Stability	1/9	1/3	1	5
Fairness	1/1	1/3	1/5	1

5.2.5 Alternatives comparisons with respect to cost

.	Solvency	Growth	Stability	Fairness
Solvency	1	3	1	3
Growth	1/3	1	9	7
Stability	1/1	1/9	1	9
Fairness	1/3	1/7	1/9	1

5.2. Alternatives values with respect to each criteria:

.	Applicability	Effectiveness	Sustainability	Flexibility	Cost
Solvency	.51664	0.49876	0.48202	0.6038	0.0063
Growth	0.3083	0.3543	0.2201	0,1721	0.0109
Stability	0.1185	0.08063	0.25253	0.11035	0.00294
Fairness	0.05649	0.06627	0.04531	0.1137	0.97983

Alternatives Final Results:

Alternative Priorities
0.4990
0.2883
0.1258
0.0866

From the alternatives results it is obvious that solvency has the highest priority which means that the decision maker is very concerned about it for it is the part where the institutions should fulfill its liabilities and make balance between all its parties.

7. Computerized AHP Tool Design

The tool design is the part where all analysis and requirements transform through technologies from a hypothesis observation and thinking to a real pragmatic implementation. An easy description for the designed tool is shown in (FIG. 5) to show all operations and interactions done inside the tool.

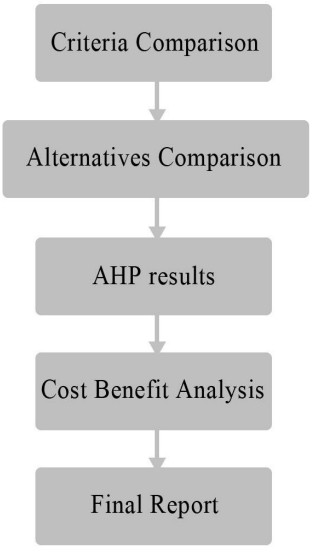

FIG. 5 AHP tool operations

The decision maker starts with comparing the criteria between each other in the first level and then the tool turns to the second level so the decision maker can compare all alternatives and finally the last phase is the cost benefit analysis where the decision maker needs to insert his budget parts to the tool so it can get analyzed with the AHP results. Lastly the tool presents the AHP results with analytic report.

8. The Tool Results

The same data which was used in the mathematical model was also used in the computerized tool and the results were compared in order to get the error percentage so that the accuracy of the tool can be assessed.

The first level of the mathematical model involves the comparison of criterias, this has also been applied in the computerized tool in the first table (Appendix II)and the tool output for this level is as shown below,

6.1 First level

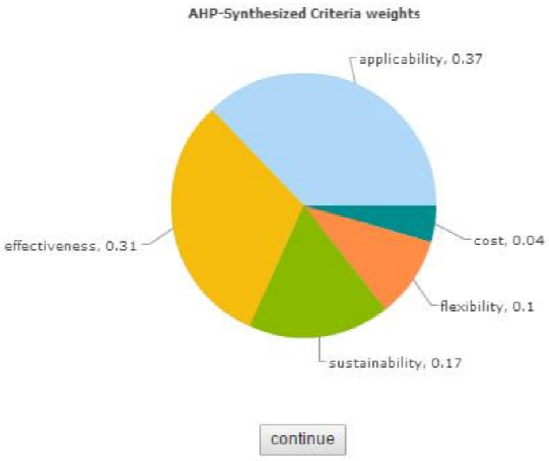

FIG. 6 AHP tool criteria raking graph

6.2 Second level

Second level of the tool is the comparison of the alternatives with respect to all the criterias which has been done in five processes, and the same thing has been done in the mathematical model where the comparison were done in five matrices and the output is as shown in (FIG. 7),

