Prioritization of Development Projects of Qazvin Municipality

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Abstract: This article is based on an MA thesis which has been supervised by the author. The purpose of this study is to gain information about the projects and the utilization of the plans of Qazvin Municipality with regard to the budget constraints through the application of decision making techniques of mathematic model of AHP. The purpose of this study is to utilize a proper method of decision making for the prioritization of the projects through exploration of effective qualitative and quantitative factors and assessment of their weight values in pairs and putting them in a matrix. Of course, this purpose is a means to the final end of the satisfaction of the customers (in municipal system the citizens). The purpose f this research is to signify the significant projects and utilize developmental plans of Qazvin Municipality; therefore, AHP has been used as a decision making technique. In this study, first the entire numbers of municipal developmental plans were recognized which included 313 plans within 82 developmental programs. Therefore, based on expert opinions and the significance of the plans, 36 criteria were put in the priority and then reduced to 25 factors through questionnaires. Finally, these factors were weighed and those with scores lower than 7 were excluded and just 13 factors were left to be analyzed. The application of the weights given to the projects and factors by a group of experts (an experienced team of 24 experts) and then collection of a series of questionnaires distributed among the public as well as the criteria which were compared in matrices and then the application of the average mean of the weight of each project concerning each one of the factors were calculated. Finally, the most appropriate project was selected through the calculation of the total priority of each project concerning all factors.
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Key Words: AHP (Analytic Hierarchical Process), Development Responsibilities, Service Responsibilities, Administrative Responsibilities.

Review of Literature:

Background:

This method was first introduced by Professor Thomas Al Saaty (the Professor of Pitsburg University) in his book by the same title which was published in 1980.

This method has been applicable in regard with several issues and so far many articles have been published on the issue, one of the best ones of which has been published by Vargas and Harker in 1987.

In Iran, for the first time, this issue was seriously discussed in 1992 in one of the scientific conferences of Research Center of Iranian National Industries.

Because of the broad application of AHP technique and its dependence on scientific methods, Professor Saaty was invited by Industrial Management Organization in 1999 to lecture on AHP in this organization.

Concept of AHP

AHP is a method which relies on the mathematic knowledge which generally includes all the thoughts related to a problem. AHP is a demonstrable and comprehensible method without the complexities of other methods of decision making. This method is an analytic procedure which enables us to measure intangible aspects and overcome the constraints of decision making. AHP is an appropriate method for a better decision making and helps us make decisions about complex issues which have no structure. Analytic Hierarchical Process also tries to combine qualitative and quantitative criteria for those decision makings in which several factors and principles are involved. This method is able to determine the priority of options involved in decision making so that the decision maker or the group of decision makers would be able to determine the best options through the definition of the goal and options involved.

The Advantages of AHP

- Being simple and applicable;
- Compiling and systematizing the very mental process of decision making and as a result, facilitating a proper and accurate judgment;
- Flexibility with regard to different problems and in various grounds;
- Creating appropriate environment and conditions for the improvement of the definitions through discussion in a decision making group (combining, analysis and adjusting the contradictions among them);

- The possibility of analyzing the sensitivity of the results and reexamination with low costs;
- Doing the numerical calculations and specifying the priority of the options and alternatives based on numerical values (a method for measuring qualitative values in the form of figures);
- The access of the manager to the data related to the evaluation standards and determining the percentage of the confidence in the data and information obtained by the decision maker (by a fixed rate or comprehensiveness) and the weight of each of the criteria as a side advantage of the method.

Method of Application of AHP

The principle of application of AHP is based on a completely natural rationale, the rationale all of us have undoubtedly practiced several times. The main problem is broken into comparable components to the extent possible (these components include the determining qualitative and quantitative factors in decision making). These components are classified based on their degree of significance and then chosen through well-known mathematical methods and based on the highest estimated score.

