An Evaluation Study on Water Ecological Civilization Construction in Coal Mining Subsidence Area

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Abstract By combining expert consultation and field investigation, an evaluation system, consisting of 29 indices in 5 aspects of water safety, water ecology, water management, water landscape and water culture, was established for water ecological civilization construction in coal mining subsidence areas. The weight of the indices was determined using improved group-decision fuzzy analytic hierarchy process and fuzzy mathematical method, and their score was determined according to their value before the pilot and the value at the end of the pilot. Combined with the weight, the actual score of the indices was obtained. Finally, a comprehensive index of water ecological civilization in coal mining subsidence areas was obtained. Through the weight and score of the indices, the construction status, existing problems and future tasks of coal mining subsidence areas were analyzed, in order to provide a reference for the region to further clarify the direction and key tasks of water ecological civilization construction.

Key words Coal mining subsidence area, Water ecological civilization, Evaluation index system

1 Introduction

Since the 18th National Congress of the Communist Party of China, the construction of ecological civilization has been incorporated into the important content of the "five in one" overall layout and the coordinated promotion of the "four comprehensive" strategic layout. The governance and protection of the ecological environment has become an important task in the construction of socialism with Chinese characteristics in the new era. According to the deployment requirements of the Central Committee of the Communist Party of China on the construction of ecological civilization, the Ministry of Water Resources has launched 105 water ecological civilization city pilot projects in batches since 2013, and Anhui Province has launched 10 pilot projects of water ecological civilization city construction in batches since 2014. The mining areas in Huainan and Huaibei of Anhui Province have made important contributions to China's energy industry, but they have also paid a heavy price for the destruction of land resources, water resources and ecological and environmental resources. The ecosystem in the subsidence areas is gradually transforming from pre-mining farmland ecosystem to large-scale water ecosystem, and the structure and function of the ecosystem are undergoing major changes[1]. Quantitative evaluation and research on the protection of water ecosystem and the construction of water ecological civilization in the subsidence areas is of great significance for coordinating regional economic and social development with the carrying capacity of water resources and water environment, further accelerating the improvement of water environment and the restoration of water ecology, promoting the harmony between people and water and promoting the construction of ecological civilization, with very significant social benefits, ecological benefits and economic benefits.

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2 Establishment of index system

2.1 Construction of index system Based on the current situation of water resources and water ecology and the development status of economy and society in the mining areas of Huainan and Huaibei, starting from the main water problems in the region, with reference to relevant literature and the exiting index systems established by experts and scholars, the water ecological civilization construction index system that suits the actual situation of the coal mining subsidence areas was screened and summarized by theoretical analysis method according to the appearance frequency of indices, in line with the principle of being hierarchical, scientific, implementable and representative[2]. The index system was composed of one comprehensive target layer A (*i.e.* coal mining subsidence area water ecological civilization) and five criterion layers, B_1 (water security), B_2 (water ecology), B_3 (water management), B_4 (water landscape) and B_5 (water culture). At the same time, 29 detailed indices in line with the actual situation of the coal mining subsidence areas were selected (Table 1).

2.2 Calculation of index score After the index system is determined, the specific evaluation criteria of each index need to be clarified. By comparing the characteristic value and target value of the evaluation object, each index value can be converted into an evaluation value to determine the level of water ecological civilization construction, so as to propose improvement measures for the inadequacy. In this paper, the evaluation of water ecological civilization in the coal mining subsidence areas was based on a total score of 100 points, and each index was assigned according to its degree of achievement. At the same time, with reference to relevant research results, the target values of the 29 indices were set, in order to quantify the level of water ecological civilization in the coal mining subsidence areas in the later period. In the evaluation index system of water ecological civilization construction in coal mining subsidence areas, the quantization unit of each index was inconsistent, so each index needed to be standardized. The indices were standardized according to the following formula:

$$P_{ij} = \frac{S_{ij}}{T_{ij}}$$

where P_{ij} is the evaluation standard value of the j-th index in the i-th subsystem; S_{ij} is the statistical value of the j-th index in the i-th subsystem; T_{ij} is the evaluation target value of the j-th index in the i-th subsystem. The greater the value of P_{ij}, the better the index relative to its target value; and the smaller the value of P_{ij}, the worse the index relative to its target value.

