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Retraction

Retracted: Development Level Evaluation of Water Ecological Civilization in Yangtze River Economic Belt

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Q. Qi and S. Song, "Development Level Evaluation of Water Ecological Civilization in Yangtze River Economic Belt," *Discrete Dynamics in Nature and Society*, vol. 2022, Article ID 8576365, 6 pages, 2022.

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Research Article

Development Level Evaluation of Water Ecological Civilization in Yangtze River Economic Belt

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Water ecological civilization (WEC) is a key component and basic guarantee of ecological civilization. This paper sets up an evaluation index system (EIS) for WEC development (WECD) level, which covers such three dimensions as social economic development, control over total water resources and water utilization efficiency, and synthetic environmental governance and adopts set pair analysis (SPA) to measure and analyze the WECD level in Yangtze River Economic Belt (YREB) from 2010 to 2019. The results show that (1) the score of each subsystem in YREB WECD grew continuously in the sample period and poised to increase in future, (2) in general, YREB WECD level steadily increased to a relatively high level, and (3) the good development trend of YREB WECD is inseparable from the fact that YREB stepped up its efforts in capital investment, water utilization, and water environment protection and recovery. Finally, pertinent measures were put forward to further improve the YREB WECD level.

1. Introduction

Water is the source of life, the crux of production, and the foundation of ecology. Therefore, it is of great significance to protect water resources and maintain a good water ecological environment. China's total freshwater resources are 2.8 trillion cubic meters, accounting for 6% of global water resources, ranking fourth in the world, but per capita is only 2,300 cubic meters, only a quarter of the world average; at the same time, China faces severe challenges from water shortage, pollution of water bodies, and imbalanced distribution of water in time and space. To realize the strategic goal of WEC development, China has taken meaningful measures for the environmental safety of water resources, speeding up the implementation of water resources management system, reasonably allocating water resources, saving water, and planting trees to prevent soil erosion and other measures.

Overall, relatively few foreign literatures clearly put forward the word. Most foreign scholars engaging in WEC tackle the sustainable utilization of water resources, basin management for ecological protection, water environment safety and management, etc. Therefore, it is worthwhile to learn from foreign research of water resources management, water environment protection, and water eco-environment restoration and management. The foreign research of water eco-environment evaluation can be tracked back to the *Clean Water Act* 1972. Due to the various factors involved in water ecology, many different evaluation systems have been established from diverse angles, namely, fish index of biotic integrity [1], biotic integrity index [2], rapid bioassessment protocols (RBPs) [3], and index of stream condition (ISC) [4]. In addition, some scholars carried out systematic research in river health theory [5], river health evaluation

[6], water resources' carrying capacity, and integrated basin management [7].

Since the implementation of WEC development (WECD) strategy, Chinese scholars have launched numerous research programs and made great progress. These programs emphasize on the following aspects: interpreting the theoretical connotations of WECD [8], constructing the development models [9], evaluation methods [10, 11], and evaluation index systems (EISs) [12], and measuring the WECD level [13–15].

To sum up, the existing studies mostly analyze the cross-sectional data of a specific province or city, failing to disclose the spatiotemporal trend of WECD in a region over a long period. To overcome the defect of previous research, this paper comprehensively measures the WECD level of Yangtze River Economic Belt (YREB) in 2020–2019, with the aim to evaluate the degree of WEC in the region and forecast the future trend of the regional WECD. The research results provide a scientific guide for WECD in YREB.

2. Methodology

2.1. EIS Construction. Following the framework of the index system in Evaluation Guide of Water Ecological Civilization Construction (SL/Z 738-2016) and drawing on relevant literature [11–13], this paper extends the pressure-state-response (PSR) model of United Nations Environment Programme (UNEP) into an EIS for the YREB WECD level. The data of the selected indices are scientific, comprehensive, and available. Specifically, the pressure subsystem contains five indices, the state subsystem contains five indices, and the response subsystem contains seven indices (Table 1).