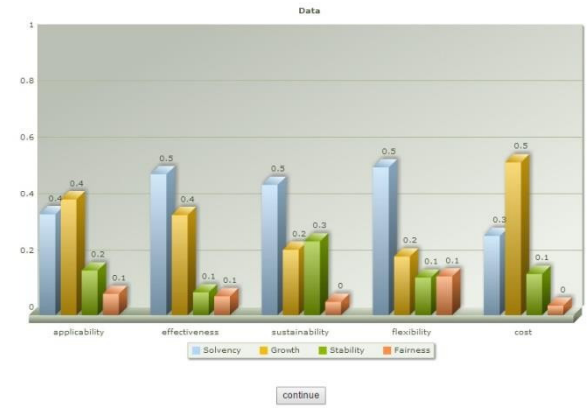

FIG. 7 comparison results of the alternatives with respect to all criterias

6.3 Alternatives priorities

The results from the second level calculation in the mathematical model were shown before which were:

$$\begin{bmatrix} Alternative\ Priorities \\ 0.4990 \\ 0.2883 \\ 0.1258 \\ 0.0866 \end{bmatrix}$$

The results from the second level from the tool:

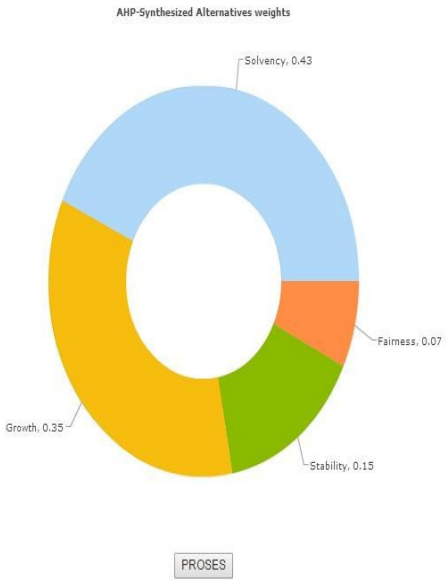

FIG. 8 AHP tool alternatives graph

9. Error Percentage

By comparing the alternative priority results from the mathematical model and the alternative priority output of the tool the accuracy of the tool is measured and through the error percentage equation shown below, it has been successfully concluded that the tool is working according to the standards of the initial AHP model as proposed by Dr.Saaty.

Equation:
Error percentage =

$$\left(\frac{computerized\ Eigen\ vector}{Mathematical\ Eigen\ Vector} * 100\right) - 100$$

$$\left(\frac{1.0002}{0.9997} * 100\right) - 100 = 0.05\%$$

According to the standards of the AHP model, if the error percentage is < 10%, then the error to performance ratio is acceptable.

10. Budget Analysis

Any kind of budget can be analyzed with this system, the conditions for budget analysis are that the budget has to be divided into 4 parts, which are the four alternatives used in the From the above 4 parts we it was possible to carefully the analysis and identified the following from the sample budget (Appendix I):

- Solvency: Summery of the budget (income less expenses).
- Growth: payroll taxes and loans.
- Stability: Expense details/ selling, Administrative, service and equipment.
- Fairness: Income details.

11. Cost Benefit Analysis

The cost benefit analysis helps the decision maker to visualize the weaknesses and strengths of his decision in the budget. The cost values were taken from an identified budget (appendix I), the budget was translated into four values which are; solvency, growth, stability, fairness, which were the alternatives in the AHP model.

Cost benefit analysis favors lowest cost and highest benefits, hence, from the chart below (FIG. 9), the alternative with the lowest cost and highest benefit is the best so the decision maker should concentrate more on alternatives with the highest cost and the lowest benefit.

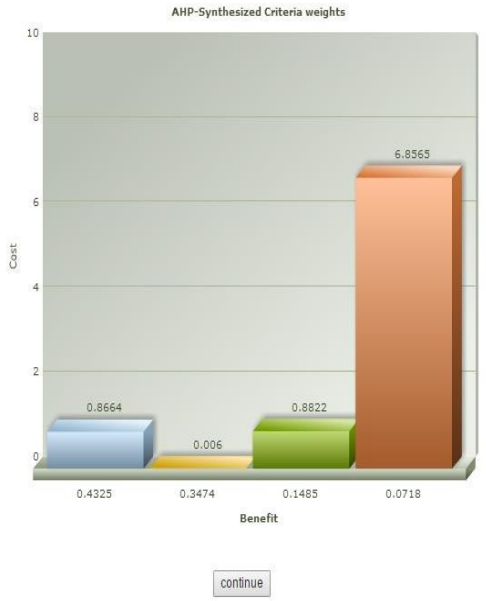

FIG. 9 AHP tool cost benefit analysis graph

12. Discussion

In this part the usefulness of AHP will be discussed and why. Moreover there will be explanations on the researcher's decisions and choice about the implementation and problem found during the project.