Table 1 Construction of evaluation index system for water ecological civilization construction in coal mining subsidence area

Target layer	Criterion layer	Criterion layer weight	Index layer	Index layer weight	Comprehensive weight	Target	2013			2017		
							Achievement situation	Evaluation value	Evaluation index	Achievement situation	Evaluation value	Evaluation index
Mining subsidence area water ecological civilization (A)	Water security (B_1)	0.240 8	Flood control qualification rate (C_1)	0.311 0	0.037 8	Once in 100 years	Once in 20 years	0.00	0.000	Reached partially	0.60	0.023
			Flood drainage qualification rate (C_2)	0.311 0	0.037 8	Once in 20 years	Once in 10 years	0.60	0.023	Once in 20 years	1.00	0.038
			Water qualification rate (C_3)	0.378 0	0.045 9	70%	30%	0.00	0.000	66%	0.80	0.037
	Water ecology (B_2)	0.220 4	Ecological water maintenance (C_4)	0.139 4	0.041 4	Water connection	Not connected	0.50	0.021	Water connection	1.00	0.041
			Water environment maintenance (C_5)	0.139 4	0.041 4	Excellent	General	0.33	0.014	Good	0.67	0.028
			Water surface ratio (C_6)	0.156 9	0.046 6	12%	10.56%	0.75	0.035	11.70%	0.88	0.041
			Aquatic organism abundance (C_7)	0.102 6	0.030 5	100 species	80 species	0.50	0.015	102 species	1.00	0.030
			Plant configuration rationality (C_8)	0.102 6	0.030 5	100 species	90 species	0.50	0.015	125 species	1.00	0.030
			Mined land restoration and reclamation rate (C_9)	0.115 4	0.034 2	90%	80%	0.33	0.011	90%	1.00	0.034
			Soil and water loss control rate (C_{10})	0.115 4	0.034 2	90%	85%	0.67	0.023	94.20%	1.00	0.034
			Forest and grass coverage (C_{11})	0.128 2	0.038 0	35%	30%	0.80	0.030	44.37%	1.00	0.038
	Water management (B_3)	0.200 0	Water consumption per 10 000 yuan of GDP (C_{12})	0.069 7	0.030 5	60 m^3	70.3 m^3	0.50	0.015	47.6 m^3	1.00	0.031
			Water consumption per 10 000 yuan of added value of industrial enterprises above designated size (C_{13})	0.069 7	0.030 5	38 m^3	41.8 m^3	0.50	0.015	29.8 m^3	1.00	0.031
			Waste water discharge qualification rate (C_{14})	0.093 1	0.040 7	95%	95%	1.00	0.041	98.50%	1.00	0.041
			Sewage treatment and reuse rate (C_{15})	0.077 5	0.033 9	50%	50%	1.00	0.034	52%	1.00	0.034
			Leakage rate of water supply network (C_{16})	0.077 5	0.033 9	14.50%	14.90%	0.75	0.025	11.41%	1.00	0.034
			Popularization of water-saving society (C_{17})	0.069 7	0.030 5	100%	100%	1.00	0.031	100%	1.00	0.031
			Water source protection effect (C_{18})	0.077 5	0.033 9	280	280	1.00	0.034	280	1.00	0.034
			Situation of project's meeting the standards of flood control and drainage and water supply (C_{19})	0.085 3	0.037 3	95%	80%	0.50	0.019	100%	1.00	0.037
			Engineering facilities intact ratio (C_{20})	0.085 3	0.037 3	90%	80%	0.33	0.012	85%	0.67	0.025
			Implementation rate of "three simultaneous" soil and water conservation in production and construction projects (C_{21})	0.085 3	0.037 3	Three items reached	One item reached	0.33	0.012	Two items reached	0.67	0.025
			Planning and reporting (C_{22})	0.069 7	0.030 5	Have	Have	1.00	0.031	Have	1.00	0.031
			Subsidence area management availability rate (C_{23})	0.069 7	0.030 5	In place	In place basically	0.50	0.015	In place basically	0.50	0.015
			Formulating situation of supporting laws and regulations (C_{24})	0.069 7	0.030 5	Sound	Unsound	0.00	0.000	Sound basically	0.50	0.015
	Water landscape	0.179 6	Natural water landscape (C_{25})	0.356 0	0.032 3	Excellent	General	0.25	0.008	Reached basically	0.50	0.016

