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Study on the Index System of Environmental Impact Assessment (EIA) of Water Conservancy Projects

Zhi-qi Zhou
Yellow river Conservancy Technical Institute, Kaifeng, China

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ABSTRACT

The post-evaluation of the impact of water conservancy projects on the ecological environment provides scientific decision-making basis for the ecological and environmental management of water conservancy projects, which has important scientific significance and application value. The post-evaluation index system of the impact of the water conservancy project on the ecological environment was constructed, and the FME-AHP evaluation model was used to evaluate the ecological environment impact of the Stone reservoir. AHP weighting method was used to determine the weight of each level, and the normal membership function was used to calculate the membership value of each level index to the next level. It can be seen from the membership degree of each grade of the ecological environment system that the maximum membership degree of the third grade is 0.4332, followed by the membership degree of the second grade, which is 0.3453. This indicates that the influence of Stone river reservoir on the ecological environment is at the third grade (no influence) and tends to the second grade (with relatively adverse influence).

INTRODUCTION

Water conservancy projects, also known as water projects, are projects that are built by controlling and deploying various water resources in the natural world to achieve the goal of eliminating harm and benefiting (Reheman & Rusuli 2017). Water conservancy projects bring great social and economic benefits to people, but at the same time, the natural geographical characteristics of rivers are also changing, and the ecological service function of rivers and the ecological environment of river basins are inevitably damaged. Water projects are often built at the expense of other resources. The feedback information, provides the support for the new project decision-making management, as well as has the important scientific value and the practical significance.

In this paper, the post-evaluation index system of the impact of water conservancy projects on the ecological environment and the FME-AHP evaluation model are applied to conduct the post-evaluation of the impact of Stone river reservoir on the ecological environment. AHP weighting method was used to determine the weight of each level, and the normal membership function was used to calculate the membership value of each level index to the next level. Finally, according to the grade value calculated by the FME-AHP evaluation model, the grade of the ecological environment impact of Stone river reservoir was determined. The results showed that the impact of Stone river water conservancy project on the ecological environment was in the third grade (no impact) and inclined to the second grade (with relatively adverse impact).

PREVIOUS RESEARCH

In recent years, the post-evaluation work on the environmental impact of water conservancy and hydropower projects mainly includes the post-evaluation of the Sanmenxia water control project in the Yellow River, the environmental post-evaluation of the Xin'anjiang Hydropower Station, the Longyangxia Hydropower Station and the post-evaluation research and investigation of the reservoir ecological environment; post-evaluation on the environmental impact of irrigation projects in Dujiangyan irrigation area of Sichuan province, Panjin irrigation area of Liaoning province and Shaoshan irrigation area of Hunan province (Xue et al. 2017). A post evaluation on the ecological impact of Heihe river basin water diversion and recent comprehensive treatment on the middle reaches (Sitzia et al. 2018). Based on AHP matter-element extension model, the post-evaluation of ecological impact in the middle reaches of Heihe river (Mo et al. 2018). Using matter-element extension model, AHP method and expert scoring method, combined with the investigation data of Heihe river recent governance, the impact of Heihe river recent governance on midstream ecology was comprehensively evaluated. The results show that the recent treatment of Heihe river has a favourable impact on the midstream ecology, partially improving the local ecological environment, providing scientific information for the restoration and protection of the ecosystem of Heihe river, and providing decision-making basis for the follow-up

projects of Heihe river and other similar projects (Mo et al. 2018). Ecological index system of water resources and hydropower engineering can be divided into the natural environment, social environment, environmental pollution condition of three subsystems. This paper introduces the fuzzy evaluation method and comprehensive index method. Fuzzy evaluation method and comprehensive index method are analysed after the ecological impact evaluation of distinction and applicability, and comparing the method, it showed that the comprehensive index method can objectively reflect the status of regional ecological environment through the evaluation results (Ding et al. 2017). After the ecological impact of the Sanmenxia Water Control Project, the status of the ecological environment in the Sanmenxia water conservancy project area was expounded, and the changes in the structure and function of the regional ecosystems during the 40 years of construction and operation of the Sanmenxia water conservancy project were analysed. The net primary productivity of the region's vegetation and the potential for climate production, the different characteristics of regional biodiversity and hazard factors before and after the reservoir is built. The results show that the construction and operation of the reservoir have a certain impact on the net productivity of local vegetation and have an adverse impact on the water ecological environment (Tsegaye 2017).

