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Application of Fuzzy Technique for Order-Preference by Similarity to Ideal Solution (FTOPSIS) to Prioritize Water Resource Development Economic Scenarios in Pishin Catchment

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Abstract

Water is a basic demand of sustainable development in most regions of the world. The non-uniform temporal and spatial distribution of water resources will lead to water shortage in arid and semi-arid areas. Pishin catchment is one of the most important catchments in South-East Iran. The basin had been faced with consecutive droughts in recent years. On the other hand, water resources development projects anticipated and necessary in this catchment. Hence, the need for a study to prioritize different scenarios and their effects on the catchment should be considered to overcome these dry periods. The main objective of the present study is to predict water development projects in the study area.

Due to the multiplicity of projects and high cost of them, the concurrent execution priority implementation of these projects is considered as an important factor. Fuzzy multiple attribute decision making is a suitable method for comparison, selection and prioritization of the different options taking into account different criteria. Hence, in this study, the effects of the water development projects are predicted using Water Evaluation and Planning System (WEAP) model. The projects according to the economic criteria are evaluated and prioritized with Fuzzy TOPSIS. Six water development projects and criteria including five economic indexes are considered. Based on the results, according to the investigated indicators, increasing irrigation efficiency in agricultural sector and reducing evaporation from the reservoir scenarios have top priority.

Keywords: Fuzzy Multiple Attribute Decision Making, WEAP Model, Prioritize, Agriculture Development Project, Pishin Catchment

Introduction

Shared water resources that are used by two or more beneficiaries lead to intensifying complexity in optimal allocation of water resources

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planning and management (Bouwer, 2000). On the other hand, the development of water projects in the region is very important and requires comprehensive review according to various indicators and prioritizes these projects. Due to the relative constancy of the water resources in the world, growing water crises is occurred with the population growth, unfair distribution of surface water and groundwater resources, increasing pollution of water resources, industrialized societies, insufficiency to international law in their treatment of joint water resources between countries, changing consumption patterns, the challenge of climate change and lack of water resource allocation mechanism (regulations allocation of water resources in the fifth development plan, 2010).

Pishin dam with a volume of about 112 million cubic meters is located in the south-east of Iran and constructed on Bahu Kalat river. This catchment due to the habitat of "Iranian short snout crocodile" is a center of tourist attraction.

Water is scarce source in Pishin catchment and this is an important input that is a very important economic and social resource for the people living in this region from Iran. It is essential to explore on how the future water resources management of the catchment will look like in order to have a better plan for sustainable social-economic development. There are wide variety of users (agriculture, drinking, environment and ...) of water with apparently different interests that are affecting on objectives.

Water efficient management in a catchment aims to increase water productivity, social justice and protection of ecosystems in the environment, require the identification and understanding a set of water-related interaction in different levels, spatial and temporal in the catchment. Lack of knowledge about the mentioned relationships, poor management of water supply and demand and actions of the management are the main causes of water crisis in many catchments. Nowadays water resources planning using multi-attribute decision-making has attracted the attention of many decision makers. This indicates that these methods provide the perfect solution for complex decision making of water (Zarghami *et al*., 2009).

Always implementing water release projects and management plans include many relevant factors and options that require appropriate management. Therefore, adoption and use of all factors are more effective and complex factors will evaluate them for the selection of the projects. In this context, in Pishin dam according to the water conditions different scenarios of the water resources management consulting with the department of energy are considered. Each of these scenarios have major impact on the water consumption in the region.

Research objectives

- Simulation of water resources system in Pishin Catchment by WEAP model.
- Determining the superior options of water development in Pishin catchment using fuzzy multi-criteria decision analysis.

Background Research

Fuzzy logic is "reasoning with fuzzy sets". Fuzzy management science is able to generate the models that almost like human processes with qualitative information intelligently. Thus, management systems become more flexible and it is possible to organize large and complex organizations in variable environments (Moemeni, 2010). Fuzzy theory is selected to take an effect action facing with uncertainty. The theory is able to convert most incorrect and enigmatic concepts, variables and systems into a mathematical form and set the context for reasoning, deduction and decision making at uncertainty conditions.

