Available online at www.ap.iauardabil.ac.ir
Islamic Azad University, Ardabil Branch
Anthropogenic Pollution Journal, Vol 4 (2), 2020: 28-34
10.22034/ap. .2020.1903672.1070
ISSN: 2783-1736- E-ISSN: 2588-4646

Developing a method based on matrixes and multi-criteria decision making approaches for environmental assessment of dams (ACase study)

Mohammad Reza Jangjoo
Tehran, Rey city, municipality, district 20
*Correspondence author Email: mohammadjangjo@gmail.com

Received: 3 March 2021/ **Accepted**: 19 April 2021/ **Published**: 22 April 2021

Abstract: Environmental impact assessment is an integrated, operational and implemental approach for sustainable development. An attitude is considered in which as an integrated system, everything is got into sustainability in the environment and with the environment, as well. Environmental assessment is a tool that has been developed to prevent environmental degradation caused by human activities. Environmental impact assessment is an approach to evaluate the environmental impacts of a project before and during the project implementation. Therefore, we need to develop a practical and quantitative method to provide a precise planning in order to estimate the effects of a dam and ultimately, to make a decision on the implementation or non- implementation of the project if knowing the impact of all activities on environmental factors. Therefore, we introduced a generalized mathematical model of ICOLD matrix and multi-criteria decision making method (method of analytic hierarchy process) as a quantitative model to analyze the project's impacts on the environment. For this purpose, the environmental impact assessment information of the Zaraj-Abad dam, as the study area, was used to demonstrate the validity of the model. Results show that unlike the main implemented method in the dam Zaraj-Abad, who gives the "implement the Dam project" option, this method shows negative effects (45%) of the implementation of the dam on the environment and gives the option of non- implementation.

Key Words: ICOLD matrix, Multi criteria decision making method, Environmental impact assessment, Quantification of criteria, Zaraj-Abad dam, Iran.

Introduction

It's inevitable to minimize the negative environmental impacts of large dams and to use the environmental impact assessment in order to reduce the negative effects (Tullos 2009). After completion of the dam projects, one can compare the actual impact of prediction by means of the environmental impact assessment with the environmental effects on the exploitation phase (Wang Q et al. 2012).

After decades of relatively little development in dam construction industry, nowadays, construction of the hydroelectric dams has intensified in the world (Vosoughifar et al., 2018). However, electricity generation as a form of renewable energy have been portrayed in purposes of such dams, but development of water resources has led to extensive changes in the river system and the resources of the local communities of the river. Therefore, Environmental Impact Assessment (EIA) rules are needed to reduce environmental impacts of such huge and man-made projects and to have some management plans to investigate these effects (Erlewin 2013; Alipour Erdi et al., 2017; Mohammadi and Fataei 2019; Parsajou and Fataei 2019).

However, the water effects on human life and civilization is known all around the world but it's claimed that the economic benefits of the project that is designed to be achieved from water resources, has not been met and also the necessary predictions to reduce the harmful effects of environmental, social and economic performances have not been properly taken place. Even some international organizations, have done studies in order to stop the water supply projects in some developing countries. For this reason, cultural, social, and economic developments have been taken into consideration in water resources management and environmental impacts that are verified with these studies have become increasingly important (Sait Tahmicioglu et al. 2007).

Assessment is one of the acceptable methods to achieve the goals of sustainable development and can be used as a planning and management tool to decision making sectors of the society, so that, in addition to the identification of potential environmental impacts caused by development projects, the choice of appropriate and reasonable options is provided, as well. The purpose of the environmental assessment and review is to involve environmental considerations in the planning process (Piry 2011; Fataei and Seiied Safavian 2017).

Environmental assessment can be considered as a mechanism that reduces the costs by means of providing a method to proper and rational use of human and natural resources in which in short and long-term planning, have considerable effects (Fataei and Sheikh Jabbari, 2005, Maanifar and Fataei 2015). In addition, the decision makers and policy makers can identify and evaluate the possible effects of a project and thereby the public's awareness and knowledge are increases, as well. On the other hand, due to the acceleration of the planning, the assessment protects the resources strongly and prevents the risk of irreversible effects on the environment and natural resources(Abazr et al. 2008). Therefore, an applied and quantitative approach is needed to provide a careful planning in estimating the effects of dam's construction and finally decision making on the implementation or non-implementation of the project. Therefore, we introduced a generalized mathematical model of ICOLD matrix and multi-criteria decision making method as a quantitative model to analyze the project's impacts on the environment. It was used case study of the Zaraj-Abad region to have a better presentation of the introduced model.