The Applications of AHP

This method has too many usages in various problems including the supervisions of programmer, selection of location, prioritization of factors of decision making. The following achievements can be mentioned for AHP:

1. It is a scientific way for quantitative discussions about several kinds of quantitative and scientific connections in a complex network.
2. It is a powerful instrument for the completion of other (progressive and regressive) planning methods which is reflected in the opinions of the personnel and manager for its reciprocal effects.
3. It is a complementary method for other research methods in operations such as estimation of cost and profit and minimum risk for selection of projects.
4. It's an instrument for warning and directing the progressive function of a dynamic set of goals of an organization.

It should be noted that this method is generally established on a natural and instinctive thought in which scores are given to several significant and qualitative factors involved in decision making and the highest score would be our choice. For this reason, this method seems to be easily perceived and its application in many problems, even our daily issues, seems possible and effective.

Designing a Hierarchy

The first step in AHP is to provide a graphic presentation of the problem in which the objective, criteria and the alternatives are illustrated. Diagram 1 illustrates the hierarchy of selection of a car. The first level in the hierarchy includes the aim which is selection of the best car and in the second level, four criteria are presented which include price, fuel consumption, comfort and model and in the final level the car options (A, B, C) are illustrated.

Estimating the weight

In AHP, the components of each level are compared with their counterpart components in the higher level in pairs and their weight is calculated; such weights are called relative weight. Then, through combining the relative weights, the final weight which is called the absolute weight, is determined for each option.

First, the cars are separately compared regarding price, fuel consumption, comfort and model, and the weight of each is specified regarding the goal determined. All comparisons in Analytic Hierarchical Process are made in pairs, for example if we are going to compare the cars with regard to their comfort, first we compare car A with car B and after that car A with car C and then car B with car C.

In such comparisons, the decision makers would use verbal judgments, so that if component (i) is compared with component (j) then the decision maker would say that the significance of (i) compared to (j) would be one of the following states:

- Extremely preferred or extremely significant or extremely desired;
- Very strong preference, significance or desirability;
- Strong preference, significance or desirability;
- Moderately preferred or moderately significant or moderately desired;
- Equal preference, significance or desirability.

These judgments are transformed into quantitative amounts from 1 to 9 by Saaty which are presented in the table (1):

It should be noted that in comparison of pairs, the preference of each element to itself equals one, so all the components located on the diagonal of the matrix equals one. Moreover, this should be noted that if the preference of A to B equals 2, the preference of B to A would be ½. Therefore, pair comparison matrix can be completed as follows:

When pair comparison matrix is provided, we can estimate the weight for each option; in other

words, based on the pair comparisons presented in pair comparison matrix we are going to come to the weight of each car with regard to its comfort.

For the estimation of weight of each option of pair comparison matrix (relative weight) several methods have been suggested the most significant of which include:

- Method of minimum ordinary squares;
- Method of minimum Logarithm squares;
- Method of specific vector;
- Approximate methods.

Here one of the approximate methods (arithmetical average which is a relatively simple method) is explained. This method includes three following steps:

First step: The values of each column are added up.

Second step: Each component in the pair comparison matrix is divided to the total of its column so that the pair comparison matrix would be normalized.

Third step: The average mean of the components of each row of the normalized matrix is estimated. These average values are the estimation of the weights considered.

In order to clarify on the issue, the estimation steps of this algorithm for tables (pair comparison matrix of three cars concerning their comfort) are demonstrated below:

First Step: Adding up the values of each column

Second Step: Division of each component of matrix to the total of its column (Note: Sum of the values of the columns in a normalized matrix equals 1.

Third Step: Estimation of the average of the components of each column

Hence, we observe that regarding comfort, car A (with the preference of 593%) is the best car. Car B (with the preference of 341%) is the second best and car C (with the preference of 66%) is the last one.

