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Research on the Outgoing Audit and Evaluation of Water Resource Assets of Leadership Cadres in City Y

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Abstract: The outgoing audit of water resource assets of leading cadres is key to promoting the management of water resource assets and investigating the responsibility for water environment damage. This paper is based on the United Nations' Sustainable Development Goals related to water resource management and natural asset green accounting. It constructs an evaluation index system for the outgoing audit and evaluation of water resource assets from four dimensions: resource, environment, society, and economy. The paper combines the Analytic Hierarchy Process (AHP) and the initial comparison scoring method to comprehensively assess the water resource management performance of the former mayor of City Y in the Yellow River Basin during 2018–2020. The Barrier Degree Model is also utilized to identify the main influencing factors. The results indicate the following: (1) the constructed index system covers critical aspects of the outgoing audit and can comprehensively reflect the leadership cadres' responsibilities in water resource management. (2) The comprehensive evaluation score of the former mayor of City Y during 2018–2020 is 85.66, falling within the "relatively good" range but not reaching the "excellent" standard. This suggests that, although progress has been made in water resource asset management, some issues remain. (3) At the index level, the top three factors influencing the comprehensive evaluation of the former mayor's water resource management performance in City Y are the proportion of ammonia nitrogen emissions (9.86%), per capita water resource (9.38%), and Chemical Oxygen Demand (COD) emissions (8.93%). At the criterion level, the environmental dimension has the most significant impact on the overall evaluation results, accounting for 42.43%. The practical application of the evaluation index system in City Y can serve as a reference for improving the regulatory framework for leadership cadres' water resource assets in other regions and provide valuable insights for international exchange in water resource management practices.

Keywords: leadership cadres outgoing audit; water resource assets; analytic hierarchy process

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1. Introduction

Water is the fundamental basis for human survival and development [1,2]. Currently, 10% of the global population resides in countries facing severe water stress, with 80% of sewage discharged untreated. On a global scale, 2 billion people lack access to safe drinking water, while 3.6 billion lack well-managed sanitation [3]. The sustainable development of water resources has emerged as a pressing global concern; if not controlled, the water crisis will eventually pose a serious threat to the healthy development of human society [4,5]. China, being one of the countries with the lowest per capita water resources, faces challenges such as water scarcity, severe water pollution, and deteriorating water ecology. The water crisis has become a key factor restricting the region's sustainable economic and social development [6,7]. In light of these circumstances, the Chinese government is proposing an audit of the water resource assets held by leading cadres when they leave their positions. The objective is to assess changes in the quantity of water resources and the quality of the water environment in the regions where these cadres served during their tenure. This audit

is intended to evaluate the ecological performance of water resource management by these leading cadres, reinforce the supervision system of water resource assets, and advance environmentally friendly and sustainable water resource development [8,9].

Within the political centralization and fiscal decentralization framework, the authority over water resource allocation in China has long resided with the government, which aims to determine the primary factor in resource water allocation [10,11]. Local governments have emerged as key agents responsible for implementing water resource allocation. Therefore, reforming the evaluation and incentive system for local government leaders represents a practical approach to enhancing the quality of the water ecological environment across different regions of China [12]. The audit of outgoing water resource assets held by leading cadres constitutes a systemic innovation within the government's governance audit. It integrates the utilization and preservation of water resource assets into the performance evaluation of these leaders. This prompts them to recognize the fallacy of sacrificing the water resource environment for economic gain. It also reinforces the awareness of water ecological protection among local governments. Consequently, this approach effectively addresses the conflict between economic growth, water resource consumption, and water ecological degradation [13,14].

The construction of an evaluation index system serves as the foundation for conducting outgoing audits [15]. The scientificity, comprehensiveness, and rationality of this index system largely determine the reliability of the audit results. Fang utilized the Pressure–State–Response (PSR) model to establish a set of evaluation index systems for the outgoing audit of natural resource assets. Through principal component analysis, she quantitatively evaluated the fulfillment of leadership cadres' responsibilities for resource and environmental conservation in different provinces and regions [16]. Li applied the fuzzy comprehensive evaluation theory in the outgoing audit of natural resource assets for leadership cadres, effectively addressing the challenge of accurately evaluating leadership cadres' responsibilities regarding environmental and resource conservation [17]. Xiong combined the entropy weight method and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) in constructing an evaluation system based on energy, economic, and environmental subsystems for the outgoing audit of natural resource assets [18]. While water resource audits represent a significant component of natural resource audits, the index above systems fail to comprehensively evaluate all aspects of water resource management when assessing the performance of leading cadres. Therefore, it becomes imperative to separate water resources from natural resources and design a holistic evaluation index system to evaluate water resource management.

