

Based on AHP, The Ecological Environment of Fenhe River Basin Is Evaluated

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Abstract: The evaluation of the ecological quality of the Fenhe River Basin is of great significance for the high-quality development of the Yellow River Basin and Shanxi Province. In this paper, the analytic hierarchy process (AHP) is used to evaluate the ecological environment of Fenhe River Basin. Firstly, based on the relevant research literature, the ecological environment evaluation index is determined, and the influencing factors of the evaluation index are determined. Secondly, the weight of different influencing factors is determined based on AHP method, and the weight of evaluation index is obtained. Finally, the ecological environment of Fenhe River Basin in different years was analyzed by weight analysis results and expert scoring method. The results show that the ecological environment evaluation indexes of Fenhe River Basin are : water loss, soil loss, water pollution and vegetation reduction; the influencing factors of the evaluation index are : rainfall factors, soil and water conservation measures, reservoir construction, industrial water use, coal mining, engineering construction, solid waste pollution, urban development, industrial structure change, population change; from 2000 to 2020, the ecological quality of the Fenhe River Basin continued to improve, indicating that the policies and measures adopted for ecological management were effective. The ecological deterioration near the main stream and tributaries of the middle and lower reaches of the Fenhe River is related to the pollution of mine environment and industrial sewage.

Keywords: Ecological environment; AHP; Fenhe River Basin; Impact assessment.

1. Introduction

As a complex social-ecological system, the basin has a deep correlation with ecosystems, hydrological systems, agricultural ecosystems, and social systems [1], and contains multiple ecosystem service functions such as climate regulation, water supply, and biodiversity protection [2], which has become the focus of ecological evaluation research in recent years. As the second largest tributary of the Yellow River, the Fenhe River is the mother river of Shanxi. With the growth of population and economy, the acceleration of urbanization and the expansion of human activities in the Fenhe River Basin, a series of ecological and environmental problems such as environmental degradation, eutrophication of water resources, biodiversity degradation, soil erosion and flood disasters have been caused [3-7]. Therefore, the evaluation of the ecological quality of the Fenhe River Basin is of great significance for the high-quality development of the Yellow River Basin and Shanxi Province.

In this paper, AHP is used to evaluate the ecological environment of Fenhe River Basin. Firstly, based on the relevant research literature, the ecological environment evaluation index is determined, and the influencing factors of the evaluation index are determined. Secondly, the weight of different influencing factors is determined based on AHP method, and the weight of evaluation index is obtained. Thirdly, the influence factors of different years in Fenhe River Basin were scored by expert scoring method. Finally, according to the scoring results and combined with the weight information, the ecological environment evaluation results of Fenhe River Basin in different time and space are obtained.

2. Establishment of Evaluation Index

According to relevant research, this paper believes that the ecological environment evaluation index of Fenhe River

Basin can be divided into three. The three evaluation indexes are water loss (P1), soil loss (P2), water pollution (P3) and vegetation reduction (P4).

Water loss can be divided into river water loss and groundwater water loss. River water loss is mainly due to the reduction of river water volume caused by natural conditions and human activities. River water is taken up by industrial water or geological changes caused by human activities lead to water loss.

The loss of soil is mainly due to the bare soil, which is eroded under the action of wind and water, resulting in the reduction of soil in the basin and the loss of soil.

Water pollution is mainly caused by human beings in the basin to pollute rivers and groundwater. There are coal resources in the study area. The mining of coal may lead to the fracture of the roof or floor of the roadway, and the mine pollutes the top river or the bottom groundwater. On the other hand, industrial activities in the basin will also cause certain pollution to the river, such as metallurgy, coal, coking, chemical industry water.

The decrease of vegetation is due to the death of plants caused by human activities, resulting in a decrease in vegetation coverage. For example, mining activities in the basin lead to the emergence of underground goafs, and the emergence of goafs will cause surface subsidence to produce cracks. The water stored in the soil will enter deeper into the soil through cracks, resulting in the inability of plant roots to absorb sufficient water, causing plant death.

3. Influencing Factors

According to the actual situation and related research [5-11], the influencing factors of the above four evaluation indexes were analyzed.