Russel and Skibniewski (1998) gave high priority to the factors including measures of reputation, past performance, financial condition, workload and technical expertise. Studies related to the discussion of water by using multiple attribute decision-making is collected as follows:

Sasikumar and Mujomdar (1998) proposed a fuzzy multi objective model for quality management in river systems. In this study, qualitative targets of organizations responsible for river water quality protection and pollutants discharge was considered in fuzzy form.

Chuntian (1999) to manage water resources in times of flood was used fuzzy multi-criteria optimization model.

Abrishamchi et al (2002) using multi-criteria decision were examined urban water management and selected the best water distribution in Zahedan city.

Group fuzzy multi-criteria decision by Razavi Toosi et al (2008) examined to prioritize projects of transferring water between basins.

Fuzzy multi-criteria decision-making methods and its application in management and flood control reservoirs were used by Fu (2008).

Talebi et al (2014) in water allocation priorities of dam Sanandaj using fuzzy analytic hierarchy process (FAHP) concluded that economic criteria with a part weight of 0.351 compared to the other two criteria have the greatest importance.

Shafaiyan fard et al (2015) were examined superior options exploitation of water resources using WEAP model and analysis and multiple attribute decision-making. According to results of this research, the scenario of further development in summer planting was selected. Other studies in this field include such as Huang et al (2015), Doulgeris et al (2015), Esteve et al (2015), Mourad and Alshihabi (2015), Asl Rousta & Araghinejad (2015), Al-omari et al (2015), Mishra et al (2015), Pouget et al (2016) and Anzab et al (2016) were investigated in a similar manner.

In the present study, the fuzzy topsis method for ranking scenarios of water projects is used in Pishin catchment to evaluate different scenarios of water management and prioritize them with some different objectives. The present study innovation is combine WAEP models and Fuzzy model in simulating and prioritizing of scenarios that for the first time this study was conducted. When a wide range of scenarios and different applications are available for the making decisions in this study area a fuzzy method is selected to compare them with each other. Also different possible scenarios are considered that can be occurred in the study area close to the real condition.

Material and Methods

Pishin catchment is formed from three important agricultural sector (agriculture demand), urban sectors and one environmental section. Priority of water supply in this region is agricultural, urban and environmental demands respectively.

In this study the combination of simulation model of water resources (WEAP) and fuzzy multiple attribute decision making (F-TOPSIS) in furtherance of the objectives of the project is performed that, so far have not been conducted in other studies with this form of water management in an arid area.

Therefore, first the water resource and planning system (WEAP) in Pishin catchment for different scenarios is simulated. Then with the application of certified expert person, opinions are determined six different scenarios of water resources in the coming years. In the next step applying scenarios in WEAP model, results of scenarios are predicted. Eventually, by using these results and the integration with fuzzy multiple attribute decision analysis the superior management options are determined. Figure (1) shows the research flowchart.

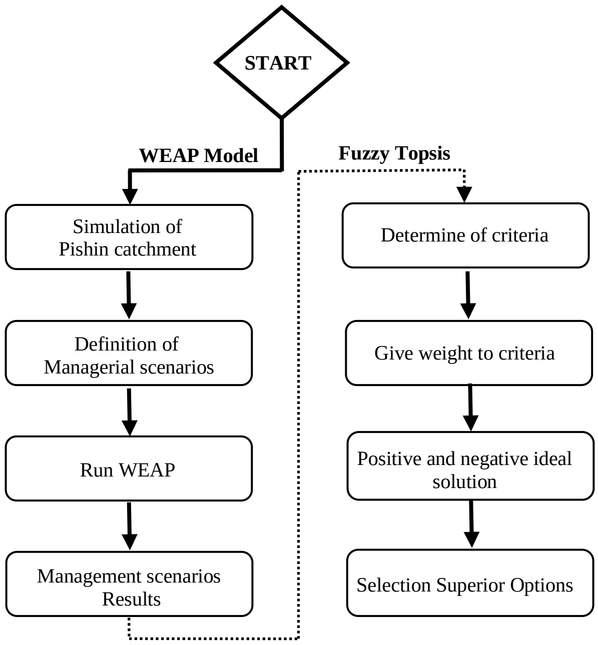

Figure 1: Conseptual model of the simulation methodology

WEAP Model

In engineering and simulation of water resources, WEAP model is developed by the *Stockholm Environment* institute and is based on the water balance, simulation, allocation and requires the drinking, agriculture, environment, services and industry demands in catchment area. The most important feature of this software is its application for simulation and allocation of the basin. (Sieber *et al*. 2005). This software delivers water allocation based on stakeholder prioritization. In general, the following equations are explained in this software; where LC is land cover, NI is non-irrigated, HU is hydro-unit and I is irrigated:

$$PrecipAvailableForET_{LC} = Precip_{HU} \times Area_{LC} \times 10^{-5} \times PrecipEffective_{LC}$$

(1)

$$ETpotential_{LC} = ETreference_{HU} \times Kc_{LC} \times Area_{LC} \times 10^{-5}$$

$$PrecipShortfall_{LC,I} = Max\left(0, ETpotential_{LC,I} - PrecipAvailableForET_{LC,I}\right)$$

(2)

$$SupplyRequirement_{LC,I} = \left(1 / IrrFrac_{LC,I}\right) \times PrecipShortfall_{LC,I}$$

$$SupplyRequirement_{HU} = \sum_{LC,I} SupplyRequirement_{LC,I}$$

(3)

Since, in this software, prioritization of allocation is very important, the following equations are considered:

$$Supply_{HU} = Calculated\ by\ WEAP\ allocation\ algorithm$$

$$Supply_{LC,I} = Supply_{HU} \times \left(SupplyRequirement_{LC,I} / SupplyRequirement_{HU}\right)$$

(4)

$$ETActual_{LC,NI} = Min\left(ETpotential_{LC,NI}, PrecipAvailableForET_{LC,NI}\right)$$

$$ETActual_{LC,I} = Min\,(ETpotentia_{LC,I}, PrecipAvailableForET_{LC,I} + IrrFrac_{LC,I} \times Supply_{LC,I})$$

(5)

$$EF_{LC} = ETActual_{LC} / ETpotential_{LC}$$

(6)

$$ActualYield_{LC} = PotentialYield_{LC} \times Max\left(0, \left(1 - YieldResponseFactor_{LC} \times \left(1 - EF_{LC}\right)\right)\right)$$

(7)

Runoff to both surface and groundwater water in basin can be calculated with the following equations:

$$Runoff_{LC} = Max\left(0, PrecipAvailableForET_{LC} - ETpotential_{LC}\right) + \left(Precip_{LC} \times \left(1 - PrecipEffective_{LC}\right)\right)$$

$$+ \left(1 - IrrFrac_{LC,I}\right) \times Supply_{LC,I}$$

(8)

$$RunoffToGW_{HU} = \sum_{LC}\left(Runoff_{LC} \times RunoffToGWFraction_{LC}\right)$$

(9)

$$RunoffToSurfaceWater_{HU} = \sum_{LC}\left(Runoff_{LC} \times \left(1 - RunoffToGWFraction_{LC}\right)\right)$$

(10)

Units and definitions for all variables above are:

Area [HA]: Area of land cover; Precip [MM]: Precipitation; Kc [-]: FAO crop coefficient; EF [-]: Fraction of potential evapotranspiration satisfied; Precip Effective [%]: Percentage of precipitation that can be used for evapotranspiration; IrrFrac [%]: Percentage of supplied water available for ET (i.e. irrigation efficiency); Potential Yield [KG/HA]: The maximum potential yield given optimal supplies of water; Actual Yield [KG/HA]: The actual yield given the available evapotranspiration; Yield Response Factor [-]: Factor that defines how the yield changes when the ET actual is less than the ET potential; Precip Available For ET [MCM]: Precipitation available for evapotranspiration; Runoff [MCM]: Runoff from a land cover; Runoff To GW [MCM]: Runoff to groundwater supplies; Runoff To Surface Water [MCM]: Runoff to surface water supplies; ET reference [MM]: Reference crop evapotranspiration; ET potential [MCM]: Potential crop evapotranspiration; Precip Shortfall [MCM]: Evapotranspiration deficit if only precipitation is considered; Supply Requirement [MCM]: Crop irrigation requirement; Supply [MCM]: Amount supplied to irrigation, calculated by WEAP allocation, Then an optimization problem can be solved according to the below:

$For\ each\ p = 1 to\ P$ — $For\ each\ demand\ priority$

$For\ each\ f = 1 to\ F \in (D_k^{P,t-n})$ — $For\ each\ supply\ preference\ to\ demand, k$

$Max\ \ Z = C_P$ — $Coverage\ to\ all\ demand\ sites\ k \in N\ with\ priority\ p$

$Subject\ to$

$$\sum_{j=1}^{n} x_{j,i}^{p} - \sum_{r=1}^{m} x_{i,r}^{p} + S_i^{t-1} = S_i^t \qquad Mass\ balance\ constraint\ with\ storage\ for\ node\ i\ to\ node\ r$$

$$\sum_{j=1}^{F} x_{j,i}^{p} = D_k^{p,t-n} \qquad Demand\ node\ constraint\ for\ demand\ k\ from\ j\ sources$$

$$\sum_{j=1}^{F} x_{j,i}^{p} = D_k^{p,t-n} \times c_k^p \qquad Coverage\ constraint\ for\ demand\ k\ from\ j\ sources$$

$$\sum_{j=1}^{F} x_{j,i}^{p} \ge D_k^{p,t-n} \times c_k^p \qquad Coverage\ constraint\ for\ ifr\ and\ reservoirs\ k\ from\ j\ sources$$

$$c_k^p = C \qquad Equity\ constraint\ for\ demand\ site\ k\ with\ priority\ p$$

$$c_k^p \ge C \qquad Equity\ constraint\ for\ ifr\ and\ reservoirs\ with\ priority\ p$$

$$0 \le c_k^p \le 1 \qquad Bound\ for\ demand\ site\ coverage\ variables$$

$$\begin{cases} x_{i,1}^{\succ p} = 0 & For\ Demand\ Site\ I\ with\ priority \succ P \\ x_{i,1}^{p} \ge 0 & For\ Demand\ Site\ k\ with\ priority = P \end{cases}$$

$$\begin{cases} x_{i,k}^{\succ f} = 0 & For\ Demand\ Site\ k\ with\ priority \succ f \quad next\ f \\ x_{i,k}^{f} \ge 0 & For\ Demand\ Site\ k\ with\ priority = f \quad next\ p \end{cases}$$

(11)

FUZZY TOPSIS Method

In the TOPSIS method, accurate and definite values are applied to determine criteria and weighted options. In most cases, human assumptions are accompanied by indeterminacy and this fact influences decision-making. Therefore, it is better to use fuzzy methods that the method of the similarity to fuzzy ideal option is one of such methods. In this case, the elements of decision-making matrix or criteria weight or both of them are evaluated by using lingual variables presented by fuzzy umbers and thereby the problems with the method of similarity to ideal option have been overcome.

Fuzzy TOPSIS method steps

Chen and Huang have described the stages of fuzzy TOPSIS method in the multi-criteria decision making with *n* criterion and *m* option as follows:

Stage 1: The formation of decision matrix

Therefore, the number of criteria and options in technique and the computing of all options main for criteria, decision matrix is formed as follows:

$$\tilde{D} = \begin{bmatrix} \tilde{\chi}_{11} & \tilde{\chi}_{12} & \cdots & \tilde{\chi}_{1n} \\ \tilde{\chi}_{21} & \tilde{\chi}_{22} & \cdots & \tilde{\chi}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{\chi}_{m1} & \tilde{\chi}_{m2} & \cdots & \tilde{\chi}_{mn} \end{bmatrix} \qquad (12)$$

When fuzzy numbers are used, $\tilde{\chi}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ is the function of the option *i* *(i=1,2,…,m)* with *n* relation to the criterion *j* *(j=1,2,…,m)*. If decision maker committee has k member and fuzzy ranking k is of decision maker $\tilde{\chi}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ (triangular fuzzy number) for *(j=1,2,…,n)* and *(i=1,2,…,m)*, considering integrated fuzzy ranking criteria $\tilde{\chi}_{ij} = (a_{ij}, b_{ij}, c_{ij})$, therefore the options could be obtained as follows (Vafaei & Babaei, 2011; Ataee, 2010):

$$a_{ij} = \underset{k}{Min}\left\{a_{ijk}\right\}$$

$$b_{ij} = \frac{\sum_{k=1}^{k} b_{ijk}}{k} \qquad (13)$$

$$c_{ij} = \underset{k}{Max}\left\{c_{ijk}\right\}$$

Stage 2: Determining the matrix of criteria weight

In this stage, different criteria significance coefficient in decision-making is defined as follows:

$$\tilde{W} = \left[\tilde{W}_1, \tilde{W}_2, ..., \tilde{W}_n\right] \qquad (14)$$