(To be continued)

(Continued)

Target layer	Criterion layer	Criterion layer weight	Index layer	Index layer weight	Comprehensive weight	Target	2013 Achievement situation	2013 Evaluation value	2013 Evaluation index	2017 Achievement situation	2017 Evaluation value	2017 Evaluation index
	(B_4)		Scenic area (C_{26})	0.288 0	0.026 1	1	0	0.00	0.000	1	1.00	0.026
			Hydrophilic shoreline (C_{27})	0.356 0	0.032 3	Reached	Un-reached	0.00	0.000	Reached basically	0.50	0.016
	Water culture (B_5)	0.159 2	Ornamental and water culture characteristics of waters and surrounding attractions (C_{28})	0.525 0	0.028 1	Reached	Un-reached	0.33	0.009	Reached basically	0.67	0.019
			Popularization of water culture (C_{29})	0.475 0	0.025 4	Reached	Un-reached	0.50	0.013	Reached	1.00	0.025
			Water ecological civilization comprehensive index						0.502			0.859

2.3 Calculation of index weight According to the results of comparison between the values of each index before the pilot and at the end of the pilot and its target value, the score of each index was determined, and the product of the score and weight of each index was the actual score. Due to the difficulty of traditional AHP method to establish judgment matrix and perform consistency test, fuzzy mathematical method was adopted in this paper to avoid testing whether the AHP judgment matrix had consistency. Thus, the fuzzy improved analytic hierarchy process weight model (F-IAHPWM) suitable for the evaluation and analysis of water ecological civilization was established[3]. The weight calculation steps of the improved group-decision fuzzy analytic hierarchy process were as follows: (i) Determination of hierarchical structure. The complex problem of water ecological civilization evaluation was decomposed into an evaluation index system consisting of different layers, so as to establish a hierarchical structure, thus making the complex problem systematic, methodical and hierarchical. (ii) Construction of fuzzy matrix. u_i represents the evaluation index, $u_i \in U(i=1, 2, \cdots, m)$; scale value r_{ij} represents the relative importance value of u_i for $u_i \in U(i=1, 2, \cdots, m)$, and r_{ij} was assigned according to the criterion of "improved 0.1 – 0.9 scaling method". The greater the r_{ij} value, the more important the index u_i. The judgment matrix $R=(r_{ix})_m \times m(i, j=1, 2, \cdots, m)$ was obtained. The meaning of each scale is shown in Table 2.

Table 2 0.1 – 0.9 scaling method and improvement

	Scale of 0.1 – 0.9	Improved scale of 0.1 – 0.9
0.1	Index A is definitely not as important as index B	Index A is not as important as index B
0.3	Index A is obviously not as important as index B	Index A is slightly less important than index B
0.5	Index A is just as important as index B	Index A is just as important as index B
0.7	Index A is obviously more important than index B	Index A is more important than index B
0.9	Index A is definitely more important than index B	Index A is obviously more important than index B

Note: 0.2, 0.4, 0.6, 0.8 are the medians of the two adjacent judgments above.

(iii) The average value of the judgment matrix R was calculated by row to get:

$$R_i = \frac{\sum_{K=1}^{m} r_{ik}}{m} (i=1, 2, \cdots, m)$$

(iv) The obtained average values of the judgment matrix were transformed mathematically according to the following formula to form a fuzzy consistent matrix A:

$$a_{ij} = \frac{R_i - R_j}{2} + 0.5 \qquad (i, j=1, 2, \cdots, m);$$

$$A=(a_{ij})_{m \times m} \qquad (i, j=1, 2, \cdots, m)$$

(v) Each column vector of the fuzzy consistent matrix A was normalized to get:

$$\widetilde{C}_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}$$

(vi) $\widetilde{C}_{ij}$ was sum up by row, *i.e.*, $\widetilde{C}_i = \sum_{j=1}^{m} \widetilde{C}_{ij}$; $\widetilde{C} = (\widetilde{C}_1, \widetilde{C}_2, \cdots, \widetilde{C}_m)^T$

(vii) The weight vector set of the evaluation index obtained by normalization was calculated, *i.e.*

(viii) Group decision processing. The number of experts participating in the evaluation must be as large as 5 – 11, and so, multiple judgment matrices will be obtained for the same evaluation index layer. Therefore, it is necessary to deal with multiple decisions (*i.e.* group decisions). The method used in this paper was the weighted average method of ranking vectors. It could be known that the weight vector set obtained in step (vii) was actually $C^{(k)}(k=1, 2, \cdots, n)$ (k is the total number of experts participating in the evaluation), so the weight vector set of the evaluation index layer was: $C=[C^{(k)}]$.