Methodology

ICOLD[1] Matrix method

This method is one of the methods that let the user present the qualitative results of the environmental assessment of the project with the quantitative data. In this method, the impact of each of the activities on the environment of the project study area is evaluated in two phases of construction and operational for each physical, biological, social and economic environment, separately and in order to extend range of impacts, scores are assigned between 0 to +3 and 0 to -3. This matrix has multiple rows and columns. The columns of the matrix contain micro-environmental factors that have been identified in previous stages and the rows contain detail information of project activities (Karimi et al. 2008; Falahatkar et al. 2010). An advantage of this matrix is the expression of the characteristics of any impact on the environment, so the signs and numbers used in this matrix describe the situation and characteristics of the impact.

In this method, the type and characteristics of the impact is expressed by the following description in a cell of the matrix that is more likely to have the impact:

1- The nature of the impact: positive and negative signs indicate the desired and undesired impacts, respectively.

2- The intensity of the impact: is classified into three sections of high, medium, low.

3- Certainty of the impact: consists of the certain, possible, improbable, and uncertain impacts indicated with C, P, I, and n sings, respectively.

4- Continuity of the impact: temporary and permanent impacts shown with T and P, respectively.

5- The timing of occurrence: consists of 3 parts of long-term, medium-term and short-term shown with to the L, M, I, respectively.

6- Known impact: K and Y are used to indicate whether the impact of activities on components of the environment is known or unknown, respectively.

After determining the type and intensity of the impact as well as its significance, the coefficients of each type are multiplied by them.

Although the matrices are prepared for specific applications, the ICOLD matrix has the disadvantages that tends to coincide the simplified directions of the impact, does not address clearly the spatial and temporal considerations and synergistic impacts are not considered adequately. Another major disadvantage of this matrix is less attention to social and economic factors (Falahatkar et al. 2010). Other main disadvantage, according to the author, is there are some quantitative restrictions on the model that does not let the impacts and their amounts on the environment to be studied easily.

Analytical Hierarchy Process (AHP) Model

Analytical Hierarchy Process is a multi-criteria decision making method that provides qualitative and quantitative measurements to determine relationships between variables. The purpose of AHP is to obtain the final score for the criteria in ranking of the options, which means that the criteria are compared in pair-wise comparison. The first objective level in a hierarchical structure is to select the best goal; the second level is that the criteria which are divided into some sub-criteria and finally the third level shows the study options. In this method, the relative value of the relating to the criteria is calculated for each criterion in the form of paired comparison matrix where, in the case of n sub-criteria, is an n × n matrix. Elements of the matrix show the weight ratio of the criterion i to criterion j.

Validation of paired comparison to verify conducted comparisons between each options via examining the consistency of comparisons is necessary (Karamouz and Karachian 2003). For this purpose, the following matrix (Equation 1), is formed to determine values of eigenvectors and to calculated consistency, as well.

(1)

$$W.w = \begin{bmatrix} 1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & 1 & \dots & w_2/w_n \\ .. & .. & \dots & .. \\ w_n/w_1 & w_n/w_1 & \dots & 1 \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ .. \\ w_n \end{bmatrix} = \lambda.W$$

Where λ is an eigenvalue, W is paired comparison matrix and w is a eigenvector corresponding to the eigenvalue λ (Qodsi pour 2006). Since the difference between the maximum value of the paired comparison matrix eigenvalue (λ max) and dim matrix (n) indicate the incompatibility of the paired comparison matrix, so the difference between n and λ max is used for defining coefficient of incompatibility (CI), as follows:

Incompatibility rate is the mechanism by which the respondent's answers to the comparison matrix are validated. This mechanism determines that the respondent's answers to the comparison of the sub-criteria with alternatives how logically are valid. Incompatibility tolerable rate in the analytic hierarchy process is considered less than 1.0 (Nikmardan 2007). Calculating the rate of compatibility in comparison matrices, in which the number of respondents is more than one person, is done based upon the geometric mean of the respondent's answers. Incompatibility rate in this study was 0.07 that is acceptable. Thus we have (Equation 2):

(2) $CI = \frac{\lambda max - n}{n-1}$

Finally, the incompatibility rate (IR) is defined in Equation 3:

(3) $IR = \frac{CI}{CRI}$

Where, CRI is the coefficient of incompatibility of a random n x n matrix which have been randomly filled. If IR <% 10, then the compatibility criteria is provided. Otherwise it is necessary to re-evaluate the paired comparison.