Preference vector which illustrates the relative preference of cars A, B, and C with regard to the criterion of comfort can be shown as follows:

(0.593, 0.341, 0.066)

Estimation of Other Relative Weights:

In the previous section, the weight of each car regarding its comfort was estimated. Now, we should estimate the weight of cars concerning other criteria (price, fuel consumption and model) and the weight of the criteria with regard to the goal. In order to estimate these weights, first the decision maker should compare the cars in pairs with regard to each one of the criteria and then prepare the pair matrix. These pair comparisons are illustrated in tables (3-7) to (3-9).

Through the application of arithmetic average method, the weights of the cars are estimated concerning each criterion. The results of these estimations are demonstrated in table (9).

As can be observed car C has the best price (with the weight of 557%) and the most suitable consumption (with the weight of 639%) but with regard to the model car B (with the weight of 655%) is better than two other cars.

After the estimation of the weight of the cars regarding all criteria, the weight of the criteria should also be signified. In other words, the share of each one of the criteria in determination of the best car should be determined. For this purpose we need to compare the criteria in pairs. The pair preference of these criteria is asked from the decision maker and then pair comparison matrix is provided which is illustrated in table (10).

The weights of the criteria are estimated by arithmetic average method which are demonstrated below:

Price	0.398
Consumption	0.085
Comfort	0.218
Model	0.299

As can be observed, the criterion of price possesses the largest weight.

Estimation of the Final Weight of the Cars

Now that the weight of the criteria is estimated with regard to the objective and the weight of the cars is estimated with regard to the criteria, it's the time for the way of combining these weights to be explained for the estimation of the final weight.

Since the weight of the criteria reflects their significance in determination of the objective and the weight of each option with regard to the criterion indicates the share of that option in the related criterion, one can easily say that the final weight of each option is obtained from the product of weight of each criterion and weight of the related option of that criterion. Table (2-11) briefly illustrates the weight of the car with regard to the criteria.

Then, regarding the relative weights estimated, the final weight for each alternative would be obtained in the following way.

Final weight of car A = 0.398*0.123 + 0.085*0.087 + 0.218*0.593 + 0.299*0.265 = 0.265

Final weight of car B = 0.398*0.230 + 0.085*0.274 + 0.218*0.341 + 0.299*0.655 = 0.421

Final weight of car C = 0.398*0.557 + 0.085*0.639 + 0.218*0.066 + 0.299*0.080 = 0.314

Therefore the preference of the cars would be as follows: As can be observed, car B is the best choice.

Case Study:

Statement of the Problem

Municipality as a public and independent NGO has a wide range of responsibilities which are classified under three main groups of development

responsibilities, service responsibilities and administrative responsibilities. Development responsibilities of Municipality are carried out through the administration of development projects in the form of 8 plans. These plans include:

1. Urban development planning;
2. Directing and discharging the surface waters of the city;
3. Improvement of urban traffic;
4. Establishment of other protective installations in the cities;
5. Improvement of urban environment;
6. Construction of tourist, cultural and sport areas and establishments;
7. Construction of revenue making establishments;
8. Construction of other urban facilities and establishments.

As can be inferred from the titles of the plans there are many qualitative and quantitative factors within the organization or outside it that affect the significance of the plans. The municipal budget is limited and the significance of each of the factors is different. Therefore, the director as a decision maker should use a powerful scientific technique to decide which project should be preferred.

Significance and Justification of the study:

One of the most significant responsibilities of the directors is to make decisions. The more the responsibilities and powers of the directors is the more significant the act of making decisions would be. Since an appropriate and timely decision can have a significant effect on the organization, the necessity of the existence of a powerful technique that would be able to help the directors in this regard is quite noticeable. In short, we can say that in those cases that the decision making includes several qualitative and quantitative criteria and variables of different weight values the prioritization of municipal development projects have the same characteristic; therefore, the application of AHP technique which is a hierarchical analysis of decision making becomes quite significant, since in this technique, after knowing significant and essential factors, it is tried to establish a rational balance among different effective criteria and to signify their effects on one another by pair comparison and prior to making the final decision.