Experimental method

Screening method for environmental impact post-evaluation index system: For a given j-th primary index, the greater the difference in X_{ij} (i = 1, 2, ..., n; n is the number of evaluation objects), the greater the comparison effect will be, that is, the more decision information it contains and transmits, the more information entropy can measure (Silvano et al. 2017). Firstly, information entropy formula is used to calculate information entropy. Secondly, determine the distinguishing ability measure W_j of the j-th evaluation index.

$$W_j = \left(1 - e_j\right) / \left(m - \sum_{i=1}^{m} e_j\right) \qquad \left(j = 1,2,\cdots,m\right) \quad \ldots(1)$$

The larger the value of X_j is, the stronger the discriminating ability of the index will be. The index with small discriminating ability can be deleted. This method is to delete the index that has little influence on the evaluation result in the index system, so it can realize the reduction of the index system.

The index system of post-evaluation of water conservancy projects on ecological environment was established: Determining the membership function is the main work of the fuzzy identification evaluation model. How to construct the membership function correctly is one of the key problems for the success of the fuzzy identification model. The object of fuzzy set research has the characteristics of fuzziness, experience and subjectivity. At present, there is no universal method to establish membership function. The normal type is the most important and the most common type of distribution. The measured values of ecological environment indicators in the ecological environment indicator system are all discrete. When the number of observations is large, it can be approximately considered that the membership function of these data for the same level is normal (Melaku 2018). Based on the conceptual framework of the post-evaluation of the impact of water conservancy projects on the ecological environment and the principle of screening the primary indicators, the final determination and construction of the index system of the post-evaluation of the impact of water conservancy projects on the ecological environment are shown in Table 1.

In the formula, a and b are constants, a > 0, b > 0; x is the index value, and f(x) is the membership function value.

The normal membership function can be expressed as:

$$f\left(x\right) = \exp\left(-\left(\frac{x-a}{b}\right)^2\right) \qquad \ldots(2)$$

AHP evaluation method: Determining the membership function is the main work of the fuzzy recognition evaluation model. How to construct the membership function correctly is one of the key issues for the success of the fuzzy recognition model. The objects of fuzzy set research have ambiguity, empiricism and subjectivity. At present, the general unified membership function establishment method has not yet been formed.

Weight determination method: Entropy is a physics term. Information entropy is the extension and application of thermodynamic entropy theory in informatics. It can be used to measure the degree of disorder of information sources. Shannon introduces the concept of entropy into the field of communication and calls it "information entropy", which reflects the average uncertainty of information sources (Banerjee et al. 2018). The information entropy is defined in the mathematical theory of information as the probability of occurrence of discrete random events. In information theory, entropy reflects the degree of information disorder. The larger the entropy is, the more disordered the information will be; on the contrary, the more ordered the information will be. Therefore, information entropy can be used to evaluate the degree of order and its utility of the obtained system information. Since the probability $P(x_i)$ of state x_i is different, the self-information $I(x_i)$ is also different (Guo 2000, Siew et al. 2019). And the mathematical expectation of the average self-information of uncertainty of the whole system in each state $I(x_i)$, denoted as $H(x_i)$, that is:

Table 1: Post-evaluation index system of water conservancy projects' impact on ecological environment.

Target layer	Criterion layer	Index layer
The impact of the ecological environment	Impact on the natural ecological environment	Reservoir submerged C1
Impact on estuaries and adjacent watersheds C9		Climate impact C2
Impact on biological resources C10		Purification environment C3
		River scouring C4
		Sedimentation C5
		Bank Shore Stability C6
		Backwater impact C7
		Soil erosion C8
	Impact on estuaries and adjacent watersheds C9	Impact on estuaries and adjacent watersheds C9
		Impact on biological resources C10
	Impact on social ecological environment	Population Migration C11
		Natural foci affect C12
		Water supply impact C13
		Flood protection benefit C14
		Impact on natural landscapes and places of interest C15
		Impact on fisheries C16

$$H(x_i) = \sum_{i=1}^{n} P(x_i) I(x_i) = -\sum_{i=1}^{n} P(x_i) \ln P(x_i) \quad (i = 1, 2, \cdots, n) \qquad \ldots(3)$$

FME-AHP coupling evaluation model: The rank can be determined by comparing the H_i size. The maximum grade of membership corresponds to the degree of impact of water conservancy projects on the ecological environment. The following grade calculation formula can also be used to evaluate the degree of impact of water conservancy projects on the ecological environment.

$$G = \sum_{i=1}^{m} i \times \frac{H_i}{\sum_{i=1}^{m} H_i} \qquad \ldots(4)$$

In the formula, G is the grade; m is the number of grades, and m = 5 in this paper.