(1) Rainfall factors (S1)

Rainfall is an important factor causing soil erosion in the basin. When the rainfall intensity is large, the soil will be

damaged, and the damaged soil will be taken away by rainwater. In addition, rainfall will also lead to the instability of the slope in the basin. The unstable soil is relatively loose and can easily be taken away by rainwater. At the same time, rainfall is also easy to induce debris flow, resulting in a large number of soil erosion.

(2) Soil and water conservation measures (S2)

A large area of afforestation was carried out in the basin, and the plant roots stabilized the soil and greatly reduced the soil and water loss in the basin. At the same time, the vegetation coverage in the basin is increased.

(3) Reservoir construction (S3)

After 1988, a large-scale 'soil and water conservation' plan was carried out in the upper reaches of the Fenhe River Basin, and a large number of reservoirs and inspection dams were built to effectively intercept runoff and sediment, which greatly reduced soil erosion.

(4) Industrial water (S4)

Taiyuan is an important industrial city in northern China, gathered a large number of high water consumption industry (such as metallurgy, coal, coking, chemical industry). The development of industrial development has led to an increase in river diversion and a decrease in upstream inflow, resulting in a certain amount of water loss.

(5) Coal mining (S5)

Mining activities in the basin lead to the emergence of underground goaf, and the emergence of goaf will cause surface subsidence to produce cracks. On the one hand, it pollutes the water body in the basin. On the other hand, fissures lead to water loss, resulting in water loss. At the same time, water loss has led to a decrease in vegetation.

(6) Engineering construction (S6)

The development of urbanization has led to the development of the construction industry. In order to improve the bearing capacity of the foundation, groundwater has been drained, resulting in groundwater loss and pollution.

(7) Solid waste pollution (S7)

The construction waste and domestic waste in the basin will cause certain pollution to groundwater and surface water

during transportation and treatment.

(8) Urban development (S8)

The development of urbanization has led to the increase of construction land in the basin, which has compressed the original farmland, grassland and forest land, resulting in a decrease in vegetation coverage. At the same time, the development of urbanization has increased the production of solid waste and threatened the water and soil environment in the basin.

(9) Changes in industrial structure (S9)

With the change of national and local policies, the economic structure in the basin has changed to some extent. In recent years, the tertiary industry has developed rapidly and improved the ecological environment in the basin.

(10) Changes in population (S10)

With the acceleration of urbanization, the population flow in the basin has undergone significant changes. More and more rural population has gradually gathered in cities. The rural population has decreased, the urban population has increased, and the rural ecological environment has been improved to a certain extent, while the urban ecological environment has been threatened.

In summary, the influencing factors corresponding to different evaluation indicators are shown in table 1.

Table 1. Influencing factors

NO.	Evaluating indicator	Influencing factor
1	P1	S2、 S3、 S4、 S5、 S6
2	P2	S1、 S2、 S3、 S5
3	P3	S4、 S5、 S6、 S7、 S8、 S10
4	P4	S1、 S2、 S5、 S6、 S7、 S8、 S9、 S10

4. Weight Analysis

The hierarchical structure model is shown in Figure 1.

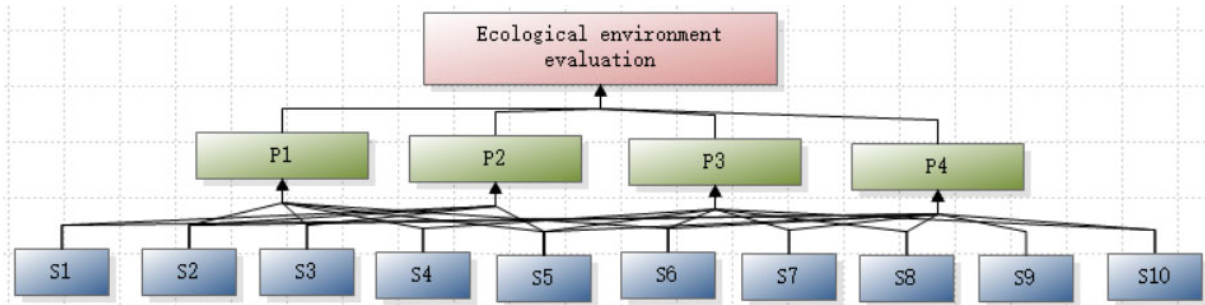


Figure 1. Hierarchical structure model

The AHP method is used to determine the weight of the influencing factors of different evaluation indicators. In which the ecological environment evaluation is set to A, the judgment matrix is as follows:

$$A = \begin{bmatrix} 1 & 2 & 3 & 1 \\ & 1 & 2 & 1/2 \\ & & 1 & 1/3 \\ & & & 1 \end{bmatrix} \quad (1)$$

$$P1 = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ & 1 & 2 & 3 & 4 \\ & & 1 & 2 & 3 \\ & & & 1 & 2 \\ & & & & 1 \end{bmatrix} \quad (2)$$

$$P2 = \begin{bmatrix} 1 & 3 & 4 & 5 \\ & 1 & 3 & 4 \\ & & 1 & 3 \\ & & & 1 \end{bmatrix} \quad (3)$$

$$P3 = \begin{bmatrix} 1 & 2 & 4 & 3 & 5 & 6 \\ & 1 & 3 & 2 & 4 & 5 \\ & & 1 & 1/2 & 2 & 3 \\ & & & 1 & 3 & 4 \\ & & & & 1 & 2 \\ & & & & & 1 \end{bmatrix} \quad (4)$$

$$P4 = \begin{bmatrix} 1 & 1/2 & 2 & 3 & 7 & 4 & 6 & 5 \\ & 1 & 3 & 4 & 8 & 5 & 7 & 6 \\ & & 1 & 2 & 6 & 3 & 5 & 4 \\ & & & 1 & 5 & 2 & 4 & 3 \\ & & & & 1 & 1/4 & 1/2 & 1/3 \\ & & & & & 1 & 3 & 2 \\ & & & & & & 1 & 1/2 \\ & & & & & & & 1 \end{bmatrix} \quad (5)$$

Equations (1) to (5) are the calculation judgment matrix of ecological environment evaluation A, P1, P2, P3 and P4. The eigenvector of A is $W=(0.3507,0.1892,0.1093,0.3507)^T$, and its consistency test CR is 0.0039. The judgment matrix passes the consistency test. The eigenvector of P1 is $W=(0.4162,0.2618,0.1611,0.0986,0.0624)^T$, the consistency test CR is 0.0153, and the judgment matrix passes the consistency test. The eigenvector of P2 is $W=(0.52,0.2682,0.1409,0.0709)^T$, and its consistency test is that the judgment matrix passes the consistency test. The eigenvector of P3 was $W=(0.3794,0.2488,0.1024,0.1604,0.0655,0.0434)^T$, and the consistency test CR was 0.0688. The judgment matrix passed the consistency test. The eigenvector of P4 is $W=(0.2273,0.3268,0.1569,0.1077,0.0242,0.734,0.034,0.0498)^T$, the consistency test CR is 0.0196, and the judgment matrix passes the consistency test.

The calculated weights are sorted from large to small as shown in Table 2.

Table 2. Weight calculation results

Influencing factor	Weight
S2	0.2325
S4	0.1895
S5	0.1524
S1	0.1233
S3	0.1185
S6	0.0696
S7	0.0589
S8	0.031
S10	0.0207
S9	0.0037

5. Ecological Environment Assessment

According to the weight size, the ecological environment of the Fenhe River Basin is evaluated. The evaluation selects the data of the influencing factors of the Fenhe River Basin from 2000 to 2020, and the data is obtained by expert scoring according to the statistical yearbook. The results show that :

(1) From 2000 to 2005 and from 2005 to 2020, the ecological environment quality showed the characteristics of decreasing first and then increasing.

(2) In 2000, the ecological quality was mainly poor, followed by medium ecological quality.

(3) In 2005, the middle and poor ecological grades were in a dominant position.

(4) From 2000 to 2020, the regional ecological quality of the whole basin showed the characteristics of improvement, and the area with significant improvement accounted for 49.69 % of the total area. There were 87.91 % and 69.07 % of the regional ecology in the mountain and basin areas, respectively, showing an improvement trend.