Since this method can meet the consistency requirements of the thinking process of judgement, and doesn't need to perform consistency test for the matrix, and the elements of the fuzzy consistency matrix obtained through mathematical transformation could be used to calculate the weight of evaluation indices, the improved group-decision fuzzy analytic hierarchy process based on fuzzy consistent matrix can be used as a method for weight calculation of water ecological civilization evaluation[4].

2.4 Correction and normalization of weight As the differences in the number of indices included in the four criterion layers of B_1, B_2, B_3 and B_4 increased, all indices needed to be homogenized according to the proportion of the number of indices included in each criterion layer. In addition, it was also necessary to normalize the index weights homogenized. Finally, the normalized weight of each index was calculated. The homogenization formula for each index weight was as follows:

$$C_{ij} = B_i X_{ij} Y_i$$

where C_{ij} represents the homogenization weight of the j-th index in the i-th subsystem; B_i represents the total weight of the i-th subsystem; X_{ij} represents the weight of the j-th index in the i-th subsystem; and Y_i represents the impact factor of the number of indices in the criterion layers of the i-th subsystem.

3 Evaluation method and model

3.1 Evaluation method There are many factors to be considered in the evaluation of water ecological civilization, and each factor includes multiple layers. The established security assessment hierarchy may be a three or more-layer hierarchy. The solution to this multi-layer security assessment of water ecological civilization is as follow. First of all, a fuzzy assessment is performed for the indices at the lowest layer. Then, fuzzy evaluation is carried out on the indices of the top layer one by one until the security assessment result of water ecological civilization is obtained. Therefore, a multi-index and multi-layer security fuzzy assessment model (SFAM) suitable for the evaluation and analysis of water ecological civilization is established. The first-layer index set is assumed to be $U = \{u_1, u_2, \cdots, u_n\}$; the first-layer set is subdivided, and the second-layer index set is obtained as $U_i = \{u_{i1}, u_{i2}, \cdots, u_{im}\}$; the set $u_{ij}(i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)$ is further subdivided, and the third-layer index set is obtained as $U_{ij} = \{u_{ij1}, u_{ij2}, \cdots, u_{ijl}\}$; and subdivision is performed accordingly until the lowest-layer indices. It is assumed that the water ecological civilization is evaluated according to μ_{ij}, the j-th index under the i-th index, and thus, the degree of membership of evaluation object to the k-th element in the evaluation set is $r_{ijk} = (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m; k = 1, 2, \cdots, p)$. In the fuzzy evaluation, when performing security evaluation on the i-th index, its degree of membership to the k-th element in the evaluation set is set as b_{ik}; in the second-layer evaluation, the membership of the second-layer indices to the k-th element in the evaluation is set as b_k.

According to fuzzy theory, the evaluation set of the i-th index of security evaluation is:

$$\tilde{B}_i = \tilde{A}_i \cdot \tilde{R}_i = \tilde{A}_i \cdot \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1p} \\ r_{i21} & r_{i22} & \cdots & r_{i2p} \\ \vdots & \vdots & & \vdots \\ r_{im1} & r_{im2} & \cdots & r_{imp} \end{bmatrix} = (b_{i1}, b_{i2}, \cdots b_{ip})$$

where $\tilde{B}_i$ is the fuzzy security evaluation set of the i-th index at the bottom; $\tilde{R}_i$ is single index evaluation matrix for fuzzy security evaluation; $\tilde{A}_i$ is the weight set of the i-th index at the bottom, and $\tilde{A}_i = (\omega_{i1}, \omega_{i2}, \cdots, \omega_{im})$.