Regarding the design of the water resource evaluation index system, Dee initiated the first research endeavor and attempted to construct the water resource audit evaluation index system [19]. In 2015, Mateus conducted a performance analysis of water resources, resulting in a new system incorporating economic and social benefits while building upon the existing evaluation index system [20]. Furthermore, to promote the implementation of the audit policy on outgoing water resource assets of leading cadres, numerous scholars in Chinese theoretical and practical circles have proposed evaluation index systems with distinct Chinese characteristics. For instance, Lu devised an evaluation index system based on the water resource balance sheet, conducting a comprehensive assessment of water resource management and protection performance in the arid and semi-arid Gansu Province from 2014 to 2016. This study also delved into the existing problems within local government's water resource management [21]. Using the Drive–Pressure–State–Impact–Response (DPSIR) model, Wang established an evaluation index system encompassing five aspects: drive, pressure, state, impact, and response. This system facilitated evaluating and analyzing water resource management among leading cadres who concluded their tenure in Z province in 2013 [22]. However, the current research outcomes suggest that existing evaluation index systems may suffer from oversimplification, disregarding the social benefits of water resources, or excessive complexity, leading to prolonged audit cycles and increased costs.

In general, there is a lack of a unified, comprehensive, and widely applicable evaluation index system that can effectively assess the water management performance of leading cadres. In light of this premise, this paper adopts a perspective from the United Nations' Sustainable Development Goals related to water resource management and the concept of natural asset green accounting. It aims to establish an evaluation index system for the outgoing audit of water resource assets held by leadership cadres. The system encompasses four dimensions: resource, environment, society, and economy. By combining the Analytic Hierarchy Process (AHP) and the initial comparison scoring method, the paper comprehensively assesses the water resource management performance of the former mayor of City Y in the Yellow River Basin during 2018–2020. The Barrier Degree Model is also utilized to identify the main influencing factors.

The main contributions of this paper are as follows: ① Innovation in establishing an evaluation index system for the outgoing audit of water resource assets held by leadership cadres, based on the United Nations' Sustainable Development Goals and integrating the concept of natural asset green accounting. The system covers four dimensions: resource, environment, society, and economy, aiming to comprehensively reflect the water resource management performance of leadership cadres. ② The comprehensive evaluation of the former mayor of City Y in the Yellow River Basin (2018–2020) regarding water resource management, using a combination of the AHP and the initial comparison scoring method. This approach ensures that the evaluation results are more accurate and avoid detachment from the actual regional situation that may occur with subjective evaluation methods. ③ Innovation by introducing the Barrier Degree Model into evaluating the outgoing audit of water resource assets. This inclusion allows for the identification of the main influencing factors in the audit, further enhancing the comprehensiveness and precision of the assessment.

2. Index System Construction and Methods

2.1. Construction of the Index System

Various factors influence water resource assets, spanning multiple aspects such as the natural environment and socio-economic development. Determining a comprehensive set of dimensions for the evaluation index system that reflects leadership cadres' performance in supervisory responsibilities is crucial. This paper takes guidance from the United Nations' Sustainable Development Goals, focusing on sustainable goals related to water resource management, such as "sustainable communities". Additionally, we integrate the principles of natural asset green accounting and construct the evaluation index system based on four dimensions: resource, environment, social and economic. The scarcer the water, the greater the water resource value [23]. The resource dimension primarily considers the quantity and supply of water resources, reflecting leadership cadres' performance in ensuring water resource supply and regulating water resource development and utilization. The value of water resource assets is intricately linked to water quality and the control of water resource pollution [24,25]. The environment dimension emphasizes the water quality status, reflecting the management of water resource's impact on the environment, ensuring the coordination of water resource management with environmentally friendly development objectives. Failing to consider the development and utilization of water resources and their integration with social and economic aspects would limit the valuation of the environmental and ecological aspects [26]. The social dimension focuses on the impact of water resource management on the public. The population is one of the main driving factors for water resource demand; excessive population pressure will cause water stress [27–29], and leadership cadres must consider population distribution, balance water supply, and demand, and avoid excessive water use. Moreover, many regions are centered around estuarine or port cities, with key rivers as pivotal development points [30,31]. Leadership cadres need to consider economic factors, such as water usage in economic development, to reflect their efforts in balancing economic growth and water resource consumption. These four dimensions form a comprehensive evaluation index system, facilitating a comprehen-

sive understanding of leadership cadres' performance and contributions to water resource management.

