Journal of Novel Applied Sciences
Available online at www.jnasci.org
©2013 JNAS Journal-2013-2-S/851-855
ISSN 2322-5149 ©2013 JNAS

Selection optimal type of dam using AHP method

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ABSTRACT: Hydro dams are affected by major factors in designing and construction process and lack of identification and evaluation lead to irrecoverable consequences in production and profitability stages. Given the number and characteristics of these factors, the use of scientific methods in management decision making and evaluation is necessary. Among these strategies there is multi-criteria decision making method. This method consists of techniques and analytic hierarchy process as one of the most widely used techniques in the field of multi-criteria decision making method. Key features and criteria were identified in this study related to Gardalan dam in Kurdistan of Iran in Iwpco. and results were provided at the end of the study.

Keywords: Multi-criteria decision making, Decision making criteria, AHP, Hydro dams, Selection optimal type of dam.

INTRODUCTION

Hydro dams due to contain water reservoirs and the production of hydropower as a renewable and clean energy is of utmost importance. Given the number of factors in the designing and construction of dams it can be referred to technical indicators, economic, social, environmental factors and need to analyze and evaluate all indictors', multi-criteria decision-making processes as the scientific method. The decision to this effect is used. AHP is one of the most famous multi-criteria decision making techniques in this field of research that has already been used. AHP has most benefit in helping to decision process and due to has image can be easily understanding. In other words, the complex decision process is divided into manageable sections. And better understanding of the elements is achieved by integration of decision criteria. In this way, the qualitative and quantitative data are scoring through the paired comparisons.

According to importance of the strategic plans advancing in section of water securance and energy producing in the countries. it is necessary to use proper executive methods of decisions making in this zone. In this regard the aim of this research is to Selection optimal type of dam with evaluation decision criterias using AHP.

MATERIALS AND METHODS

Hydro Dams

Any obstacle in flow of water leads to increase the height of water and saving it and it is called dam. In other hand, dam is a structure constructed in width of livers in order to collect and increase height of water.

Selection optimal type of dam and its body

Since water collected behind a dam could apply considerable amount of forces on the dam body so the static and stability of dam is considered in designing and the dams are classified into a gravel embankments or concrete coverage (CFRD) and concrete dams are divided. Criteria considered for evaluating and selecting the appropriate option in the properties are as follows:

- Geological conditions
- Building Materials

- Hydraulic Structures
- Cost

AHP

The data collected from the hierarchical analysis of clinical research in the field of multi-criteria decision making techniques are used. This type of decision making rather than a measure of optimality, multiple criteria are used together to determine the best option.

This method was first proposed in 1980 by Thomas Saati and it is based decision making paired comparisons. The comparison of each of the alternatives evaluated according to the criteria and their relative weights are calculated. The logic of such matrices of AHP is paired comparisons which makes the combined weight of the decision optimal (Mehregan, 2006).

Another benefit of this method of multi-criteria decision is determine the consistency and inconsistency of decision. Also in this process different alternatives interfering in decision and Sensitivity analysis on the criteria and sub-criteria are possible.

Practical application of the analytic hierarchy process involves four basic steps (Atai, 2010):

First, the hierarchical diagram: In this stage, the decision problem is decomposed into a hierarchy of levels in the graph. The first layer indicates main objectives of the decisions making and the second layer contains principle indices and the third level offers decisions making options.

In the second step every level is measured as indices and options relative to related element in higher level as pair. This measurement is done by formation of matrices that their importance is determined numerically relative to each other and then the options are selected . In order to calculations and measuring indices weights the scores of distributed questioners with numeric value of 1 to 9 are used that they are proposed as pair comparison. A paired comparison matrix is shown below: (Atai - 2010).

$$A=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

The matrix element a_{ij} is the element of favor *i* relative to *j*. In the paired comparison matrix of criteria other than the base diameter of the inverse matrix are:

$$a_{ij}=\frac{1}{a_{ji}}$$

Paired comparison matrix is as n*n where n is number of indices of each level relative to related indices compared in its higher level.

For each paired comparison matrix, the diagonal elements are equal and do not need to evaluate the other matrix and the elements should be determined based on paired comparisons. Symmetric elements relative to the diagonal entries of the matrix are inverse to each other. The number of paired comparisons for each paired comparison matrix n*n is:

$$N_c=\frac{n(n-1)}{2}$$

In general, if the decision of m alternatives and n criteria must be n paired comparison matrix m*m and a paired comparison matrix n*n. The number of paired comparisons hierarchy (the whole thing) is:

$$N_h=\frac{n(n-1)}{2}+\left[n\times\frac{m(m-1)}{2}\right]$$

Different methods for calculating the relative weights of the paired comparison matrix are the most important, least-squares, logarithmic least squares method, eigenvector methods and techniques are approximate. Among these methods, the eigenvectors method is more accurate.