Mathematical modeling based on the matrix method and the analytic hierarchy process model

Preliminary identification of the environmental impacts (Monavari, 2001) using the ICOLD matrix

Encoding procedure in the preliminary identification matrix of environmental impacts, according to the Environmental Impact Assessment Guidelines for Dams (ICOLD, 1988; Monavari, 2001), is as follows:

A – Depending on the type of activity in the projects or plans, ideas and expertise, the assessor group assigns one of the numbers from 1 to 5, according to the following classification, in each cell of the matrix:

Table 1. Numerical encodings in identification matrix of environmental impacts

Code	Impact Type
1	positive
2	negative
3	Non-impact
4	Need more Information
5	Arbitration is currently not possible

B - Final comments of the group is made based on the detection and identification of the impacts of the plan or project activities on the environmental elements by typing one or a few letters of the Latin(code) contained in the manual (and expressed in the ICOLD matrix method) in each cell and next to the filled number.

As described in Table 2, the Latin alphabets are used to determine the characteristics of the impacts:

Table 2. Encodings by the letters in identification matrix of environmental impacts

code	Impact Type	Code	Impact Type
A	Very High	K	Non Reversible
B	high	L	Short Term
C	Moderate	M	Long Term
D	Low	N	accumulative
E	Sectional	O	Direct
F	Permanent	P	Indirect
G	Deterministic	Q	Strategic
H	Probabilistic	R	Important
I	Improbable	S	Non important
J	Reversible		

The example of this matrix is shown in Table (3):

Table 3. The example of encoding in ICOLD Matrix

Project Action / Environment Factors	waste disposal	excavation
Increase vectors	2AEGQ	4
shape of the land	3	IDFMS

Quantification of the identification part

In order to cumulate and integrate the positive and negative effects and to consider them in the form of the arithmetic operation, each of the classifications and the Latin letters in table (3) will take the corresponding integer. Table (4) shows the numbers properly:

Table 4. The quantification of the ICOLD matrix codes according to the type and the characteristics of the impact

Place in Matrix		Code	Quantification Code
First Word (Q)	Severity	A	1
		B	2
		C	3
		D	4
Second word (A)	Magnitude	E	2
		F	1
Third Word (S)	probability of occurrence	G	1
		H	2
		I	3
	Reversibility	J	2
		K	1
	Duration	L	2
		M	1
	Causal relationship	N	1
		O	2
		P	3
Fourth word (D)	Importance	Q	1
		R	2
		S	3

Final mathematical model

Since the above mentioned cases have different values in the matrix, so depending on its application each of the words will has a particular coefficient:

Since the first word, the intensity of the impact, show the status of any work in any environment and also have a high value to the output results will take weight ratio of 0.4, so that the higher the intensity of the impact, it influences the values in the range of 3 other words and so the impacts always have a negative value. The second word indicates the permanent and temporary impacts and have weight ratio of 0.2 and the third and fourth words take equally coefficient 0.15. This division is due to the fact that the impact is more permanent than its duration, nature and … where are effective and practical impacts on dam projects.

In which the first word was taken in the range of 0.4 to 1.6

The second word was taken in the range of 0.2 to 0.4

The third word was taken in the range of 0.45 to 0.15

The third word was taken in the range of 0.45 to 0.15

Formula 1 was used for the rest of the process:

$$Oi = [(Qi \times WQ) + (Ai \times WA)] + [(Si \times WS) + (Di \times WD)] \quad (4)$$

Where, Oi includes the final number for each square in the identification matrix of environmental impacts. Also:

Qi = the quantified value of the first word for project activities. WQ = the weight of the word. Ai = the number of characters for project activities. WA = weight of the second word. Si = the quantified value of the third word for project activities. WS = weight of the third word. Di = the quantified value of the fourth word for project activities. WD = weight of the fourth word.