EXPERIMENTAL RESULTS

According to the post-evaluation index system of ecological engineering impact on water environment, and the FME-AHP coupling evaluation model, the composite element of the ecological environment system of the Stone river basin is established. Determined the evaluation level standard and the weight of each indicator in the natural ecological ring subsystem and the social ecological environment subsystem according to the AHP empowerment method, and the weight of the two subsystems on the ecological environment system. By using the normal membership function, the membership degree of each index in the subsystem is calculated, and the subsystem fuzzy membership compound element is established. Through the weighted average calculation of each index and subsystem, the fuzzy membership element of the ecological environment system of the Stone river basin is obtained, and the influence degree of the Stone river reservoir on the ecological environment is determined according to the degree of fuzzy membership. The results show that the impact of the Stone reservoir on the ecological environment is at the third level (no impact) and biased towards the second level (with more adverse effects).

Constructing the elements of the ecological environment system in the Stone River Basin: According to the post-evaluation index system of ecological environment impact of water conservancy projects, the composite matter element of the ecological environment system of the Stone river basin is constructed. On the basis of collecting the statistics of the Stone river basin, many experts are asked to score each index in the Eco-environment System of the Stone river basin. The eigenvalues of the impact of the Stone river reservoir on the ecological environment are listed in Table 2.

Table 2: Characteristic values of post-evaluation indicators for the impact of water conservancy projects on ecological environment.

Target layer	Criterion layer	Indicator layer	Indicator eigenvalue
Ecological environment	Impact on the natural ecological environment	Reservoir submerged C1	30
		Climate impact C2	50
		Purification environment C3	85
		River scouring C4	45
		Sedimentation C5	50
		Bank Shore Stability C6	40
		Backwater impact C7	55
		Soil erosion C8	50
		Impact on estuaries and adjacent watersheds C9	55
		Impact on biological resources C10	35
	Impact on social ecological environment	Population Migration C11	40
		Natural foci affect C12	45
		Water supply impact C13	95
		Flood protection benefit C14	95
		Impact on natural landscapes and places of interest C15	40
		Impact on fisheries C16	75

Table 3: Judgment matrix of each indicator in the social ecological environment subsystem and AHP method empowerment.

Index	C11	C12	C13	C14	C15	C16	Weights
C11	1	8	3	4	5	6	0.4476
C12	1/8	1	1/6	1/5	1/4	1/3	0.0318
C13	1/3	6	1	2	3	4	0.2216
C14	1/4	5	1/2	1	2	3	0.1444
C15	1/5	4	1/3	1/2	1	2	0.0932
C16	1/6	3	1/4	1/3	1/2	1	0.0614

AHP method to determine weight: According to the selected evaluation indicators, the opinions of a number of experts are collected, and the weights of each index in the subsystem are calculated by AHP method. The relative importance of the two indicators is evaluated by experts, and the judgment matrix of each index in the social ecological environment subsystem and the AHP method are assigned as shown in Table 3.

The AHP method is to formally express and process people's subjective judgments, and gradually eliminate subjectivity, so as to transform into objective descriptions as much as possible. Its correctness and success depend on whether the objective component can reach a reasonable enough level. Due to the complexity of objective things and the subjectivity of decision makers, it is impossible for a pairwise comparison matrix of practical problems to achieve strict consistency.

Constructing fuzzy membership elements of ecological environment system: The fuzzy membership component of the ecological environment system can be obtained:

$$H = \begin{bmatrix} M_1 & M_2 & M_3 & M_4 & M_5 \\ H\,0.0177 & 0.3802 & 0.5021 & 0.0819 & 0.0181 \\ 0.0011 & 0.2756 & 0.2952 & 0.0056 & 0.3725 \end{bmatrix}$$

According to the AHP weight assignment method, the weights of the two subsystems in the ecological environment system are W = (0.6667, 03333). According to the weighted operation, the fuzzy membership element of the ecological

environment system can be obtained.

$$H = \begin{bmatrix} & M_1 & M_2 & M_3 & M_4 & M_5 \\ H & 0.01722 & 0.3453 & 0.4332 & 0.0731 & 0.1362 \end{bmatrix}$$