In this study, using the arithmetic mean method of calculating the relative weights are approximate and we calculate the relative weights of criteria and alternatives. This is expressed by the following formula and we normalized each column and each row vector of average weight was achieved.

$$\frac{\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}}{\sum_{i=1}^{n} x_{i1} \quad \sum_{i=1}^{n} x_{i2} \quad \sum_{i=1}^{nm}\sum_{j=1} x_{ij}} \Rightarrow \begin{bmatrix} \frac{x_{11}}{\sum_{i=1}^{n} x_{i1}} & \frac{x_{12}}{\sum_{i=1}^{n} x_{i2}} & \cdots & \frac{x_{1m}}{\sum_{i=1}^{n} x_{ij}} \\ \frac{x_{21}}{\sum_{i=1}^{n} x_{i1}} & \frac{x_{22}}{\sum_{i=1}^{n} x_{i2}} & \cdots & \frac{x_{2m}}{\sum_{i=1}^{n} x_{ij}} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{x_{n1}}{\sum_{i=1}^{n} x_{i1}} & \frac{x_{n2}}{\sum_{i=1}^{n} x_{i2}} & \cdots & \frac{x_{nm}}{\sum_{i=1}^{n} x_{ij}} \end{bmatrix} \Rightarrow \begin{bmatrix} \frac{\frac{x_{11}}{\sum_{i=1}^{n} x_{i1}} + \frac{x_{12}}{\sum_{i=1}^{n} x_{i2}} + \dots + \frac{x_{1m}}{\sum_{i=1}^{n} x_{ij}}}{m} \\ \frac{\frac{x_{21}}{\sum_{i=1}^{n} x_{i1}} + \frac{x_{22}}{\sum_{i=1}^{n} x_{i2}} + \dots + \frac{x_{2m}}{\sum_{i=1}^{n} x_{ij}}}{m} \\ \cdots \\ \frac{\frac{x_{n1}}{\sum_{i=1}^{n} x_{i1}} + \frac{x_{n2}}{\sum_{i=1}^{n} x_{i2}} + \dots + \frac{x_{nm}}{\sum_{i=1}^{n} x_{ij}}}{m} \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ \cdots \\ a_n \end{bmatrix}$$

The final weight of each item on an analytic hierarchy process, multiplying the weight of each criterion is obtained by the rating option. Total points earned for each option can be obtained from the following equation:

$$A_{AHP_{Score}} = \sum_{j=1}^{n} a_{ij}.w_j = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \cdots & \cdots & \cdots & \cdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ . \\ w_j \end{bmatrix} \qquad i = 1,2,\dots,m$$

Where a_{ij} represents the relative importance of alternative i for criterion c_j and w_j is the importance and weight of criterion c_j. It also has the option values and weights of indices are normalized using the following relations.

$$\sum_{i=1}^{m} a_{ij} = 1 \qquad i = 1,2,\dots,m \qquad\qquad \sum_{j=1}^{n} w_j = 1$$

The final weight of each feature by calculating the options, the options is selected.

One of the benefits of AHP is control of consistency of decisions making. In other hand; the level of consistency can be calculated in AHP and judge acceptability and rejection of the measurements. In case of a inconsistency rate of 1/0 comments should be reviewed in the judgment and it is used to calculate the adjustment process (Atai, 2010)

1. Calculation of sum of the weight vectors: by the paired comparisons matrix we multiply the column vector of relative weights. Vector can be obtained through this new vector that is called a weighted sum.
2. Calculate the consistency vector: Vector elements of weighted sum obtained in the first stage assigned to the vector of the relative weights. The resulting vector is called vector compatibility.
3. Calculate Maxλ: gives the average consistency vector elements of Maxλ.
4. Consistency Index: it is obtained from following formula.

$$CI = \frac{\lambda_{Max} - n}{n-1}$$

n: is the number of options in the

5.-consistency ratio: in this stage adaptation of the index into the random consistency ratio obtains.

$$CR = \frac{CI}{RI}$$

Table 1. randomized Indicators

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.51

RESULTS AND DISCUSSION

Numerical Example

In this example, selection optimal type of dam are described. First, a hierarchical graph is drawn for Selection type of dam.