Then,

$$Pi = \frac{\sum_{i=0}^{n} Oi \times Xi}{n} \quad (5)$$

Where, X is the weight of each environmental impact with respect to multi-criteria decision and N is the number of projects impacts on the environment factor

For instance:

Project Action Environment Factors	waste disposal	excavation
Increase vectors	2AEGQ	4
shape of the land	3	IDFMS

O's number for 2AEGQ is as follows: Since 2 is apposite to the option, so the number is negative and equal to -1.1. Also, the value for 1DFMS is 2.4.

A weight value should be achieved according to the formula (2) and multi-criteria decision making methods for environmental factors, including vectors increase and shape of the land so that in this example, the weight value will be assigned to the word X in the formula in which was considered equally.

Finally, the weight of each factor is multiplied in the O’s value in an impact and then these numbers are added together in each row and divided by the number of impacts that have such value. Hence, we will obtain - 0.55 in the first row and 1.2 in the next one where the sum of two numbers is equal to 0.65. Finally, dividing this number in 2.9 and multiply it by 100, gives the percent of the project completion in which the profit from the project on the regional environment will be 22%.

Case study

Zaraj Abad is a gravel dam with clay core with a height of about 22 meters from the river bed. Dam has been located in Ardebil province and at a distance of about 60 km from west of the Khalkhal city and 3 km from northwest of the Zaraj Abad village (Figure 1). The dam is in geographical coordinates of 48º, 00 ', 05 to 48º, 00', 00 'east longitude and 37º, 37', 29 to 37º, 42 ', 34' 'north latitude (Azarab Andish Consulting Engineers 2012).

Zaraj Abad river water quality is affected by sewage entering from the Akbar Abad village. Since this village is the only one that is inhabited all year, so because of the harsh and difficult mountainous roads, this village is the main source of pollution in the area. There is not any type of industrial or mining activities in the catchment area of dam and its coastal lands, to have impact on the ecosystem of the rivers and dam’s reservoir. During the field visits, animal manure and its accumulation in the environment and the countryside was diagnosed as one of the largest potential sources of water pollutions. Due to maintenance of anaerobic conditions, these types of fertilizers contain considerable amounts of ammonia. Traditional agricultural activities including agriculture, horticulture and animal husbandry are considered as potential sources with unclear origins. Excess fertilizers and chemical pesticides that are used in agriculture and horticulture and also livestock waste may enter to the Zaraj Abad River and contaminate it through drainage or surface currents induced by irrigation or rainfall.

River hydraulic conductivity changes during the year leads to changes in the intensity of pollutants. In contrast, the hydraulic conductivity decrease, intensity of pollutants and harmful effects intensity are increased, as well. The drying of water in some parts of the river during the year, the survival of aquatic organisms may come to end.

Wastewater and surface runoff of a village in the Zaraj Abad reservoir area are not controlled in public places and streets and with respect to the slope of the land eventually drains into the Zaraj Abad River. Wastewater of the Akbar Abad and Mahmud Abad villages in upstream, riverbank, and river course of the Zaraj Abad River are key factors in contaminating the river’s water in current phase and its contamination in the reservoir in operation phase, as well. Also, the wastewater from villages in downstream of the dam is considered as one of the main origins of microbial contamination of water which increases possibility of water-related diseases. As a result, the collection and disposal of sewage and animal wastes should be considered as the main programs in management plan in these villages (Azarab Andish Consulting Engineers 2012).