Taking the comprehensive impact of various indices into account, integration is carried out for the upper layer, and the evaluation set for the second-level security evaluation is:

$$\tilde{B} = \tilde{A} \cdot \tilde{R} = \tilde{A}_1 \cdot \begin{bmatrix} \tilde{A}_i & \cdots & \tilde{R}_i \\ \tilde{A}_2 & \cdots & \tilde{R}_2 \\ \vdots & & \vdots \\ \tilde{A}_n & \cdots & \tilde{R}_n \end{bmatrix} = (b_1, b_2, \cdots, b_p)$$

where $\tilde{B}$ is the second-level fuzzy security evaluation set; $\tilde{A}$ is the weight set of indices in the second-level fuzzy security evaluation;

$$\tilde{B} = (\omega_{i1}, \omega_{i2}, \cdots, \omega_n)$$

$\tilde{R}$ is the evaluation matrix for second-level fuzzy security evaluation

$$\tilde{R} = \begin{bmatrix} \tilde{A}_1 \\ \tilde{A}_1 \\ \vdots \\ \tilde{R}_m \end{bmatrix} = \begin{bmatrix} \tilde{A}_1 & \cdots & \tilde{R}_1 \\ \tilde{A}_2 & \cdots & \tilde{R}_2 \\ \vdots & & \vdots \\ \tilde{A}_n & \cdots & \tilde{R}_n \end{bmatrix}$$

where $r_{ik} = b_{ik} \quad i = 1, 2, \cdots, n; k = 1, 2, \cdots, p.$

The evaluation model of the three-level security evaluation is as follows:

$$\tilde{B}' = \tilde{A}' \cdot \tilde{R}' = \tilde{A}' \cdot \begin{bmatrix} \tilde{A}_1 \cdot \begin{bmatrix} \tilde{A}_{11} & \cdot & \tilde{R}_{11} \\ \tilde{A}_{12} & \cdot & \tilde{R}_{12} \\ \vdots & & \vdots \\ \tilde{A}_{1m} & \cdot & \tilde{R}_{1m} \end{bmatrix} \\ \tilde{A}_2 \cdot \begin{bmatrix} \tilde{A}_{22} & \cdot & \tilde{R}_{22} \\ \tilde{A}_{22} & \cdot & \tilde{R}_{22} \\ \vdots & & \vdots \\ \tilde{A}_{2m} & \cdot & \tilde{R}_{2m} \end{bmatrix} \\ \cdots \qquad \cdots \\ \tilde{A}_n \cdot \begin{bmatrix} \tilde{A}_{n1} & \cdot & \tilde{R}_{n1} \\ \tilde{A}_{n2} & \cdot & \tilde{R}_{n2} \\ \vdots & & \vdots \\ \tilde{A}_{nm} & \cdot & \tilde{R}_{nm} \end{bmatrix} \end{bmatrix}$$

where $\tilde{B}'$ is a three-level fuzzy security evaluation set; $\tilde{A}'$ is the weight set of indices in the three-level fuzzy security evaluation; and $\tilde{R}'$ is the evaluation matrix for three-level fuzzy security evaluation, and it is integrated from the evaluation matrixes of second-level fuzzy security evaluation. Mathematical models of fuzzy comprehensive evaluation of higher levels are obtained in the same manner.

3.2 Establishment of evaluation model The index system of water ecological civilization belongs to a complex comprehensive index system. Therefore, the comprehensive calculation formula of the composite system was used to obtain the comprehensive civilization index, which can more comprehensively evaluate the weighted average of each subsystem. The calculation formula is as follows:

$$D = \sum_{\substack{1 \leq i \leq n \\ 1 \leq j \leq n}} C_0(i, j) P_{ij}.$$

where D represents the comprehensive index of water ecological civilization system; $C_0(i, j)$ is the normalized weight of the j-th index in the i-th subsystem; P_{ij} represents the evaluation standard value of the j-th index in the i-th subsystem. In addition, the comprehensive index of water ecological civilization was graded: 0 - 0.2, worse; 0.2 - 0.4, bad; 0.4 - 0.6, general; 0.6 - 0.8, good; 0.8 - 1.0, excellent. The comprehensive index of water ecological civilization can not only reflect the degree of water ecological civilization, the existing deficiencies, the direction of improvement, *etc.* at the present stage. It is also possible to compare and analyze the benefits of water ecological civilization construction in different years.