(5) From 2000 to 2020, the ecological quality of the Fenhe River Basin continued to improve. It shows that the policies and measures of ecological governance formulated and adopted by the government over the years are effective. In 2020, the impact of the new coronavirus epidemic led to the failure of various ecological measures to be carried out perfectly in the basin. In the same year, two forest fires occurred in the Fenhe River Basin, resulting in a decrease in mountain vegetation coverage and a decline in ecological environment quality. The ecology near the main stream and tributaries of the middle and lower reaches of the Fenhe River shows a trend of continuous and significant deterioration, which is related to the pollution of mine environment and industrial sewage in the river channels and surrounding river beach wetlands.

6. Conclusion

As the second largest tributary of the Yellow River, the evaluation of the ecological quality of the Fenhe River Basin is of great significance for the high-quality development of the Yellow River Basin and Shanxi Province. Based on AHP, this paper evaluates the ecological environment of Fenhe River Basin. The main conclusions are as follows:

(1) This paper argues that the ecological environment evaluation index of Fenhe River Basin can be divided into three. The three evaluation indexes are water loss, soil loss, water pollution and vegetation reduction.

(2) The influencing factors of the four evaluation indicators are : rainfall factors, soil and water conservation measures, reservoir construction, industrial water, coal mining, engineering construction, solid waste pollution, urban development, changes in industrial structure, and changes in population. Among them, the most influential factor is soil and water conservation measures, and the smallest factor is the change of industrial structure.

(3) From 2000 to 2020, the ecological quality of the Fenhe River Basin continued to improve. It shows that the policies and measures of ecological governance formulated and adopted by the government over the years are effective. The ecology near the main stream and tributaries of the middle and lower reaches of the Fenhe River shows a trend of continuous and significant deterioration, which is related to the pollution of mine environment and industrial sewage in the river channels and surrounding river beach wetlands.

References

- [1] Cabello V, Willaarts BA, Aguilar M, et al. River basins as social-ecological systems: Linking levels of societal and ecosystem water metabolism in a semiarid watershed[J]. *Ecology and Society*, 2015, 20: 20.
- [2] Miao Xinhui, Liang Qinou. Analysis of ecological environment change in Yongjiang River Basin based on remote sensing ecological index. *Resources and Environment in the Yangtze River Basin* [J], 2021, 30 (2) : 427-438.
- [3] Zhao Yanfeng. Phytoplankton community characteristics and environmental factors in Fenhe River Basin [J]. *Water conservancy planning and design*, 2024, (09) : 35-39 + 43.
- [4] Tian Shimin, Han Bing, Zhao Gaolei, et al. [4] Analysis of water ecological environment change characteristics in the Yellow River Basin [J]. *People 's Yellow River*, 2024, 46 (09) : 112-119.
- [5] Li Zhanxing, Wang Yanhui. Ecosystem vulnerability assessment and change analysis of Fenhe River Basin [J]. *Geographical spatial information*, 2024, 22 (08) : 45-49.
- [6] Wang Yong, Zhou Shuqin, Jing Yaodong, et al. Comprehensive evaluation of ecological sensitivity and spatial-temporal evolution analysis of Fenhe River Basin [J]. *Zhongnan Agricultural Science and Technology*, 2024, 45 (7): 140-146 + 170.
- [7] Li Zhenhan, Li Jingwen, Yu Hongwei, et al. Study on the strategy of water ecological environment protection and sustainable development in Fenhe River Basin [J]. *Journal of Environmental Science*, 2024, 44 (8): 1-11.
- [8] Jia Caihong. Analysis of ecological protection and restoration path in Fenhe River Basin [J]. *Comprehensive utilization of resources in China*, 2024, 42 (5): 189-191.
- [9] Liang Yinjiao. Analysis and prediction of water ecology in Fenhe River Basin based on neural network [J]. *Water conservancy technical supervision*, 2024, (5): 109-110 + 134.
- [10] Zhang Yufei, Yang Wenfu, Zhang Wenkai et al. Analysis of spatial and temporal differentiation characteristics and influencing factors of NPP in Fenhe River Basin from 2001 to 2021 [J]. *Surveying and Mapping Science*, 2024, 49 (5): 30-43.
- [11] Li Jingwen, Li Zhenhan, Wu Haibin, et al. Assessment of water resources carrying capacity and ecological sensitivity analysis of Fenhe River Basin [J]. *Journal of Environmental Engineering*, 2024, 18 (2): 359-370.