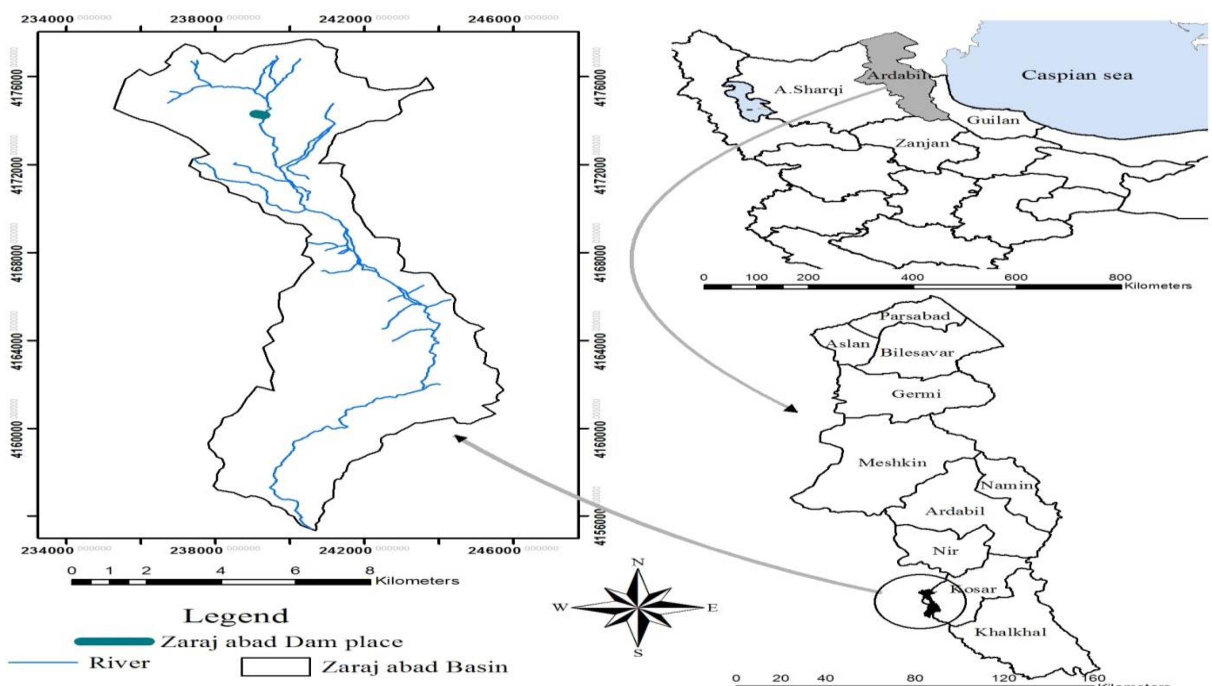

Fig 1. Location of the study area in Ardebil province, Iran.

Results

The preliminary identification matrix of environmental impacts

Available studies were used to assess the environmental impacts of the Zaraj Abad dam to implement the model developed in this research. The ICOLD matrix model was used in the main study.

Table 5. Identification Matrix in Physical phase on Construction section of Zaraj-abad dam

	excavation and embankment	construction of roads and asphalt pavement	constructions and buildings	waste disposal	mining activities	transportation of materials	clean masonry	water supply	dam construction	protection of walls	sealing the reservoir	not implementing the project
Microclimate	2BEJS	3	3	3	3	2DEKS	3	3	3	3	3	1CEHS
air quality	2CELS	3	3	3	3	3	3	3	1CFHS	3	3	1BFGR
Noise	2DELS	3	3	3	3	3	3	3	3	3	3	1DFHR
flood regime	3	2CEGS	3	3	3	3	2DEGR	3	1BEGR	1DEGS	1DEGS	2BFGR
surface water quality	3	2CEGS	2CEGR	3	2DEGS	2CEHS	1DEGR	3	1BEGR	1DEGS	1DEGS	2BFGR
use of surface water	3	3	3	3	3	3	2DFGR	3	1CFGR	3	3	2CEHS
river morphology	3	3	3	3	3	3	3	3	1AFGR	3	3	2BFGR
sedimentation in the reservoir	3	3	3	3	3	3	3	3	2BFGR	3	3	1CEHR
soil erosion	3	2BFGR	2BFGR	3	3	3	3	3	3	3	3	1BFKS
soil characteristics and its salinity	3	3	3	3	3	3	3	2BEHR	2BEGR	3	3	3
soil stability	3	3	3	2BFHR	3	3	3	3	3	3	3	2DFHS
drainage	3	3	3	3	3	3	3	3	3	3	3	1DFHS
shape of the land	2DFKR	3	3	3	3	3	3	3	3	3	3	2DFHS

The results of the analytic hierarchy process model

The analytic hierarchy process was used to compare environmental factors and the importance of them in the studied area. The output results for this case in the physical part of the construction phase have been shown in table (6).