Is AHP Useful?

During the project work, the tool was tried with different inputs, and in executing the algorithm it was found out that for small decisions people can use their intuition to decide. When the decision elements increase, every choice become difficult to make, while it is still easy to compare elements in pair, it can therefore be claimed that pairwise comparison (which is the main feature of AHP) makes the algorithms very useful and simple to use.

The main advantage of AHP is the possibility to divide the criteria (decision elements) in sub criteria [17], which can be useful when more details must be considered for an element.

Moreover, the AHP algorithm provides very precise results, since it has a complete control on all the comparisons of elements.

In addition, it has been decided to show results after the evaluation for each level and for the whole survey. The results after the first level are shown in a graphical mode so that the user can know which criteria is more favored before proceeding to the alternative comparisons.

The results are decimal values, so the biggest value means the most favorable element. Another important thing is that it is possible to know not only which the best element is, but also how much better it is. So it could happen that the first element is much better than the others, but also that the first and the second are almost on the same level. This helps the decision maker to have a deep look in the results, which are more than a simple classification.

Figuring a simple interactive way to simulate the AHP technique was a very disturbed phase for it required a lot of testing and maintenance to achieve reliability and prosperity for the decision maker. The main designed interface (Appendix II) was approached by the same idea that AHP uses, which is pairwise comparison. The decision maker interacts with a dynamic table comprises from drop down lists that contains the comparison scales and consecutive instructions to know exactly which elements is being compared at the moment. This provided a clear path for matrices to be calculated in the sight of the decision maker.

AHP provides an appropriate tactic for facilitating multi-criteria decision making problems in finance and budgeting [16]. It supported many decision making fields by reducing confusion giving a simplified and understandable picture of how the problem will be structured and solved sequentially. Therefore implementing the AHP technique in the designed tool provided many benefits can be summarized in the following:

1. The results are obtained in a short time.
2. The results are graphical and interactive giving the user clear understanding of the favored criterion and alternatives.
3. Simple, effective and the results are oriented.

13. Conclusion

This paper proposed a tool for finding the most suitable plan for budgeting by using the AHP technique. The AHP is a dominating technique in stretching thinking and providing an indicating map to find the best ways and through them choosing the most suitable solution. Budgeting is a cumulative process and it requires a lot of decision making and using a multi-criteria decision making technique such as AHP will make it easier to grasp what's important from not and finally building an applicable budget.

