Evaluation of the Ordered Weighted Averaging Method

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Abstract. This paper discusses and evaluates the ordered weighted averaging (OWA) approach. OWA is one of the decision-making methods. The order weights of OWA are key factors that make the decision for the given slections. There are several approaches to determine the order weights such as the minimal variability mean and the fuzzy linguistic quantifier method. This short paper proposes to use an analytic hierarchical process (AHP) to solve the same decision-making issue as OWA analyzed. A water resources management problem is selected as testing example. The simulation results shown that the proposed AHP based approach can obtain the best results.

Introduction

Decision making (DM) is a tool and approach that is used for problem solving. DM will make best or comprehensive decision for the possible choices in problem solving. It cares about what action or decision or selection that will be adopted. DM is also a process of cognitive function. However, it more addresses on what selection or decision to take and what other choices are available in the given problem. The processes of DM will certainly obtain a final decision. This decision or choice is corresponding to an opinion about the problem. Generally, the DM process contains the several steps as below[1]:

1). Determine the problem.
2). Find the relative factors.
3). Search the potential choices.
4). Analyze the choices.
5). Select the best choices.
6). Make the final decision.
7). Set up a control and evaluation system.

OWA is one of the decision-making approaches or tools. The order weights of OWA are important factors that make the decision for the given slections. There are several approaches to determine the order weights such as the minimal variability mean and the fuzzy linguistic quantifier method. Reference [2] introduced a new model based on sensitivity analysis to reflect the optimal level of the decision making, which demonstrated the different behaviors of the OWA when the order weights were computed by the fuzzy linguistic quantifiers (FLQ) and the minimal variability (MV) method. It reported a new reliable criteria to select the best project, which is applied in a water resources management problem. The obtained results are comprehensive optimal based on the criteria and sensitivity feature. However, Reference [2] did not consider the relative importance of the criteria, that is, all the criteria are handled with the same importance or weight. This short paper uses an analytic hierarchical process (AHP) to deal with this issue, and applies it to the same test example, that is a water resources management problem. The results, which are compared with those obtained by the ordered weighted averaging method, show that the proposed approach is more meaningful than OWA method for the same test example.

Application of AHP and Compare it with OWA

The analytic hierarchy process (AHP) is also a decision-making method [3-6]. AHP concerns the criteria and choices or alternatives, assesses the tradeoff or compromise, and conducts a comprehensive analysis to reach a final choice. It is a good mean to solve the complex problems. These problem generally are very difficult to handle quantitatively. Therefore, AHP is very suit to the senarios that involve complicated problem with both qualitative and quantitative.

For the purpose of comparsion, the same example from reference [2] is used in the paper. The example is about evaluations of water resources projects. The corresponding data based on seven criteria of the example are shown in Table 1.

Table 1. Data for assessments of water resources projects

Projects /criteria	Allocation of water to prior usages	Number of beneficiaries	Supporting other projects	Benefit/ cost	Range of environmental impacts	Public participatio n	Job creation
1 Sahand	0.64	0.1	0.59	0.49	0.85	0.78	0.78
2 Shahriar	0.48	0.7	0.59	0.59	0.85	0.65	0.78
3 Ghalechai	0.95	0.3	0.24	0.5	0.42	0.13	0.44
4 Kalghan	0.48	0.2	0.47	0.55	0.42	0.65	0.44
5 Germichai	0.95	0.4	0.71	0.47	0.42	0.53	0.67
6 Givi	0.48	0.1	0.12	0.49	0.85	0.78	0.67
7 Taleghan	0.80	0.7	0.82	0.46	0.28	0.39	0.56
8 Talvar	0.80	0.7	0.12	0.55	0.85	0.13	0.56
9 Galabar	0.80	0.4	0.12	0.65	0.85	0.13	0.78
10 Sanghsiah	0.48	0.2	0.59	0.46	0.85	0.13	0.78
11 Soral	0.48	0.2	0.47	0.46	0.85	0.13	0.78
12 Siazakh	0.48	0.7	0.71	0.46	0.85	0.13	0.78
13 Bijar	0.95	0.7	0.82	0.37	0.42	0.13	0.78

In this short paper, the importance of the seven criteria won't be the same. It is hard to directly get the order of the criteria since some factors cannot be quantified directly. But AHP can deal with these factors or data through quantifying the decision-maker's thinking. Thus, it can be adopted to calculate the weightings for different factors or criteria. According to the principle of AHP, the weighting coefficients of the factors or criteria can be obtained through the calculations of a judgment matrix, which reflects the comparison and judgment of a series of pair of criteria or factors.

Since the criteria "Number of beneficiaries", "Benefit/cost", and "job creation" have similarity compared with the other criteria, we call them as a SET. However, three criteria in the SET are not of equal importance. According to the experience of the project managers and the 9-scale method [6], a judgment matrix can be formed as shown in Table 2.

Table 2. Judgment matrix of criteria SET

SET Judgments	Number of beneficiaries	Benefit/ cost	Job creation
Number of beneficiaries	1	2	3
Benefit/cost	1/2	1	3
Job creation	1/3	1/3	1

Similarly, for the other four criteria and the SET, the following judgment matrix can be formed as shown in Table 3.

Table 3. Judgment matrix of SET and four criteria

Other Judgments	Allocation of water to prior usages	Range of environmental impacts	SET	Supporting other projects	Public participation
Allocation of water to prior usages	1	1/2	1/3	1	2
Range of environmental impacts	2	1	1/2	2	3
SET	3	2	1	4	5
Supporting other projects	1	1/2	1/4	1	1
Public participation	1/2	1/3	1/5	1	1

By use of AHP algorithm, the weighting factors of the seven criteria are computed and listed in Table 4, and the final weighting factors and ranking of the 13 projects are shown in columns 3 and 4 of Table 5, where the project Shahriar is ranked number one, and the project Ghalechai is ranked last. Comparing with the best results of reference [2] that are listed on column 2 of Table 5, the results obtained in this paper are more reasonable since the relative importance of the criteria is considered.

Table 4. The weighting factors of seven criteria

Projects	Allocation of water to prior usages	Number of beneficiaries	Supporting other projects	Benefit/ cost	Range of environmental impacts	Public participation	Job creation
Weights	0.1346	0.2282	0.1105	0.1439	0.2347	0.0853	0.0605

Table 5. The results and comparison of the water resources projects

Projects	OWA method Ranking [2]	The proposed method Weighting factors	Ranking No.
1 Sahand	3	0.077453	7
2 Shahriar	1	0.100203	1
3 Ghalechai	7	0.059133	13
4 Kalghan	6	0.062248	12
5 Germichai	2	0.079704	6
6 Givi	13	0.066088	10
7 Taleghan	4	0.084713	5
8 Talvar	9	0.085105	4
9 Galabar	11	0.076154	8
10 Sanghsiah	10	0.066737	9
11 Soral	12	0.064656	11
12 Siazakh	5	0.089949	2
13 Bijar	8	0.085557	3

Conclusion

This short paper analyzed one of the decision making methods - the ordered weighted averaging (OWA), and compared it with another decision making approach - analytic hierarchical process (AHP). Two methods are tested on the same example, that is, water resources management problem. The calculated results show that the proposed AHP approach obtained the better and more meaningful results compared with the OWA method.

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