Table 6. The weight ratio for each factor using analytic hierarchy process

Environment Factors	Weight	Environment Factors	Weight
Microclimate	0.061	sedimentation in the reservoir	0.066
Air quality	0.033	soil erosion	0.033
Noise	0.027	soil characteristics and its salinity	0.032
Flood regime	0.037	soil stability	0.03
Surface water quality	0.216	drainage	0.074
Use of surface water	0.107	shape of the land	0.125
River morphology	0.089	sedimentation in the reservoir	0.069

Medellin

According to the formula (4), the coefficients and the numbers was devoted to the qualitative scale in the matrix, so that, the results are shown in Table 5 for the Zaraj Abad area.

Then, the coefficients of the analytic hierarchy process, (Table 6), were multiplied by the numbers in each part of the related element and these numbers were then added together and were divided by the number of digits (project activities). Table 8 shows the results.

Table 7. Assessment matrix of physical impacts of the Zaraj Abad dam in the construction phase and after implementing equation (4).

	excavation and embankment	construction of roads and asphalt pavement	constructions and buildings	waste disposal	mining activities	transportation of materials	clean masonry	water supply	dam construction	protection of walls	sealing the reservoir	not implementing the project
Microclimate	-1.95	-	-	-	-	-2.6	-	-	-	-	-	1.45
air quality	-2.35	-	-	-	-	-	-	-	1.65	-	-	2.35
noise	-2.75	-	-	-	-	-	-	-	-	-	-	1.4
flood regime	-	-2.2	-	-	-	-	-2.45	-	2.15	1.2	1.2	-1.45
surface water quality	-	-2.2	-2.05	-	-2.6	-2.35	1.35	-	2.15	1.2	1.2	-1.45
use of surface water	-	-	-	-	-	-	-2.25	-	1.95	-	-	-2.35
river morphology	-	-	-	-	-	-	-	-	2.75	-	-	-1.45
sedimentation in the reservoir	-	-	-	-	-	-	-	-	-1.45	-	-	1.6
soil erosion	-	-1.45	-1.45	-	-	-	-	-	-	-	-	2.05
soil characteristics and its salinity	-	-	-	-	-	-	-	-1.8	-1.65	-	-	-
soil stability	-	-	-	-1.6	-	-	-	-	-	-	-	-2.55
drainage	-	-	-	-	-	-	-	-	-	-	-	1.25
shape of the land	-2.25	-	-	-	-	-	-	-	-	-	-	-2.55

Table 8. Allocation coefficients of the analytic hierarchy process model to Table 7 for the physical impacts of the Zaraj Abad dam in construction phase

	excavation and embankment	construction of roads and asphalt pavement	constructions and buildings	waste disposal	mining activities	transportation of materials	clean masonry	water supply	dam construction	protection of walls	sealing the reservoir	not implementing the project
Microclimate	-0.11895	0	0	0	0	-0.1586	0	0	0	0	0	0.08845
air quality	-0.07755	0	0	0	0	0	0	0	0.05445	0	0	0.07755
noise	-0.07425	0	0	0	0	0	0	0	0	0	0	0.0378
flood regime	0	-0.0814	0	0	0	0	-0.09065	0	0.07955	0.0444	0.0444	-0.05365

surface water quality	0	-0.4752	-0.4428	0	-0.5616	-0.5076	0.2916	0	0.4644	0.2592	0.2592	-0.3132
use of surface water	0	0	0	0	0	0	-0.24075	0	0.20865	0	0	-0.25145
river morphology	0	0	0	0	0	0	0	0	0.24475	0	0	-0.12905
sedimentation in the reservoir	0	0	0	0	0	0	0	0	-0.0957	0	0	0.1056
soil erosion	0	-0.04785	-0.04785	0	0	0	0	0	0	0	0	0.06765
soil characteristics and its salinity	0	0	0	0	0	0	0	-0.057	-0.0528	0	0	0
soil stability	0	0	0	-0.048	0	0	0	0	0	0	0	-0.0765
drainage	0	0	0	0	0	0	0	0	0	0	0	0.0925
shape of the land	-0.28125	0	0	0	0	0	0	0	0	0	0	-0.31875

After adding the numbers and dividing them by the number of environmental factors in each row and then dividing it by 9.2, ultimately, the final number of -0.19058 was obtained for the physical part in construction section, indicating that this phase will damage about 19% to the environment. Table 9 shows the results for all parts.