2.2. Modelling. This paper sets up a set pair analysis (SPA) model to objectively evaluate the YREB WECD level.

2.2.1. Construction of Evaluation Matrix. Suppose the evaluation system is a set $E = \{e_1, e_2, \ldots, e_n\}$ of n objects, where e_n is the nth object. Each object needs to be evaluated against m indices $F = \{f_1, f_2, \ldots, f_m\}$, where f_m is the mth index. The scores of each index are recorded as d_{ij} ($i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$). Following the idea of SPA, a multiobjective evaluation matrix Q can be obtained:

$$Q = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ d_{m1} & d_{m2} & \cdots & d_{mn} \end{bmatrix}. \tag{1}$$

The indices in matrix Q are compared to select the optimal indices of each evaluation scheme, forming the best evaluation set $U = [d_{u1}, d_{u2}, \ldots, d_{un}]^T$, and the worst evaluation set $V = [d_{v1}, d_{v2}, \ldots, d_{vn}]^T$, where d_{uj} is the score of the c_{pk}th index in the best evaluation set, i.e., the optimal score among the $[v_p, u_p]$ indices in matrix Q, and d_{vj} is the score of the c_{pk}th index in the worst evaluation set, i.e., the worst score among the $[v_p, u_p]$ indices in matrix Q.

By comparing the score w_p of each index in the evaluation matrix and the score d_{uj} of the corresponding index in the optimal evaluation set $U = [d_{u1}, d_{u2}, \ldots, d_{un}]^T$, a weightless similarity matrix A can be obtained for each object and set $[U, V]$:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}. \tag{2}$$

By comparing the score w_p of each index in the evaluation matrix and the score d_{vj} of the corresponding index in the worst evaluation set $V = [d_{v1}, d_{v2}, \ldots, d_{vn}]^T$, a weightless difference matrix B can be obtained for each object and set $[U, V]$:

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix}. \tag{3}$$

In matrices A and B, $\begin{cases} a_{pk} = (u_p v_p / d_{pk}(u_p + v_p)) \\ c_{pk} = (d_{pk} / (u_p + v_p)) \end{cases}$; b_{ij} is the similarity and difference between index f_m and set $[U, V]$, respectively.

If d_{ij} has a positive effect on the evaluation result,

$$\begin{cases} a_{ij} = \dfrac{d_{ij}}{d_{uj} + d_{vj}}, \\ \\ b_{ij} = \dfrac{d_{uj} d_{vj}}{d_{ij}\left(d_{uj} + d_{vj}\right)}. \end{cases} \tag{4}$$

If d_{ij} has a negative effect on the evaluation result,

$$\begin{cases} a_{ij} = \dfrac{d_{uj} d_{vj}}{d_{ij}\left(d_{uj} + d_{vj}\right)}, \\ \\ b_{ij} = \dfrac{d_{ij}}{d_{uj} + d_{vj}}. \end{cases} \tag{5}$$

2.2.2. Construction of the Evaluation Model. According to the weights of indices $W = (w_1, w_2, \ldots, w_m)$ in the EIS for the YREB WECD level, the similarity matrix A, the weighted similarity matrix A_w can be obtained for each object and set $[U, V]$:

Table 1: EIS for YREB WECD level.

Goal layer	System layer	Weight	Factor layer	Unit	Weight
WECD level evaluation	Pressure (P)	0.247	Social economic development pressure		0.504
			Eco-environmental pressure		0.496
	State (S)	0.332	Resource state		0.527
			Eco-environmental state		0.473
	Response (R)	0.421	Eco-environmental governance		0.601
			Humanistic social response		0.399
Goal layer	System layer	Weight	Index layer	Unit	Weight
WECD level evaluation	Pressure (P)	0.247	Per-capita water consumption	m^3	0.305
			Water consumption per 10,000 yuan of gross domestic product (GDP)	ton	0.323
			Water consumption per 10,000 yuan of industrial added value	ton	0.372
			Ammonia nitrogen emissions per 10,000 yuan of GDP	kg	0.451
			Industrial wastewater emissions per 10,000 yuan of GDP	kg	0.549
	State (S)	0.332	Annual mean rainfall	mm	0.374
			Per-capita water resources	m^3	0.626
			Urban green coverage	%	0.462
			Proportion of safe centralized drinking water sources	%	0.538
	Response (R)	0.421	Number of "national water-saving city" titles	Each	0.213
			Reuse rate of industrial water	%	0.353
			Centralized treatment rate of municipal sewage	%	0.174
			Harmless treatment rate of municipal domestic waste	%	0.309
			Percentage of safe municipal water supply	%	0.164
			Water resource management funds as a proportion of GDP	yuan	0.447
			Effective implementation rate of water-intaking permission system	%	0.295
			Penetration rate of water cultural knowledge	%	0.258

$$A_w = W \times A = (w_1, w_2, \ldots, w_m) \times \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} = (a_1, a_2, \ldots, a_n), \tag{6}$$

where a_j is the similarity between the jth object and set $[U, V]$.