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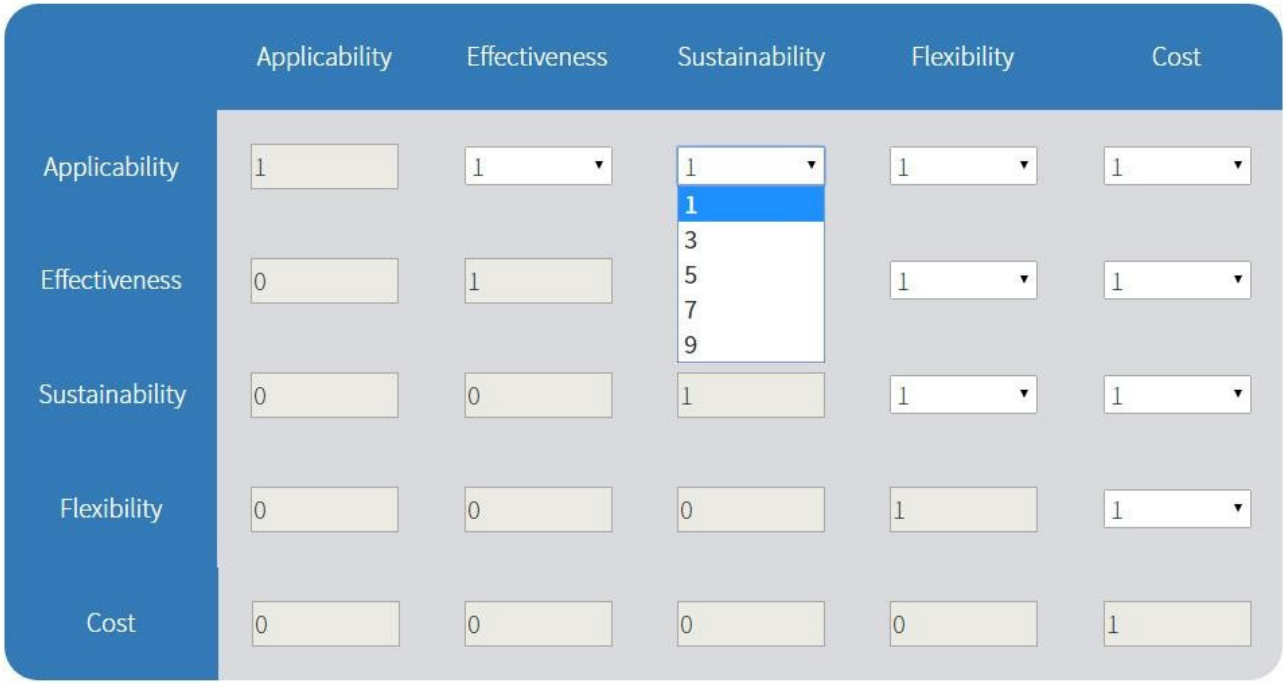
SUMMARY	ACTUAL	BUDGETED	OVER BUDGET	UNDER BUDGET
Total income	1,432,500.00	1,318,080.00	114,420.00	
Total expenses	339,760.00	314,910.00	24,850.00	
Income less expenses:	1,092,740.00	1,003,170.00	89,570.00	

INCOME DETAILS	ACTUAL	BUDGETED	OVER BUDGET	UNDER BUDGET
Sales	1,400,000.00	1,200,000.00	200,000.00	
Interest earned	5,000.00	4,500.00	500.00	
Fees	1,000.00	980.00	20.00	
Commissions	10,000.00	98,000.00		-88,000.00
Rent	9,000.00	8,000.00	1,000.00	
Royalties	2,500.00	2,600.00		-100.00
Other	5,000.00	4,000.00	1,000.00	
Total income:	1,432,500.00	1,318,080.00	114,420.00	

EXPENSE DETAILS	ACTUAL	BUDGETED	OVER BUDGET	UNDER BUDGET
SELLING				
Salaries and wages	246,000.00	248,000.00		-2,000.00
Commissions	10,000.00	12,000.00		-2,000.00
Advertising	6,000.00	8,000.00		-2,000.00
Delivery	0.00	0.00		
Shipping	0.00	0.00		
Travel	4,600.00	5,600.00		-1,000.00
Other	1,000.00	1,200.00		-200.00
Total sales expenses:	267,600.00	274,800.00		-7,200.00
Percent of total:	78.76%	87.26%		
ADMINISTRATIVE				
Salaries and wages	12,000.00	10,000.00	2,000.00	
Employee benefits	5,000.00	6,000.00		-1,000.00
Payroll taxes	500.00	500.00		
Insurance	14,000.00	14,000.00		
Loans	6,000.00	5,000.00	1,000.00	
Office supplies	4,000.00	4,100.00		-100.00
Travel & entertainment	200.00	190.00	10.00	
Postage	300.00	320.00		-20.00
Furnishings	0.00	0.00		

Appendix I


Applicability
Effectiveness
Sustainability
Flexibility
Cost
Applicability
Effectiveness
Sustainability
Flexibility
Cost
1
3
5
7
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Appendix II