Which if triangular fuzzy numbers is used, each component w_j (the weight of each criterion) is defined as $\tilde{W}_j = (\tilde{W}_{j1}, \tilde{W}_{j2}, \tilde{W}_{j3})$. If decision-making committee have k member and the k[th] significance coefficient of the decision maker $\tilde{W}_{jk} = (\tilde{W}_{jk1}, \tilde{W}_{jk2}, \tilde{W}_{jk3})$ (triangular fuzzy number) for j=1, 2,…, n the integrated fuzzy ranking $\tilde{W}_j = (\tilde{W}_{j1}, \tilde{W}_{j2}, \tilde{W}_{j3})$ could be obtained as follows:

$$W_{j1} = \underset{k}{Min}\left\{W_{jk1}\right\}$$
$$W_{j2} = \frac{\sum_{k=1}^{K} W_{jk2}}{k} \qquad (15)$$
$$W_{j3} = \underset{k}{Max}\left\{W_{jk3}\right\}$$

Stage 3: The normalization of fuzzy decision matrix

When every X_{ij} is fuzzy, every r_{ij} is undoubtedly fuzzy, as well. To normalize, linear scale change for transforming different criteria scale into applicable criterion is used. If fuzzy number is triangular, it will be calculated in non-scale decision arrangements for criteria with negative and positive dimensions as follows (Vafaei & Babaei, 2011; Ataee, 2010):

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c^*_j}, \frac{b_{ij}}{c^*_j}, \frac{c_{ij}}{c^*_j}\right)$$
$$\tilde{r}_{ij} = \left(\frac{a^-_j}{c_{ij}}, \frac{a^-_j}{b_{ij}}, \frac{a^-_j}{a_{ij}}\right) \qquad (16)$$

Which in these equations:

$$c^*_j = \underset{i}{Max}\, c_{ij}$$
$$a^-_j = \underset{i}{Min}\, a_{ij} \qquad (17)$$

Therefore, non-Scale fuzzy decision matrix ($\tilde{R}$) obtain as follows:

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{m\times n} \quad i = 1, 2, ..., m\ ;\ j = 1, 2, ..., n \qquad (18)$$

That m is the number of alternatives and n is the number of criteria.

Stage 4: Determining weighted fuzzy decision matrix

So, the weight of main different criteria, weighted fuzzy decision matrix is counted through multiplying significance coefficient related to each criterion in fuzzy normalized matrix as follows:

$$\tilde{V}_{ij} = \tilde{r}_{ij}.\tilde{w}_j \qquad (19)$$

That $\tilde{w}_j$ demonstrates the coefficient of criteria important C_j. Therefore, weighted fuzzy decision matrix will be as follows:

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n} \quad i=1,2,...,m\ ;\ j=1,2,...,n \qquad (20)$$

In this fuzzy technique, in the event that fuzzy numbers are triangular, for main criteria with a positive and negative measure, therefore (Vafaei & Babaei, 2011; Ataee, 2010):

$$\tilde{V}_{ij} = \tilde{r}_{ij}.\tilde{w}_j = \left(\frac{a_{ij}}{c^*_j}, \frac{b_{ij}}{c^*_j}, \frac{c_{ij}}{c^*_j}\right).(w_{j1}, w_{j2}, w_{j3}) = \left(\frac{a_{ij}}{c^*_j}.w_{j1}, \frac{b_{ij}}{c^*_j}.w_{j2}, \frac{c_{ij}}{c^*_j}.w_{j3}\right)$$