Table 9. Final results of the implementation of the model for all parts

Section	Phase	Results
Physical	Construction	-0.19058
Physical	operation	-0.00593
Biological	Construction	-0.46774
Biological	operation	-0.02146
Socio-Economical	Construction	0.066631
Socio-Economical	operation	0.166257

Although the results indicate that the construction of the dam is a positive action for the economic and social sectors, but results with negative numbers in other sectors were overcome to these results and finally the final number for the Environmental Impact Assessment of construction of the Zaraj Abad earth-filled dam is about -0.45 which shows the implementation of the project will damage 45% to the environment.

Discusion

Due to many problems in studying the dams, reviewing the environmental impact assessment plans of the dams is difficult. Also, several methods for assessing the impacts of dams as ICOLD matrix couldn't indicate the quantification of environmental impacts of the dams. Unlike many other impacts assessment methods, the ICOLD matrix, like fast assessment method, is in qualification mode but in the end, the results of the fast assessment are quantitative. In this survey, to assess the environmental impacts of the Zaraj Abad dam on the physical, biological, and socioeconomic environment of the Zaraj Abad region and based on multi-criteria decision making and encoded words of the matrix, the conversion of the ICOLD qualitative matrix to quantitative mode was employed. According to the results, it was determined that the project has 45% damage to the physical, biological, and socio-economic environment in the construction as well as operational phase which is shown in Figure 2 and Table 10 for each stage.

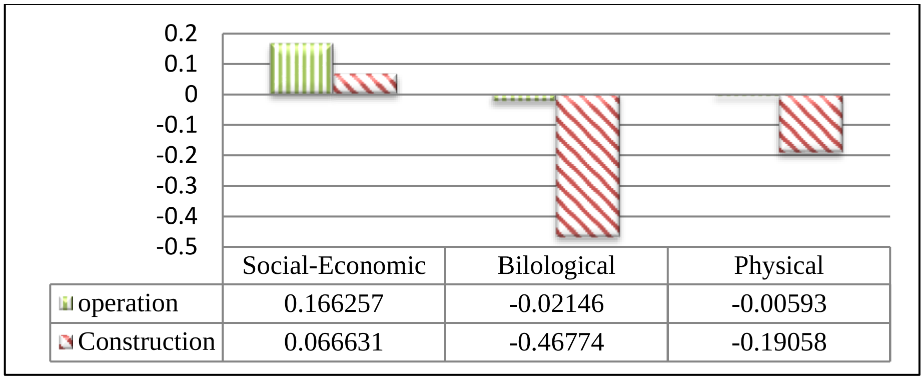

Fig 2. The effects of dams on Environments in all sections

Table 10. Compares the results of the main plan of the Zaraj Abad dam with the proposed model

		Phase	Final Score in Main Matrix	Final Score in Created Quantitative Model
Implementation of the dam	Physical	Construction	10.5	-0.19058
		Operation		-0.00593
	Biological	Construction	-164.2	-0.46774
		Operation		-0.02146
	Socio-economical	Construction	648	0.066631
		Operation		0.166257
	SUM of options		494.3	-0.45
	Results		Implementation of Project	Non- Implementation of Project

According to the results, it is clear that due to reservoir clean masonry and utilization of primary sources and credits, the greatest impact on the biological environment is happened during construction phase and also because of employment of the natives as laborers in the construction and operational phases as well as improving the living and health conditions in the region, the most positive impact will happen on the socio-economic environment. But it's noteworthy that the project had been accepted without ICOLD quantifying the matrix and it had been approved because of improvement on the socio-economic conditions of the region and offering corrective solutions in which the results in table 10 shows this fact.

Finally, in order to investigate the impacts of different projects on the environment based on the method developed in this study, Table 11 can be addressed.

Table 11. Classification of the results obtained from the model implemented for various projects

Project is acceptable	With high usefulness	+70 to +100
	With significant positive impact on the environment	+30 to +70
	With positive impact on the environment	0 to +30
Unchanged	Unchanged	0
Project is acceptable with providing mitigation and control	Negligible damaging impact	0 to -25
	moderated damaging impact	-25 to -50
Project is rejected	High damaging impact	-50 to -100

Conclusion

The results of the model used in this study shows that in spite of the positive socio-economic impacts on the environment, excessive exploitation of unspoiled biological environment of the region, causing severe damage to the environment, in which even corrective measures and long-term rehabilitation will not compensate such damages. Therefore the results of the model, with a final score of -0.45, suggest not implementing the project that is against the ICOLD matrix method in which it has actual compliance with environmental requirements of the construction site. Finally, based on the results of the main plan of the Zaraj Abad dam with the proposed model, constructing the Zaraj Abad dam with moderated damaging impacts and providing mitigation phase, is implementable.