Similarly, the weighted difference matrix B_w can be obtained for each object and set $[U, V]$:

$$B_w = W \times B = (w_1, w_2, \ldots, w_m) \times \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix} = (b_1, b_2, \ldots, b_n), \tag{7}$$

where b_j is the difference between the jth object and set $[U, V]$.

2.2.3. Calculation of Relative Closeness. The relative closeness r_j between the jth object and the optimal evaluation set $U = [d_{u1}, d_{u2}, \ldots, d_{un}]^T$ can be calculated by

$$r_j = \frac{a_j}{a_j + b_j}. \tag{8}$$

On this basis, the relative closeness matrix R can be derived for all objects:

$$R = (r_1, r_2, \ldots, r_m). \tag{9}$$

The relative closeness r_j represents the association between an object and the optimal evaluation set $U = (d_{u1}, d_{u2}, \ldots, d_{un})^T$. The greater the value of r_j, the closer the object to the optimal scheme, the better its score against all indices, and the higher its ranking among all objects.

Before multilayer composite evaluation, it is necessary to carry out calculation layer by layer. That is, the initial model should be applied on factors of multiple layers. The evaluation result of the current layer should be introduced to the composite evaluation of the next superior layer. This measure should be repeated until reaching the highest layer.

2.3. Index Weighting. Using information entropy, the entropy method calculates the objective weight of each evaluation index, according to the degree of variation of that index. This objective weighting method can prevent the bias induced by subjective factors. Hence, the entropy method is adopted here to assign weights to the indices for the YREB WECD level.

The basic steps of index weighting by the entropy method are as follows.

Suppose m schemes need to be evaluated against n indices. Then, a multi-index evaluation matrix $X = (x_{ij})_{m\times n}$ can be established:

$$X = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix}, \tag{10}$$

where x_{ij} is the original score of the ith scheme against the jth index.

To reduce the huge differences between indices in dimensionality and magnitude, the original index data should be normalized by formulas (11) and (12).

For positive indices (the greater, the better), the normalization formula is

$$X'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}. \tag{11}$$

For negative indices (the smaller, the better), the normalization formula is

$$X'_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}, \tag{12}$$

where x_{ij} and X_{ij}' are the original and normalized scores of an index, respectively.

Next, the information entropy E_i of the ith index can be calculated by

$$E_i = -\frac{1}{\ln(m)} \sum_{i=1}^{n} \frac{q_{ij}}{q_j} \ln\left(\frac{q_{ij}}{q_j}\right), \quad (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n), \tag{13}$$

where q_{ij} is the normalized score of the original data on index x_{ij} and q_j is the sum of the normalized scores of indices on the jth year; if $(q_{ij}/q_j) = 0$, then $(q_{ij}/q_j)\ln(q_{ij}/q_j) = 0$.

According to the theory of the entropy method, the weight of the ith index can be derived from the information entropy E_i of that index:

$$Q_i = \frac{(1 - E_i)}{(n - \sum_{i=1}^{n} E_i)}, \quad (i = 1, 2, \ldots, n), \tag{14}$$

where Q_i is the weight of the ith index, E_i is the information entropy of the ith index, n is the number of indices, and $\sum_{i=1}^{n} Q_i = 1$, $Q_i \in [0, 1]$.

The entropy method was applied to solve the weights of the indices in the EIS for the YREB WECD level in 2010–2019 (Table 1). The solved weights are listed in Table 1.

2.4. Data Sources. The research data mainly come from China Statistical Yearbooks (2011–2020), Yearbooks of China Water Resources (2011–2020), and China Environment Yearbooks (2011–2020), as well as the statistical yearbooks, water resources bulletins, statistical bulletins of national economy and social development, and environmental bulletins issued by YREB regions in 2011–2020. The original data were sorted comprehensively before use.

Table 2: Scores of the three subsystems, 2010–2019.

Year	Pressure subsystem	State subsystem	Response subsystem
2010	0.3104	0.3067	0.4016
2011	0.2952	0.3100	0.4467
2012	0.3148	0.3228	0.4931
2013	0.3517	0.3623	0.5214
2014	0.3951	0.3976	0.5422
2015	0.4014	0.4285	0.5413
2016	0.4580	0.4899	0.5604
2017	0.4549	0.5024	0.5836
2018	0.4962	0.5459	0.6012
2019	0.5187	0.5998	0.6453

3. Results' Analysis

3.1. Spatiotemporal Level of WECD. Through SPA on the original index data, the scores of the three subsystems of our EIS were obtained (Table 2).