(21)

$$\tilde{V}_{ij} = \tilde{r}_{ij}.\tilde{w}_j = \left(\frac{a^-_j}{c_{ij}}, \frac{a^-_j}{b_{ij}}, \frac{a^-_j}{a_{ij}}\right).(w_{j1}, w_{j2}, w_{j3}) = \left(\frac{a^-_j}{c_{ij}}.w_{j1}, \frac{a^-_j}{b_{ij}}.w_{j2}, \frac{a^-_j}{a_{ij}}.w_{j3}\right)$$

(22)

Stage 5: Finding ideal fuzzy solution (FPIS, A*) and anti-ideal fuzzy solution (FNIS, A^-)

In fuzzy Topsis technique, Fuzzy Positive Ideal Solution (FPIS, A^*) and Fuzzy Negative Ideal Solution (FNIS,A^-) are calculated as follows:

$$A^* = \left\{\tilde{v}^*_1, \tilde{v}^*_2, ..., \tilde{v}^*_n\right\}$$
$$A^- = \left\{\tilde{v}^-_1, \tilde{v}^-_2, ..., \tilde{v}^-_n\right\} \qquad (23)$$

Which $\tilde{v}^*_i$ is the best value of i among all option and $\tilde{v}^-_1$ is the worst value among of all option. The values are obtained through the following equation:

$$\tilde{v}^*_j = \underset{i}{Max}\left\{\tilde{v}_{ij3}\right\} \quad i=1,2,...,m\ ;\ j=1,2,...,n$$
$$\tilde{v}^-_j = \underset{i}{Min}\left\{\tilde{v}_{ij1}\right\} \quad i=1,2,...,m\ ;\ j=1,2,...,n \qquad (24)$$

The options that are placed in A^{*} & A^{-}, show better and worse options respectively. In this study, $A^{*}=(1,1,1)$ is considered as positive ideal reply and $A^{-}=(0,0,0)$ as negative ideal reply.

Stage 6: Calculating fuzzy ideal solution and fuzzy anti-ideal solution

The interval of each main option from fuzzy ideal solution and fuzzy anti-ideal solution could be calculated as follows:

$$S_i^{*}=\sum_{j=1}^{n} d(\tilde{v}_{ij},\tilde{v}_j^{*}) \quad , \quad i=1,2,...,m$$
$$S_i^{-}=\sum_{j=1}^{n} d(\tilde{v}_{ij},\tilde{v}_j^{-}) \quad , \quad i=1,2,...,m \qquad (25)$$

d (.,.) is the interval between two fuzzy numbers in this technique, which in the event that (a_1,b_1,c_1) and (a_2,b_2,c_2) are two triangular fuzzy numbers, the interval between two mentioned numbers is:

$$d_v(\tilde{M}_1,\tilde{M}_2)=\left(\frac{1}{3}\left[(a_1-a_2)^2+(b_1-b_2)+(c_1-c_2)\right]\right)^{1/2} \qquad (26)$$

It could be said that $d(\tilde{v}_{ij},\tilde{v}_{ij}^{-})$ and $d(\tilde{v}_{ij},\tilde{v}_{ij}^{+})$ are crisp number.

Stage 7: Similarity attributes calculations

Similarity attribute is obtained by the following equation

$$CC_i = {S_i^{-}}\Big/{S_i^{+}+S_i^{-}} \qquad i=1,2,...,m \qquad (27)$$

Stage 8: Ranking the options

In this stage, considering the amount of the similarity attribute, the options are ranked, so that the options with similarity attribute are prioritized (Vafaei & Babaei, 2011; Ataee, 2010).

A Shannon's Entropy Method

Entropy algorithm is an important approach to computing weights of criteria. Consider P_{ij} in a decision matrix for alternatives' evaluation is in this tool. There are n alternatives and K criteria in decision matrix. The matrix components for jth criterion is as below (Ebrahimi *et al*., 2014):

$$P_{ij} = {f_j(a_i)}\Big/{\sum_{i=1}^{n} f_j(a_i)} \qquad (28)$$

Entropy is calculated as below:

$$E_j = -M \sum_{i=1}^{n} P_{ij} \, Ln \, P_{ij} \qquad (29)$$

M is calculated as a constant value in next step:

$$M = 1 / Ln\, n \qquad (30)$$

E_j is a value between 0 and 1.