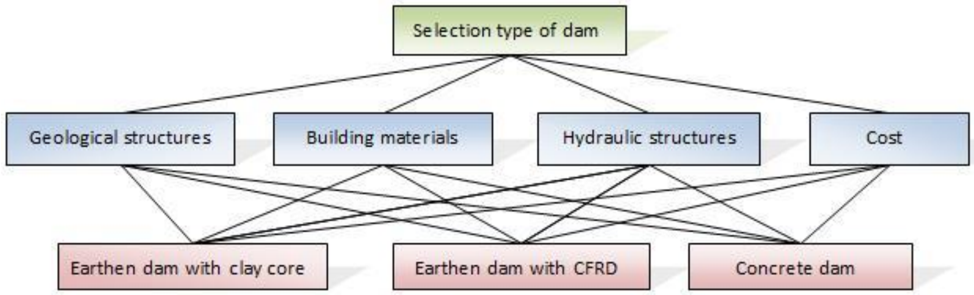

Figure 1. Diagram of hierarchical selection optimal type of dam

Second, the decision matrix is formed and paired comparisons are carried out between alternatives based on the criteria of selection type of dam and its paired comparisons of criteria.

Table 2. Paired comparisons of dam type selection with criteria Geological structure

	Clay core	CFRD	Concrete
Clay core	1	1	1
CFRD	1	1	1
Concrete	1	1	1

Table 3. Paired imprisons of dam type selection with criteria Building materials

	Clay core	CFRD	Concrete
Clay core	□	1/3	1/5
CFRD	3	□	1/4
Concrete	5	4	□

Table 4. Paired comparisons of dam type selection with criteria Hydraulic structures

	Clay core	CFRD	Concrete
Clay core	1	1	1/4
CFRD	1	1	1/5
Concrete	4	5	1

Table 5. Paired comparisons of dam type selection with criteria Cost

	Clay core	CFRD	Concrete
Clay core	1	1/3	1/4
CFRD	3	1	1/2
Concrete	4	2	1

Table 6. Paired comparisons criteria of dam type selection

	Geological structure	Building materials	Hydraulic structures	Cost
Geological structure	1	5	5	4
Building materials	1/5	1	1	1
Hydraulic structures	1/5	1	1	1
Cost	1/4	1	1	1

Third step involves the calculation of the relative weights and consistency ratio for each of the weights.

Table 7.Calculate the relative weight of dam type selection with criteria Geological structure

	Clay core	CFRD	Concrete	Inconsistency
weight	0.333	0.333	0.333	0

Table 8. Calculate the relative weight of dam type selection with criteria Building materials

	Site A	Site B	Site C	Inconsistency
weight	0.101	0.226	0.674	0.08

Table 9. Calculate the relative weight of dam type selection with criteria Hydraulic structures

	Site A	Site B	Site C	Inconsistency
weight	0.160	0.148	0.691	0.005

Table 10. Calculate the relative weight of dam type selection with criteria Cost

	Site A	Site B	Site C	Inconsistency
weight	0.122	0.320	0.558	0.02

Table 11. Calculate the relative weight of dam site selection criteria

	Geological structure	Building materials	Hydraulic structures	Cost	Inconsistency
weight	0.608	0.128	0.128	0.136	0.002

Table 12. The final weight of type dam for choosing optimal type of dam .

Fourth, relative weights are integrated to calculate the net weight of options for optimal selection.

CONCULSION

In today's world due to the complexity of decision-making environments and planning, high volume of Information and numerous problems in this environments, Not possible the One-dimensional attitudes of problems and does entail the holistic necessity in decisions. Therefore use the multi-criteria decision-making methods is considered for solving problems and providing appropriate solutions and results for managers and professionals.

Every project follows particular factors due to its conditions. Evaluation is usually done before implementation and production of the project by feasibility studies in order to reduce side effects and empower positive effects. Dam projects are important projects In the field of energy and water resources securance In every country because of effect of different strategic factors like political, economic, and social and environmental factors. Thus utilization of appropriate strategy in decision making process seems necessary in the field of pathology in different issues and its reduction and Increase efficiency and productivity.

By using AHP as an efficient method in multipurpose decision making it can be achieved effective results in evaluation and selection of the optima alternative. In this paper with case study of Gardalan dam and analyze the data obtained by using AHP method, the concrete dam was selected as the optimal type of dam.

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