



## Environmental risk assessment of Alborz Dam using Topsis and Fuzzy Topsis methods

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**ABSTRACT:** The purpose of this study was to evaluate the environmental risks of Alborz Dam on Bababrood River in Babol city, using multi-criteria decision making methods. Initially, environmental identification of the study area was carried out, Then a list of environmental risks identified in the construction and exploitation phase was prepared and presented to environmental experts familiar with the Alborz dam area in the form of a questionnaire. environmental risks scored by environmental experts based on three indicators, Severity of occurrence, Probability of occurrence, Then environmental risks ranking was performed using TOPSIS and Fuzzy TOPSIS methods. The most important risks of Alborz dam using TOPSIS method in the construction phase, respectively: Was Obtained, Destruction of forest within the dam with a score of 0.926, Displacement of reservoir residents with a score of 0.837 And in the phase of operation: Thermal stratification of dam reservoir with a score of 0.847, Landslide with a score of 0.751. Also, the most important risks of the Alborz dam using the Fuzzy Topsis method in the construction phase, respectively: Was Obtained, Displacement of reservoir residents with a score of 0.682, Demolition of forest within the dam with a score of 0.677, And in the phase of operation, respectively: Thermal stratification of dam reservoir with a score of 0.645, Landslide with a score of 0.630. Finally, one method of integration (average rating method) was used to resolve the conflict between the results.

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## 1. INTRODUCTION

Environmental risk assessment studies have been identified to eliminate or mitigate the adverse consequences of large projects, including the construction of necessary dams. Using multi-criteria decision-making methods in dam environmental risk assessment, it makes the right decision making process and selects the best option from a set of options. A review of the research background has shown that many risk assessment projects have been carried out using multi-criteria decision making techniques. (Donjin *et al.*, 2005) in 73rd Annual Meeting of ICOLD<sup>1</sup> In an article they mentioned the safety assessment of dams and AHP have introduced an effective method in this evaluation [1]. (karamuz *et al.*, 2009) They identified the hazards to the Karaj Dam reservoir Then, based on Swot analysis, the existing conditions were evaluated for vulnerability [2]. (Rezaian *et al.*, 2016) Using TOPSIS and RAM-D Methods to Assess Environmental Risk of Pavehrood Dam in Zanjan during Construction [3]. (Malmasi *et al.*, 2017) To Rank the Environmental Risks of Kurdistan Azad Dam in Construction and Operation Phase, were used Topsis, Haw and Electre methods [4].

In the present study, the environmental risks of Alborz

Dam in the construction phase were evaluated separately in three parts of physical environment, biological environment and economic, social and cultural environment and in the exploitation phase in two parts physical and biological environment. In order to rank the existing risks, a combination of TOPSIS and Fuzzy TOPSIS methods has been used.

## 2- METHODOLOGY

### Case study

Alborz Reservoir Dam on the Babol River is 45 km southeast of Babol and 50 km southwest of Ghaemshahr. Alborz reservoir dam is a Rock-Fill type with clay core. design Flood deviation system, floods with a 1000-year return period and a peak discharge of 370 m<sup>3</sup> / s have been calculated [5].

After studying the environmental impact assessment of Alborz Dam, the background of research and potential risks in similar dam construction projects, Alborz Dam environmental risks were identified. Then the identified risks based on three indices, risk severity, probability of occurrence and risk importance, were assessed by a questionnaire by 10 environmental experts familiar with the field of dam and with a master's or doctorate degree.

After identifying the environmental risks of Alborz Dam and scoring them, multi-criteria decision making methods, TOPSIS and fuzzy TOPSIS were used to rank the environmental risks.

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**TOPSIS Method**

In order to rank the environmental risks of Alborz Dam using TOPSIS method, all of the considered indices were weighted using Shannon entropy method. Then the ranking was done using TOPSIS model [6].

Steps of the Shannon Entropy Method:

$$P_{ij} = \frac{a_{ij}}{\sum_{j=1}^m a_{ij}} \tag{1}$$

$$E_j = -k \sum_{i=1}^m [P_{ij} \ln P_{ij}], K = \frac{1}{\ln(m)} \tag{2}$$

$$d_j = 1 - E_j \tag{3}$$

$$W_j = \frac{d_j}{\sum_{j=1}^m d_j} \tag{4}$$

Steps of the TOPSIS Method:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \tag{5}$$

$$n_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^m a_{ij}^2}} \tag{6}$$

$$V = N \times W_{n \times n} \tag{7}$$

8) Determine the ideal positive solution and the ideal negative solution:

$V_j^+$ : (Ideal positive solution): The best values of any matrix V index.