RESULTS AND DISCUSSION

The impact of the natural ecological environment subsystem is at the third level, that is, the water conservancy project has no impact on the ecological environment, and the impact on the social ecological environment subsystem is at the fifth level, that is, the water conservancy project has a favourable impact on the social ecological environment. The ecological environment system can be seen in the membership degree of each level. The membership degree of the third level is 0.4332, and the degree of membership of the second level is 0.3453, which indicates that the influence of Stone reservoir on the ecological environment is the third level (no impact) and biased towards the second level (with more adverse effects). According to the post-evaluation index system of ecological engineering impact on water environment and the fuzzy matter-level analysis coupling model (FME-AHP model), the composite matter element of the ecological environment system of the Stone river basin is established, and the evaluation grade standard is established. According to the AHP empowerment method, the weights of the indicators in the natural ecological ring subsystem and the social ecological environment subsystem are determined, and the weights of the two subsystems on the ecological environment system are determined. By using the normal membership function, the membership degree of each index in the subsystem is calculated, and the subsystem fuzzy membership compound element is established. Through the weighted average calculation of each index and subsystem, the fuzzy membership element of the ecological environment system of the Stone river basin is obtained, and the influence degree of the Stone river reservoir on the ecological environment is determined according to the degree of fuzzy membership. The results show that the impact of the Stone reservoir on the ecological environment is at the third level (no impact) and biased towards the second level (with more adverse effects).

CONCLUSION

The post-evaluation of the impact of water conservancy projects on the ecological environment will continue to be enriched and improved with human practice activities, economic development and social progress. People have also re-recognized a series of ecological and environmental problems between nature and human society. In a large number of studies, the establishment of an ecologic environment indicator system will become more and more well-founded, the evaluation methods will become more mature, and the calculation results will be more realistic and accurate. Applying the theory of ecological hydraulics, establishing a post-evaluation index system for the impact of water conservancy projects on ecological environment, and conducting research on the post-evaluation index system and evaluation method for the impact of water conservancy projects on ecological environment, providing a basis for water conservancy projects to evaluate ecological environment, and for water resources regulation strategies. The formulation and implementation of the coordinated development strategy of society, economy and environment has realistic guiding significance and application prospects.

REFERENCES

Banerjee, P., Ghose, M.K. and Pradhan, R. 2018. AHP-based spatial analysis of water quality impact assessment due to change in vehicular traffic caused by highway broadening in Sikkim Himalaya. Appl. Water Sci., 8(2): 72.

Ding, J., Zhang, Y., Cheng, H., Shen, Y. and Song, L. 2017. Establishment of environmental impact assessment index system on agricultural planning. Transactions of the Chinese Society of Agricultural Engineering, 33(7): 177-182.

Guo, Z.L. 2000. Methods for environmental impact assessment of agricultural water conservancy projects. Transactions of the Chinese Society of Agricultural Engineering, 16(5): 16-19.

Melaku, N.D., Renschler, C.S., Flagler, J., Bayu, W. and Klik, A. 2018. Integrated impact assessment of soil and water conservation structures on runoff and sediment yield through measurements and modelling in the northern Ethiopian highlands. Catena, 169: 140-150.

Mo, Z., Liu, Y., Jing, W. and Wang, T. 2018. Index system of urban resource and environment carrying capacity based on ecological civilization. Environ. Impact Assess. Rev., 68: 90-97.

Reheman, A. and Rusuli, Y. 2017. Ecological effects of the first water diversion hub station in Kaidu river based on the vegetation index. J. Soil Water Conserv., 15(2): 115-124.

Silvano, R.A.M., Hallwass, G., Juras, A.A. and Lopes, P.F.M. 2017. Assessment of efficiency and impacts of gillnets on fish conservation in a tropical freshwater fishery. Aquat. Conserv., 27(2).

Sitzia, T., Campagnaro, T. and Grigolato, S. 2018. Ecological risk and accessibility analysis to assess the impact of roads under habitats directive. J. Environ. Plann. Manag., 59: 1-21.

Tsegaye, F. 2017. Technical and managerial aspects of environmental and health impact assessment of water resource development projects: the Ethiopian experience. Ethiop. J. Health Dev., 42(1): 81-89.

Xue, L., Zhang, H., Zhang, L., Chi, Y. and Sun, C. 2017. Impact of water conservancy projects on eco-hydrological regime of Tarim river based on improved RVA method. J. Hohai Univ., 45(3): 189-196.