Purposes of the Study:

Since the Municipal Office is a public and independent institution and supplies its revenues from the citizens, then it is obliged to be responsible for the needs of the public. Some of these duties are fulfilled through the accomplishment of development projects.

The Municipal Office can not accomplish all projects at the same time, so it has to prioritize the projects in order to have the optimum selection and utilize its limited resources in the best possible way.

The purpose of this study is to utilize a proper method of decision making for the prioritization of the projects through exploration of effective qualitative and quantitative factors and assessment of their weight values in pairs and putting them in a matrix. Of course, this purpose is a means to the final end of the satisfaction of the customers (in municipal system the citizens).

Research Questions:

A- Main Question:

How are the municipal development projects of Qazvin prioritized?

B- Subordinate questions:

1. What are the effective criteria in prioritization of municipal development projects of Qazvin?
2. What value each criterion may have in prioritization of municipal development projects of Qazvin?

Statistical Community: Projects of Qazvin Municipal Office.

Data Analysis

Introduction

One of the major work processes of any human being is to make decisions. During the process of decision making people are willing to optimize their goal based on the best determined choices and criteria. In this part, the decision is to be made about the projects of Qazvin Municipal Office. First, the completed forms are distributed in order to collect data based on the opinions of experts and directors. Then, through classification of the opinions presented in the questionnaires, the factors affecting the projects of Municipal Office were signified based on the highest scores acquired (higher than 7).

Then, through utilizing pair comparison method the projects are compared with regard to the effective factors. After providing the matrices and normalized matrix, the score of each project is determined with regard to all factors. Finally, the priority of the proposed projects is determined based on the analysis of compatibility rate of the comparisons. All municipal development projects within 8 development plans of the year 2003 were analyzed through several sessions of determining the repetitions of all criteria and indices, the 313 projects were distinguished and recorded.

These criteria were classified under 5 dimensions including:

1. Social criteria;
2. Municipal techno-developmental;
3. Environmental;
4. Economical;
5. Safety and health.

The total number of 313 projects were reduced to 26 and then to 25 criteria in the following specialized sessions and after more analyses. Projects were given scores from (1) to (9) and then submitted to the development and municipal experts in municipal and provincial headquarters who are experience in the administration of the projects.

The projects accomplished are demonstrated below in order. General indices of municipal developmental plans have designed 36 projects based on the opinions of the experts which are demonstrated below.

These factors were reduced to 25 criteria based on the opinions of the experts.

Table 1- These scores are presented by a group of experts and then they have been evaluated. As a result, the average means of the scores for each option have been listed in table 14 based on 22 factors.

In order to determine the score of the most significant factor affecting the selection of the appropriate project, those factors which have an average score higher than 7 are selected and the others are eliminated. The real factors which affect the selection of the appropriate project among those factors with scores higher than 7 include the following 11 factors.

Security and safety and welfare of the users;
Improvement of urban traffic;
Infrastructural aspects of the plan;
Possession of the land;
Improvement of urban sight;
Being economical and providing revenue making resources or reducing the costs;
Cost of administration of the project based on the budget;
Documentation of the plan;
Geographical and ecological conditions;
Coordination with other plans;
Recreational criteria and Chances for public to spend spare times;
Absorption of national and provincial credits;
Period of the plan.

Selection of the Proposed Project to Create Utilization Affairs

In this part, the evaluated projects are selected. First, the projects are named and then in the prioritization stage and in pair comparison tables, numbers are used. So, in order to give them preferences, the following projects are selected based on 10 factors which have been considered appropriate.

1. Administration of comprehensive program of privacy;
2. Garbage recycling;
3. Improvement of city entrances;
4. Directing and discharging the surface waters;
5. Improvement of urban traffic and transportation;
6. Establishment of Baragin Park;
7. Reestablishment and improvement of traditional gardens in Qazvin;
8. Establishment of western, eastern and central terminals ;
9. Administration of Green Belt in Qazvin;
10. Securing Navvab and Baragin Rivers within the urban limits.