If in the corresponding calculations there is a little difference between criterion values, it shows that alternatives are indifferent according to this criterion therefore its effect in decision-making should be diminished. In this case, according to the data, deviation degree is calculated as below:

$$d_i = 1 - E_j \qquad (31)$$

In the last step in Shanon entropy is to computing weights based on following equation (Ebrahimi *et al*., 2014):

$$W_j = d_j \Big/ \sum_{j=1}^{k} d_j \qquad (32)$$

The definition of scenarios and criteria

Water resource management scenarios that have been predicted in Pishin catchment and as options of fuzzy multi-attribute model in this study are considered as follows:

Table 1: Introducing used criteria

Options (Scenarios)	
SC_1	Current account
SC_2	Increased irrigation efficiency in agricultural sector
SC_3	Reduce evaporation losses
SC_4	Removal of unauthorized agricultural land
SC_5	Drinking water supply of Chabahar with desalination plant
SC_6	Operation of Kahir dam for the agricultural sector
Criteria	
C_1	The ratio of profit to cost
C_2	The initial cost of the project
C_3	The possibility of developing Area under cultivation
C_4	Instability and effectiveness of uncertainty
C_5	Availability of funds

Results and Discussion

Evaluate options based on the criteria No.1 and 3 is applied according to WEAP model results then criteria No.2, 4 and 5 determined based on certified experts opinions. Table (2) shows criteria weighted matrix based on Shannon entropy.

Table 2: Criteria weighted matrix based on Shannon entropy

Criteria	C_1	C_2	C_3	C_4	C_5
Weight	0.5	0.23	0.12	0.1	0.05

Source: research findings

According to the results, the criterion No.1 has most weight. Criterion No.2 is in second place and criteria No.3, 4 and 5 were next in the ranking respectively. Table (3), (4) and (5) show the steps of fuzzy Topsis method.

Table 3: Total Decision Matrix

	C_1	C_2	C_3	C_4	C_5
SC_1	(1/1/1)	(1/1/1)	(3/5/7)	(1/3/5)	(1/1/1)
SC_2	(3/5/7)	(3/5/7)	(5/7/9)	(1/3/5)	(1/3/5)
SC_3	(3/5/7)	(3/5/7)	(5/7/9)	(3/5/7)	(1/3/5)
SC_4	(1/3/5)	(1/3/5)	(3/5/7)	(1/3/5)	(1/3/5)
SC_5	(1/3/5)	(3/5/7)	(1/3/5)	(3/5/7)	(3/5/7)
SC_6	(3/5/7)	(1/3/5)	(1/3/5)	(3/5/7)	(1/3/5)

Source: research findings

Table 4: Normalized Matrix

	C_1	C_2	C_3	C_4	C_5
SC_1	(0.14/0.14/0.14)	(0.14/0.14/0.14)	(0.33/0.56/0.78)	(0.14/0.43/0.71)	(0.14/0.14/0.14)
SC_2	(0.43/0.71/1)	(0.43/0.71/1)	(0.56/0.78/1)	(0.14/0.43/0.71)	(0.14/0.43/0.71)
SC_3	(0.43/0.71/1)	(0.43/0.71/1)	(0.56/0.78/1)	(0.43/0.71/1)	(0.14/0.43/0.71)
SC_4	(0.14/0.43/0.71)	(0.14/0.43/0.71)	(0.33/0.56/0.78)	(0.14/0.43/0.71)	(0.14/0.43/0.71)
SC_5	(0.14/0.43/0.71)	(0.43/0.71/1)	(0.11/0.33/0.56)	(0.43/0.71/1)	(0.43/0.71/1)
SC_6	(0.43/0.71/1)	(0.14/0.43/0.71)	(0.11/0.33/0.56)	(0.43/0.71/1)	(0.14/0.43/0.71)