Compliance with Ethical Standards:

All authors promise that the work described has not been published before; and it is not under consideration for publication anywhere else.

This publication has been approved by all co-authors, if any, as well as by the responsible authorities – tacitly or explicitly – at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

The authors declare that they have no conflict of interest.

References

Abazr, H., Bisset, R., & Sadler, B. (2008). Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach: UNEP Publication.

Alipour Erdi, M, Fataei E, Ramezani ME, Ravan Nakhjavani H, (2017) Spatial-Systematic Analysis Approach for Conservation Purposes, Journal of Wildlife and Biodiversity, 1(1):٤٦-٣٧.

Azarab Andish Consulting Engineers (2012). Environmental impact assessment of constructing a dam on the Zaraj Abad River. Iran. (pp. 7): ministry of energy, Ardabil Regional Water Authority.

Erlewin, A. (2013). Disappearing rivers- The limits of environmental assessment for hydropower in India. Environmental Impact Assessment Review, 43, 135-143.

Falahatkar, S., Sadeqi, A., & Sofyanian, A. (2010). Environmental impact assessment of Qmyshlou highway construction using ICOLD matrix and Check list Land use Planing magazine, 2(2), 110-132.

Fataei E and Sheikh Jabbari H, (2005). Study of environmental impact assessment of the 2nd industrial TownShip of Ardabil. Environmental Science (in persian), 2 (7), 29-44. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=65307

Fataei E, Seiied Safavian ST, (2017)Comparative study on efficiency of ANP and PROMETHEE methods in locating MSW landfill sites, Anthropogenic Pollution Journal,1(1):٤٥-٤٠

Karamouz, M., & Karachian, R. (2003). Quality Planning and Management of Water Resources Systems: University of Amirkabir Publish.

Karimi S, Salehi moayed M, Jafari H R, (2008). A new method on exploitation of drainage areas in arid regions (Case study of Marvast's dam). Journal of Ecology, 34(47), 87-98.

Maanifar, M.R. and Fataei, E. (2015) Environmental Assessment of Municipal landfills (Case Study: East Azerbaijan Province/Iran). Advances in Bioresearch, 6, 52-58.

Mohammadi M, Fataei E, (2019) Comparative life cycle assessment of municipal wastewater treatment systems: lagoon and activated sludge Caspian journal of Environmental Science, 17(4): ٣٣٦-٣٢٧.

Nikmardan, A. (2007). Introduction Expert choice 11 software: Jahad daneshgahi of Amirkabir university.

Parsajou, H., & Fataei, E. (2019). Environmental assessment of the life cycle of sludge treatment systems of ardabil and khalkhal wastewater treatment plants. AMIRKABIR JOURNAL OF CIVIL ENGINEERING (AMIRKABIR), 51(2), 243-255. https://www.sid.ir/en/journal/ViewPaper.aspx?id=698136

Piry, H. (2011). Environmental impact assessment of the fourth quarter's well dam in Zabol- Iran. Quarterly Journal of the land use planning, 3(15), 145-163.

Qodsi pour, H. (2006). Analytical Hierarchy process: University of Amirkabir publish.

Sait Tahmicioglu, M., Anul, N., Ekmekci, F., & Durmus, N. (2007). Positive and negative impact of dams on the environment. Paper presented at the International Congress on River Basin Management, Turkey,

Tullos, D. (2009). Assessing the influence of environmental impact assessments on science and policy: An analysis of the Three Gorges Project. Journal of Environmental Management, 90(Supplement 3), 208-223.

Vosoughifar HR, Mirabi K, Jalalzadeh A, (2018) Evaluating a Novel Approach of Finite Volume Method for Discretization of Seepage Equation in Embankment Dams, Case study: Sonboleroud dam, Anthropogenic Pollution Journal, 2(2): 33-40

Wang Q, G., Y Y, H., Du , & Chen K, Q. (2012). Environmental Impact Post-Assessment of Dam and Reservoir Projects: A Review. Procedia Environmental Sciences, 13, 1439-1443.