Application of AHP

Now that the projects are selected for prioritization of effective factors in evaluation of the projects, the projects are evaluated by AHP method which is a multi-stage method.

Structure of the Tree of Decision Making

The first step in Analytic Hierarchical Process is to provide a graphics illustration of the problem.

The tree of decision making is the graphic presentation of decision making strategy. In this structure, first the objective of decision making is written and then, the effective factors in making decision are written vertically and in order of their significance in separate levels of decision making tree (In this study, the factors affecting decision making are placed at the same level). In the bottom level of the tree (level 3) the options involved in decision making (proposed projects) are written. The column can be described in the following way:

Level 1: The objective of decision making is to utilize qualitative and quantitative factors and determining the priority of the appropriate project for utilization.

Level 2: The effective factors in determination of the appropriate project are those 13 factors which had been selected in the previous part.

Level 3: The proposed projects are those 10 projects selected in the previous chapters. The graphic structure is presented below.

Based on the AHP method and analysis of the data, the final result is reported according to table 17 As can be observed, the project of improving urban transportation and traffic obtains the first preference.

Conclusion:

When a group of experts finished the job of data collection especially on weighing the projects and calculation operations, the results of the research are presented to the directors and researchers. It should be mentioned that decision making techniques do not affect the decision making; however, they provide us with a systematic method so that we would be able to come to the best answer with our own priorities.

The calculations made about the prioritization of the projects by the method of AHP and base on 13 factors and 10 options (projects) indicate that the

proposed projects which have been evaluated are prioritized in the following order:

1. First priority: Improvement of urban transportation and traffic scoring 0.118;
2. Second priority: Improvement of the city entrances scoring 0.115;
3. Third priority: Administration of Qazvin's Green Belt scoring 0.1032
4. Forth Priority: Establishing Barajin Park scoring 0.1029;
5. Fifth priority: Establishment of Eastern, Western and central terminals scoring 0.1025
6. Sixth priority: Implementation of the comprehensive plan of privacy scoring 0.1014;
7. Seventh priority: Controlling and discharging the surface waters scoring 0.100;
8. Eighth priority: Recycling the garbage scoring 0.0864;
9. Ninth priority: Making Navvab and Barajin Rivers secure within the urban district scoring 0.086;
10. Tenth priority: Reconstruction and improvement of traditional gardens of Qazvin scoring 0.083.

Table (1) the value of the preferences for pair comparisons

Degree of significance	Definition	Description
1	Equally preferred	Both activities play an equal role in achieving the desired destination
2	Moderately preferred	The experience and the judgment support one of the activities to some degree
5	Strongly preferred	The experience and the judgment strongly support one of the activities
7	Very strongly preferred	One of the activities is focused much more than other activities and its prevalence is evident in practice
9	Extremely preferred	Evident preference of one activity over another; the highest possible order is verified
2,4,6,8	For the states where the degree of significance is between the above-mentioned values	The preferences within the above-mentioned intervals

Table 2. Comparison matrix for 3 cars regarding their comfort.

	Car A	Car B	Car C
Car A	1	2	8
Car B	½	1	6
Car C	1/8	1/6	1

Table 3: The results of first step of the algorithm (adding up of the columns)

	Car A	Car B	Car C
Car A	1	2	8
Car B	½	1	6
Car C	1/8	1/6	1
Sum of each column	13/8	19/6	15

Table 4: The results of second step of the algorithm (normalizing the columns)

	Car A	Car B	Car C
Car A	8/13	12/19	8/15
Car B	4/13	6/19	6/15
Car C	1/13	1/19	1/15