Next, an SPA was carried out again on the scores of each subsystem, using the subsystem weights in Table 1. Through comprehensive computation, the composite scores of the YREB WECD level were obtained for 2010–2019 (Table 3).

From Tables 2 and 3 and Figure 1, it can be observed that the scores of pressure, state, and response subsystems in the YREB WECD level evaluation changed stably, exhibiting a linear growth. From 2010 to 2019, the score of pressure subsystem increased from 0.3014 to 0.5187, with an annual mean growth rate of 6%. The result show that YREB achieved a good result on water eco-environmental protection in 2020–2019, and the pressure on WECD in the region continued to decrease. From 2010 to 2019, the score of state subsystem rose from 0.3067 to 0.5998, with an annual mean growth rate of 7.8%; the score of response subsystem increased rapidly, except for the decline in 2015. It can be inferred that, from 2010 to 2019, YREB invested more funds and technologies, improved water utilization efficiency, and stepped up the protection of water resources and water environment, aiming to enhance the water eco-environmental quality and strengthen the environmental carrying capacity of water resources. These measures led to a continuous improvement of the WECD level in YREB.

Further observation of Figure 1 reveals that the overall WECD level of YREB continued to rise in 2010–2019, following the same trajectory as the scores of the three subsystems. Therefore, YREB boasts a strong competitiveness in water eco-environment and a high WECD level. Despite facing long-term heavy pressure of WECD, different regions of YREB have taken forceful protective measures for water environment and water

Table 3: Composite scores of the YREB WECD level in 2010–2019.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Composite score	0.3124	0.2997	0.3547	0.3896	0.4292	0.4134	0.4517	0.4886	0.5015	0.5247
Ranking	9	10	8	7	5	6	4	3	2	1

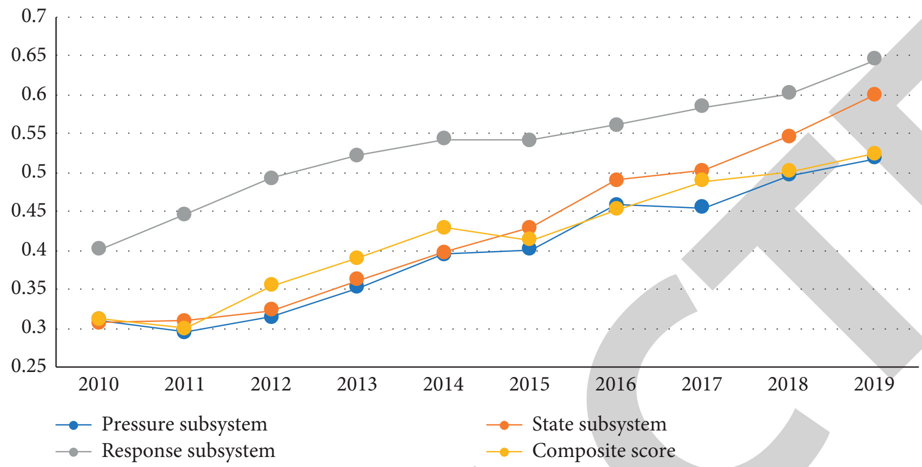

Figure 1: The scores of each subsystem and the composite scores of the YREB WECD level.

resources, which ensure the continued improvement of the overall WECD level and water eco-environmental carrying capacity in YREB from 2010 to 2019.

4. Conclusions

This paper firstly measures the YREB WECD levels in 2010–2019 and then analyzes the spatiotemporal trend of the WECD levels through SPA. The main conclusions are as follows:

(1) From 2010 to 2019, the scores of pressures, state, and response subsystems in YREB WECD level evaluation changed stably, exhibiting a linear growth. The overall WECD level of YREB continued to rise in 2010–2019, a sign for strong competitiveness in water eco-environment and high WECD level.

(2) The good development trend of YREB WECD in 2010–2019 is inseparable from the fact that YREB stepped up its efforts in capital investment, water utilization, and water environment protection and recovery. To future improve WECD level and achieve the harmony between human and water, YREB should make further efforts to improve water management system, reinforce water supervision, and protect and repair water ecosystem.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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