MULTI-STAKEHOLDER WATER RESOURCES MANAGEMENT PROBLEM USING IMPROVED OWA OPERATOR

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ABSTRACT

In this paper a group decision making model has been developed for the extraction of the effective criteria and their weights, needed in ranking water resources projects. This model is based on the improved version of Ordered Weighted Averaging (OWA) as an aggregation operator. The order weights of this operator have been extracted by using the Minimal Variability method. Using Improved OWA, 13 water resources projects in Sefidrud watershed has been ranked based on the group opinions on the criteria.

INTRODUCTION

It is necessary to consider the technical, environmental and social implications of water resources projects, in addition to the economical criteria to ensure sustainable decisions and favorable decision outcomes. This requires engaging stakeholders and DMs at every stage of the decision making process, which uses multi-criteria decision making (MCDM) and group decision making (GDM) techniques. A MCDM model needs relative importance weights of the criteria. In this paper by GDM analysis, the preference information presented by the DMs are aggregated to form a collective opinion. OWA [2] as an aggregation operator is a mapping, $F: I^n \longrightarrow I$ that has an associated n-dimensional vector $w_i = (w_1, w_2, ...; w_n)$, namely order weights where $I, w_i \in [0,1]$ and $\sum_{i=1}^{n} w_i = 1$, and then:

$$F = OWA(a_1, a_2, ..., a_n) = \sum_{j=1}^{n} w_j b_j = w_1 b_1 + w_2 b_2 + ... + w_n b_n \qquad (2)$$

b_j is the j th largest element of the set of the aggregated objects $(a_1;\ a_{2;}\ ...; a_n)$ and n is the number of inputs. This paper at the first describes Improved OWA to aggregate the preferences of a group of DMs. After describing a real case study some water projects will be ranked by using the Improved OWA.

METHODOLOGY: IMPROVED OWA

Actually initial OWA have been extended in three steps to model the GDM problem in Sefidrud case study. At first, order weights have been extracted by the Minimal Variability method. Second linguistic inputs have been modeled by triangular fuzzy numbers and third the inputs had various importance according to the different powers of DMs (p_j). This extended version of OWA has been named Improved OWA and described more in the following steps:

Step 1: Following Table 3, in this paper the Minimal Variability method has been used in exploring order weights. This method was introduced by [1] as a nonlinear optimization problem to derive order weights based on the entropy model.

Step 2: Since the inputs of OWA should be normal values it is needed to convert linguistic inputs of decision matrix (for example data in Table 2) to numbers in the interval [0, 1]. Linguistic numbers can be modeled by equivalent triangular fuzzy numbers and then defuzified by max-membership method.

Step 3: OWA supposes the same importance for inputs. But according to the Table 2, power of DMs (p_j) are different. Then it is necessary to multiply the preferences of DMs with their importance.

In application the Improved OWA**,** the optimism degree of supervisor**,** θ is needed**.** In this study linguistic quantifiers have been used by questioning the supervisor. How much the supervisor wants to include preferences of more people in the GDM problem he is more pessimistic.

CASE STUDY: SEFIDRUD WATERSHED

The watershed of Sefidrud, located in the Northwestern region of Iran, has an area of 58000 square kilometers and includes a population around four millions. Sefidrud is an important watershed in Iran with respect to water potential and possibilities of water resources development. This study needs identifying the effective criteria and their importance. In order to achieve this, 30 experts conducted a hierarchy of criteria. They participated in several sessions applying Value Management methodology. Experts were selected from the Government, consulting companies, universities and Non-Governmental Organizations (NGOs). After defining the criteria the Water Resources Management Company as representative of the central Government conducted a board of decision makers including representatives of six water authorities sharing the Sefidrud. Then relevance powers of DMs according to the values applied by an independent consultant are assigned and are shown in Table 1 (Power of DMs). After describing the criteria to representatives of six water authorities, they gave their preferences (weights) as shown in Table 1 for the criteria. The preferences are: very high (VH), high (H), slightly high (SH), medium (M), slightly low (SL), low (L), and very low (VL).