Table 5: Estimation of the average mean of the components of each row

	Car A	Car B	Car C	The average of the row
Car A	0.615	0.631	0.533	0.593
Car B	0.308	0.316	0.316	0.341
Car C	0.077	0.053	0.053	0.066
Sum	1.000	1.000	1.000	1.000

Table 6: Pair comparison matrix for three cars regarding their price

	Car A	Car B	Car C
Car A	1	1/3	¼
Car B	3	1	½
Car C	4	2	1

Table 7: Pair comparison matrix for three cars regarding their consumption

	Car A	Car B	Car C
Car A	1	1/4	1/6
Car B	4	1	1/3
Car C	6	3	1

Table 8: Pair comparison matrix for three cars regarding their model

	Car A	Car B	Car C
Car A	1	4	4
Car B	3	1	7
Car C	1/4	1/7	1

Table 9: Weight of cars for the criteria of price, consumption and model

	Price	Consumption	Model
Car A	0.123	0.087	0.265
Car B	0.320	0.274	0.655
Car C	0.557	0.639	0.080

Table 10: Pair comparison matrix of the criteria

	Price	Consumption	Comfort	Model
Price	1	3	2	2
Consumption	1/3	1	¼	¼
Comfort	1/2	4	1	1/2
Model	1/2	4	2	1

Table 11: The weight of the cars concerning the criteria

	Price	Consumption	Comfort	Model
Car A	0.123	0.087	0.593	0.256
Car B	0.320	0.274	0.341	0.655
Car C	0.557	0.639	0.066	0.080

Table 12: Final Preference of the cars

Final weight	Car	Preference
0/431	B	1
0/314	C	2
0/265	A	3

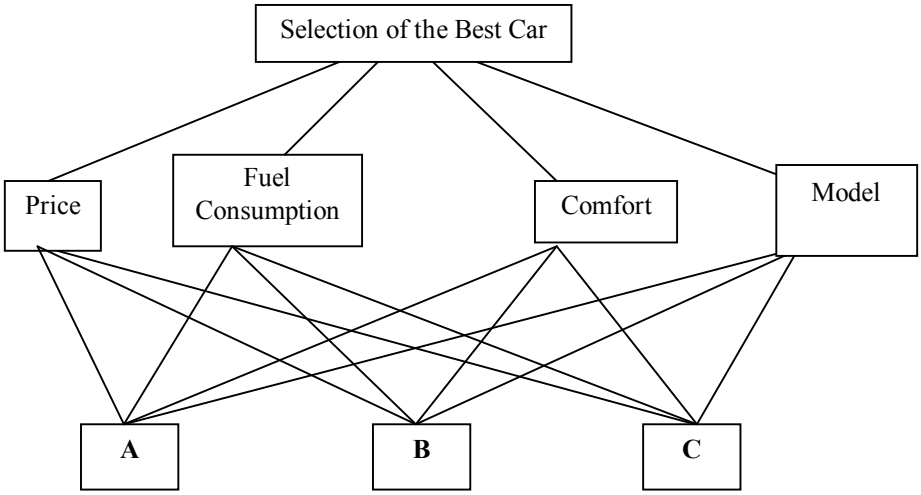

Fig 1: hierarchy of selection of a car

Table 13: 36 Developmental plans based on the opinions

Row	Developmental plans	Row	Developmental plans
1	Providing revenue making resources	19	Municipal and architectural criterion
2	Cost of the plan	20	Public recreation
3	Public need for the plan	21	Ecological conditions of the plan
4	Geographical conditions	22	Infrastructural aspects
5	Chances for public to spend spare times	23	Absorption of capital from the private sector
6	The rate of added value of the plan	24	Being attentive to the public health
7	Social criterion	25	Possession of the land used for the plan
8	Cultural criterion	26	Tourist attraction
9	Historical criterion	27	Promotion of public knowledge
10	Population of users	28	Reducing public roughness