$V_j^-$ : (The ideal negative solution): Worst values of any matrix V index.

$$d_i^+ = \sqrt{\sum_{j=1}^n (V_{ij} - V_j^+)^2}, i = 1, 2, \dots, m \tag{9}$$

$$d_i^- = \sqrt{\sum_{j=1}^n (V_{ij} - V_j^-)^2}, i = 1, 2, \dots, m \tag{10}$$

$$C_i = \frac{d_i^-}{d_i^- + d_i^+} \tag{11}$$

12) Options are ranked based on the Ci value. The option with more Ci is a priority.

Fuzzy TOPSIS Method:

Steps of the Fuzzy TOPSIS Method:

$$\tilde{D} = \begin{matrix} & C_1 & C_2 & \dots & C_n \\ A1 & x_{11} & x_{12} & \dots & x_{1n} \\ A2 & x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ Am & x_{m1} & x_{m2} & \dots & x_{mn} \end{matrix} \tag{13}$$

$$x_{ij} = (a_{ij}, b_{ij}, c_{ij})$$

$$r_{ij} = \left( \frac{a_{ij}}{c_j}, \frac{b_{ij}}{c_j}, \frac{c_{ij}}{c_j} \right) \text{ and} \tag{14}$$

$$c_j^* = \max c_{ij} \text{ (benefit criteria)}$$

$$r_{ij} = \left( \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right) \text{ and} \tag{15}$$

$$a_j^- = \min a_{ij} \text{ (cost criteria)} \tag{16}$$

$$V_j = r_{ij} \cdot W_j, W_j = (W_1, W_2, \dots, W_n)$$

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}, i = 1, 2, \dots, m \tag{17}$$

$$A^- = (v_1^-, v_2^-, \dots, v_n^-) \text{ where}$$

$$v_j^- = \min \{v_{ij}^-\}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \tag{18}$$

$$d_i^+ = \sum_{j=1}^n d_{ij}^+(v_j^-, v_j^+), i = 1, 2, \dots, m$$

$$d_i^- = \sum_{j=1}^n d_{ij}^-(v_j^-, v_j^-), i = 1, 2, \dots, m$$

$$d = \sqrt{\frac{1}{3} \times ((a-v_1)^2 + (b-v_2)^2 + (c-v_3)^2)} \tag{19}$$

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}, i = 1, 2, \dots, m$$

20) Options are ranked based on the CCI value. The option with more CCI is a priority.

**3. RESULTS AND DISCUSSION**

At risk identification stage, 26 risk in the construction phase and 22 risk in the operational phase were determined. The results of expert ratings of risks were analyzed in Excel software and the geometric mean of each option was obtained.

Then, using TOPSIS Method, the risks were ranked based on three indicators of risk severity, probability of occurrence and importance of risk. The results are shown, The most important risks of Alborz dam using TOPSIS method in the construction phase, respectively: Was Obtained, Destruction of forest within the dam with a score of 0.926, Displacement of reservoir residents with a score of 0.837 And in the phase of operation: Thermal stratification of dam reservoir with a score of 0.847, Landslide with a score of 0.751. Also, ranking

was performed using fuzzy TOPSIS method. The results are shown, the most important risks of the Alborz dam using the Fuzzy Topsis method in the construction phase, respectively: Was Obtained, Displacement of reservoir residents with a score of 0.682, Destruction of forest within the dam with a score of 0.677, And in the phase of operation, respectively: Thermal stratification of dam reservoir with a score of 0.645, Landslide with a score of 0.630.

#### 4. CONCLUSIONS

According to the results of the environmental risk identification stage, Alborz Dam had the most negative impact on the environment in the construction phase with 26 identified risks. Most of the risk factors in this phase are related to the process of construction of dam reservoir, excavation and embankment, Withdrawals from loan sources, blasting and so on.

According to the ranking, the most important risks in the construction phase are related to the biological environment and then the economic, social and cultural environment, and the most important risks during the operation phase occurred in the physical environment.

The TOPSIS method is a precise yet simple method that can be used for any number of options and criteria, positive and negative, qualitative and quantitative. But the

uncertainties in this model are not taken into account, with the development of the fuzzy model the weaknesses of this method are eliminated.

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