Source: research findings

Table 5: Weighted Matrix

	C_1	C_2	C_3	C_4	C_5
SC_1	(0.07/0.07/0.07)	(0.03/0.03/0.03)	(0.04/0.07/0.09)	(0.01/0.04/0.07)	(0.01/0.01/0.01)
SC_2	(0.21/0.36/0.5)	(0.1/0.16/0.23)	(0.07/0.09/0.12)	(0.01/0.04/0.07)	(0.01/0.02/0.04)
SC_3	(0.21/0.36/0.5)	(0.1/0.16/0.23)	(0.07/0.09/0.12)	(0.04/0.07/0.1)	(0.01/0.02/0.04)
SC_4	(0.07/0.21/0.36)	(0.03/0.1/0.16)	(0.04/0.07/0.09)	(0.01/0.04/0.07)	(0.01/0.02/0.04)
SC_5	(0.07/0.21/0.36)	(0.1/0.16/0.23)	(0.01/0.04/0.07)	(0.04/0.07/0.1)	(0.02/0.04/0.05)
SC_6	(0.21/0.36/0.5)	(0.03/0.1/0.16)	(0.01/0.04/0.07)	(0.04/0.07/0.1)	(0.01/0.02/0.04)

Source: research findings

In this section, the distance of each option is calculated from both positive and negative ideal. In the final step, distance options calculated in to ratio of ideal solution. Whatever options are closer to ideal solution, value of CC_i will be closer the value of one. Then the value of CC_i in order to show the ranking options should be arranged. Fig 4 is shown the ranking options (scenarios).

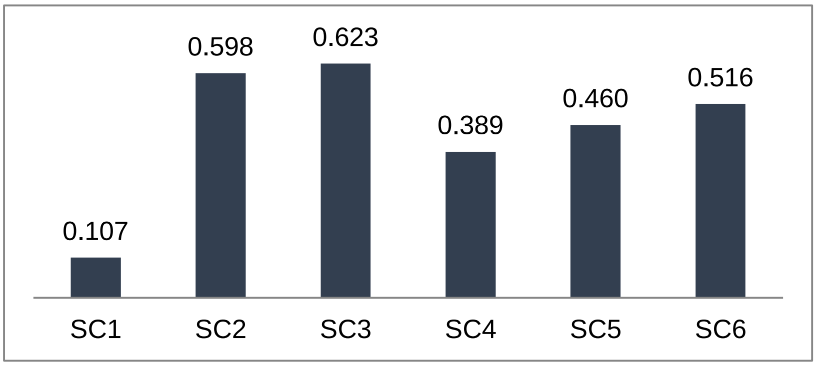

Figure 2: Options ranking (scenarios)

According to the results it is identified that:

$$SC_3 \succ SC_2 \succ SC_6 \succ SC_5 \succ SC_4 \succ SC_1$$

Also with the results, scenario No.3 is in the first rank. Scenario No.2 is located in second rank, Scenario No.6 and 5 of equal value in ranking are located in third and fourth and the latest ranking related to scenario No.1.

Conclusion and Suggestions

One way to get out of deadlock in the water resources management is the application of systems analysis tools and managerial decision-making in evaluation of water simulation. After each simulation a selection of preferred option is required. In Pishin Catchment, according to the available resources results of the simulation in the catchment will obtain, so in water resources management it should be done with appropriate policy. Irrigation efficiency was in the second rank among the different scenarios. To implement this scenario, the government financial support is needed exactly compatible with the evaluation results. The remarkable thing in the ranking of scenarios is that the current account scenario (SC_1) is located in the next rankings that shows Pishin catchment water status, according to the study criteria is not suitable. Results showed that evaporation reduction scenarios (SC_3) have top priority; therefore, this problem should determine priority in the study area and planning that is necessary for this region to be performed. In multiple attribute decision making under fuzzy logic the ability to provide a setting of appropriate decision and develop different management scenarios will obtain, so it is recommended to planners of water allocation in the region that managing and optimizing the utilization of dams and other water sources will considered these methods. By interviewing with relevant experts revealed that there is no detailed plan of operation by water crisis situations in the region, Therefore it is recommended that developed policies should be selected and long-term strategies must be applied for future plans regarding to the allocation and utilization of water to keep the current situation in the region. In this study, combining the WEAP model and fuzzy multi-criteria analysis, a tool for decision support system is created.

According to results Scenario No.3 has the highest value and so considered as the preferred option than the others. On this basis, it is recommended that transferring water to the lands in Pishin agriculture sector can be in the government agenda. After that, scenario No.2 is in second ranking that required proper planning is considered for transmission direct of water to this agricultural sector.

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