Table 1- Weights of the criteria according to each DM
(Very high (VH), high (H), slightly high (SH), medium (M), slightly low (SL), low (L), and very low (VL))

Criteria		DMs: Water Authorities					
		1	2	3	4	5	6
No.	Power of DMs	M	H	SH	SL	L	H
1	Allocation water to prior usages	VH	H	H	M	SH	VH
2	Number of beneficiaries	H	H	M	SH	H	M
3	Supporting other projects	VH	L	M	SH	SL	VH
4	Benefit/Cost	SL	H	M	SH	M	SL
5	Range of negative environmental impacts	M	H	SH	SH	H	H
6	Public participation	VH	H	M	VH	M	SH
7	Job creation	H	M	H	H	M	H

Now by using Improved OWA the aggregated weights of each criterion have been resulted as in Figure 1.

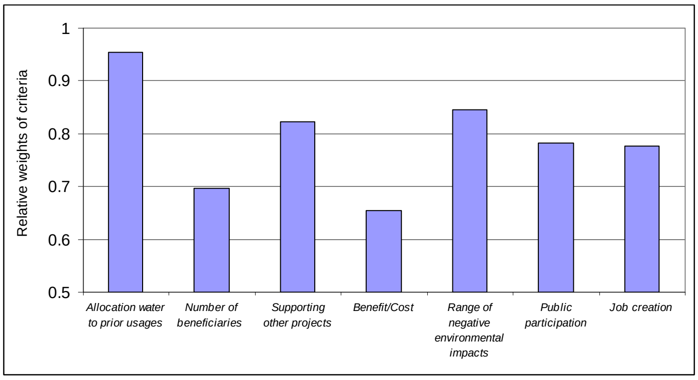

Fig. 1. Relative weights of criteria by group preferences aggregation using OWA operator

It is important to have consensus on the values of aggregated preferences before using them in the MCDM problem. In this paper, consensus measure is calculated by a distance method.

RANKING WATER RESOURCES PROJECTS

There are 13 water projects under construction in the Sefidrud watershed. By using the Improved OWA on the decision matrix, the scores of alternatives (13 water projects) has been calculated and then ranked as shown in Figure 2. According to the Fig. 2, 'Shahriar', 'Siazakh' and 'Bijar' are the three most preferred projects respectively and the 'Ghalechai' is the least preferred one.

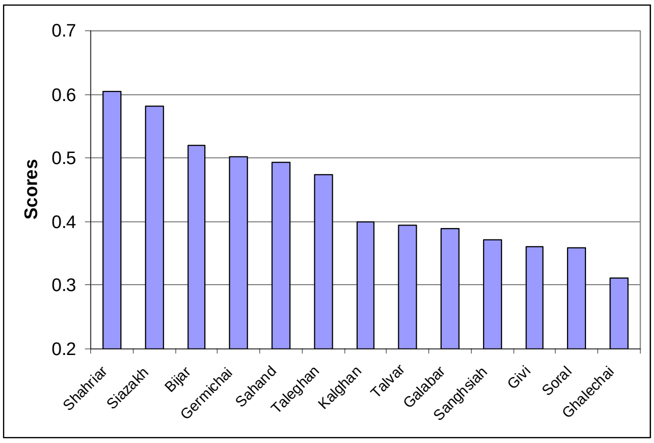

Fig. 2. Ranked Scores of water resources projects (under construction) using Improved OWA

CONCLUSION

Extraction of the effective criteria and their weights for ranking water projects in Sefidrud watershed were the main objective of this study. Implementation of Improved OWA in this case study revealed its capability for participatory water resources management.

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REFERNCES

[1] Fulle´r, R., P. Majlender, On obtaining minimal variability OWA operator weights, *Fuzzy Sets and Systems,* 2003, 136 , 203–215.

[2] Yager, R.R., On Ordered Weighted Averaging Aggregation Operators in Multi-Criteria Decision, *IEEE Transactions on Systems, Man and Cybernetics*, 1988, 18, 183-190.