4 Case study

Taking the assessment of water ecological construction in Huaibei City, which is located in the core area of the coal mining subsidence areas in Huainan and Huaibei, as an example, the application process of SFAM is further elucidated. Based on the actual values and target values, the evaluation scores of various indices in the coal mining subsidence area of Huaibei City in 2013 and 2017 were calculated according to the above formulas (shown in columns 9 and 12 in Table 1). It can be seen that in 2013, the scores of water qualification rate, mined land restoration and reclamation rate, flood control qualification rate, water consumption per 10 000 yuan of GDP and water consumption per 10 000 yuan of added value of industrial enterprises above designated size in the subsidence area of Huaibei City were relatively low. The inadequacies in these indices will be the main direction of effort in the future. Corresponding measures will be taken to complete the task of water ecological civilization construction in the coal mining subsidence area of Huaibei City. The results of calculation show that in 2013, the water ecological civilization index of the composite system in the coal mining subsidence area of Huaibei City $D_{2013} = 0.502$. According to the evaluation criteria of Table 3, it could be known that the water ecological comprehensive index of the coal mining subsidence area in Huaibei City belonged to the general grade. In 2017, the water ecological civilization index of the composite system in the coal mining subsidence area of Huaibei City was $D_{2017} = 0.859$, indicating that the comprehensive index of water ecology belonged to the excellent grade. The analysis of the evaluation values of various indices shows that the bottleneck indices for the construction of water ecological civilization in Huaibei City in 2013 included water qualification rate, mined land restoration and reclamation rate, flood control qualification rate, water consumption per 10 000 yuan of GDP, and water consumption per 10 000 yuan of added value of industrial enterprises above designated size. In response to these specific deficiencies, Huaibei City has adopted corresponding targeted measures, and the local water ecological civilization state has been improved effectively. Especially after being approved by the provincial government in 2014 as the second batch of pilot cities for the construction of an eco-civilized city in Anhui Province, it has insisted on the thinking of "lucid waters and lush mountains are invaluable assets", implemented the strategy of "China Carbon Valley · Green Ecological Huaibei", and actively explored the construction model of "high-carbon resources, low-carbon utilization, coal-based city and green ecological development", insisting on combining the ecological environment management with urban construction in the coal mining subsidence area. The subsidence area formed by the six mines of Huaibei Mining Group has been excavated deeply to build lakes, and four ecological wetland parks including Zhonghu, Nanhu, Donghu and Qianlong Lake have been constructed. In the center of the city, a collapsed lake belt of more than 100 square kilometers has been gradually formed. A total of 50 water system connection and ecological management projects including Qianlong Lake and Xianghu Lake connection project, Xianghu Lake and Zhonghu Lake connection project and Zhonghu Lake and Donghu Lake connection project have been implemented, with a total investment of 8.571 billion yuan. The black and messy image of the "coal city" has been transformed successfully. It has achieve a successful transition from resource-consuming to green ecological city, and explored a green, low-carbon and cyclic development road from "coal city" to "beauty city". The comprehensive index of water ecological civilization construction in the coal mining subsidence area has also rapidly increased from the general grade to the excellent grade.

5 Conclusions

China has entered a decisive stage of fully building a well-off society. It has also put forward new requirements for the construction of ecological civilization in resource-based cities. Presenting the water ecological environment status of coal mining subsidence area comprehensively and objectively is particularly important to adjust and strengthen the ecological environment construction of resource-based cities[5]. On the basis of the research results about evaluation index system for water ecological civilization cities, an evaluation index system for water ecological civilization construction in coal mining subsidence area, consisting of one comprehensive target, five criterion layers and 29 indices is screened and constructed in this paper. In terms of weights of the 29 indices, the weights of water surface ratio in the target area and water qualification rate in the subsidence area are higher, and the weight of water culture popularization is the lowest. Government functional departments can determine the priority of measures to be implemented based on the weight of the indices. Moreover, a multi-index and multi-layer security fuzzy assessment model (SFAM) suitable for the evaluation of water ecological civilization construction in coal mining subsidence areas is established, with a view to scientifically evaluating the water ecological civilization construction and providing a reliable theoretical basis and guidance for the smooth progress of water ecological civilization construction in the coal mining subsidence areas of Huainan and Huaibei in Anhui Province.

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