11	Natural criterion	29	Improvement of urban sight
12	Environmental criterion	30	Public security
13	Economical criterion	31	Service utilization of the plan
14	Administration period	32	Improvement of urban traffic
15	Economical plan	33	Public participation in the plan
16	Public welfare	34	Credit for the plan
17	Absorption of national and provincial credits	35	Coordination with other plans
18	Employment	36	Documentation of the plan

Table 14. average means of the scores for each option

Row	Factor	Scores out of 9
1	Cost of administration of the plan	7.29
2	Providing revenue making resources	7.79
3	Absorption of national and provincial credits	7.16
4	Geographical conditions and area	7.63
5	Ecological conditions	7.29
6	Infrastructural aspects of the plan	8
7	Possession of the land	7.95
8	Improvement of urban sight	7.83
9	Improvement of urban traffic	8.04
10	Coordination with other plans	7.29
11	Documentation of the plan	7.75
12	Recreational criteria	7.20
13	Chances for public to spend spare times	7
14	Population of users	7.75
15	Promotion of public knowledge	7.04
16	Public welfare	7.62
17	Public health and security	8.16
18	Being economical	7.29
19	Period of the plan	7.08

Table 15. Final result

Rank	Final score	Description
6	0.1014	Implementation of comprehensive plan of privacy
8	0.0864	Recycling
2	0.1155	Organization of the entrances of the city
7	0.1002	Controlling and discharging the surface water
1	0.1182	Improving the urban transportation and traffic
4	0.1029	Establishment of Barajin Park
10	0.0836	Reconstruction and improvement of traditional gardens of Qazvin
5	0.1025	Establishment of east, west and central terminals
3	0.1032	Implementation of Qazvin green belt
9	0.0860	Making Barajin and Navvab rivers secure within the urban restrict

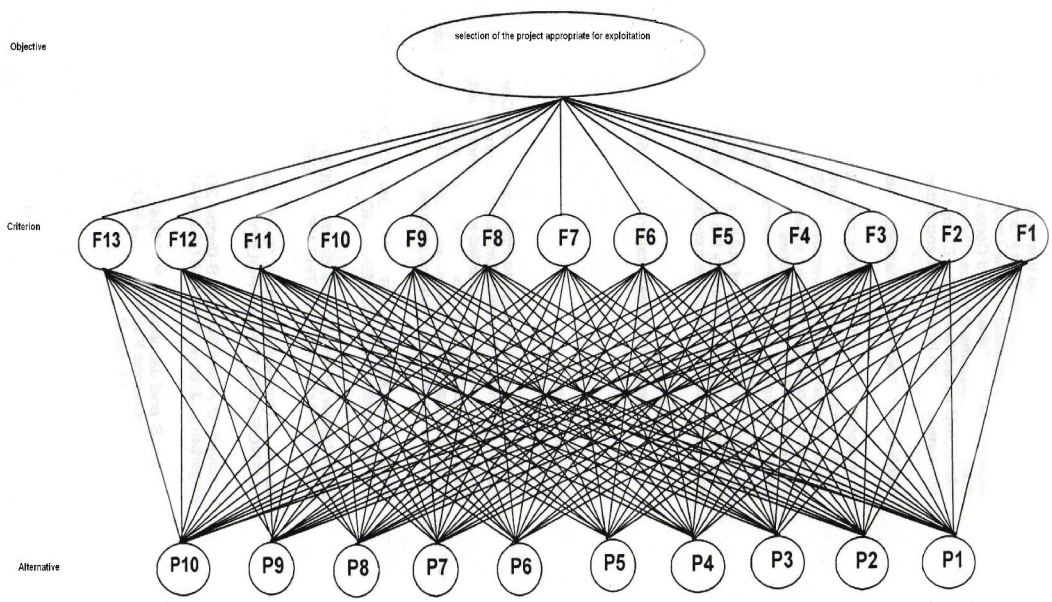

Fig 2: Structure of the Tree of Decision Making

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