The collected indicators are organized and summarized based on the confirmed dimensions of the evaluation index system. Single indicators are then screened based on their accessibility and operationality in calculations. Specifically:

(1) Resource Dimension

For the resource dimension, seven indicators are selected: total water resource, recycled water volume, water area growth rate, year-on-year increase rate in water resource, water resource development utilization rate, groundwater resource, and the difference in water intake and drainage in the Yellow River irrigation area. Each indicator serves a specific purpose in reflecting the performance of leadership cadres in water resource management. Total water resource reflects the abundance of water in the region. Recycled water volume indicates the situation of water recycling and reuse. Water area growth rate and year-on-year increase rate in water resource monitor the trend of water resource changes and reflect the effectiveness of leadership cadres in maintaining and distributing water resource. The water resource development utilization rate is an essential indicator for evaluating the potential of water resource development and utilization, which helps drive water resource management towards efficiency and sustainability. Considering the specific situation of Y City, two additional indicators are added to the resource dimension: groundwater resource and the difference in water intake and drainage in the Yellow River irrigation area. In Y City, most groundwater resources are concentrated in the Yellow River irrigation area, mainly replenished by water from the Yellow River. Therefore, selecting groundwater resource as an indicator can reflect the abundance of groundwater resources during the leadership cadres' tenure. The difference in water intake and drainage in the Yellow River irrigation area reflects the water resource protection in the Yellow River Basin by the leadership cadres. A higher water intake and drainage difference indicates better water resource eco-protection in that region.

(2) Environment Dimension

For the environment dimension, six indicators are selected: industrial wastewater treatment rate, urban domestic sewage centralized treatment rate, ammonia nitrogen emission, Chemical Oxygen Demand (COD) emission, sewage treatment volume of wastewater treatment enterprises, and the annual completed investment in pollution prevention and control by old industrial enterprises. Each indicator is crucial in assessing water quality improvement and water pollution control in the region, providing essential references for optimizing water resource management. Industrial wastewater treatment and urban domestic sewage centralized treatment rates are vital indicators to evaluate water quality improvement and pollution control. They help assess the area's overall level of water pollution control and offer significant insights for enhancing water resource management. Ammonia nitrogen and COD are major pollutants in water bodies, directly affecting water quality. Monitoring the emission levels of ammonia nitrogen and COD allows the assessment of water pollution status and enables timely detection of water pollution issues. Sewage treatment enterprises are essential units responsible for treating urban domestic sewage. Monitoring their sewage treatment volume helps evaluate the overall effectiveness of sewage treatment and promotes water pollution control towards higher efficiency and sustainability. The annual completed investment in pollution prevention and control by old industrial enterprises reflects the government's commitment to pollution control. Old industrial enterprises are often significant sources of water pollution, and the government's investment in pollution control directly influences the effectiveness of water quality improvement. Paying attention to the investment amount provides insights into the leadership cadres' dedication to pollution control and the effort to improve water quality.

(3) Social Dimension

For the social dimension, three indicators are selected: per capita water resource, population density, and per capita GDP. Each indicator is crucial in assessing the leadership cadres' water resource protection and management performance. Per capita water resource are important reference indicators to measure the availability of water resource in the region. Monitoring per capita water resource helps evaluate how leadership cadres protect and utilize water resources rationally. Population density reflects the distribution of the population within a unit area. A higher population density may indicate excessive population concentration, increasing the demand pressure on water resources in that area. Monitoring population density aids in evaluating the efforts of leadership cadres in water resource distribution and rational utilization. The level of social development is closely related to water resource utilization and management. Higher per capita GDP typically implies greater water demand, requiring more scientific and rational water resource management. Monitoring per capita GDP helps assess whether leadership cadres have fully considered the coordinated development of social development and water resource protection in water resource management.

(4) Economic Dimension

For the economic dimension, five indicators are selected: water consumption per ten thousand yuan of industrial added value, water consumption per ten thousand yuan of GDP, urbanization rate, water consumption per mu of agricultural land, and irrigation water-use efficiency coefficient. Each indicator is crucial in evaluating water resource utilization efficiency in economic development. Water consumption per ten thousand yuan of industrial added value and water consumption per ten thousand yuan of GDP are important indicators to measure the efficiency of water resource utilization in industrial and economic development. Monitoring these indicators helps assess whether leadership cadres prioritize water resource conservation while promoting industrial and economic growth, providing an essential basis for promoting green economic development. Urbanization rate refers to the proportion of the urban population to the total population. Monitoring the urbanization rate aids in evaluating whether leadership cadres consider the balance between water supply and demand and the coordination of urban and rural development in urban development planning, providing important references for optimizing urbanization development strategies. Considering that Y City's farmland accounts for 20.86% of the total land area and agricultural water consumption constitute as high as 90% of the total water usage, and that there is a severe waste of agricultural water in Y City, this study adds two indicators in the economic dimension: water consumption per mu of agricultural land and irrigation water use efficiency coefficient. Agricultural water consumption is a significant part of water resource consumption, and the efficient use of agricultural water is essential to improve agricultural productivity and protect water resource. Monitoring these two indicators helps assess whether leadership cadres have implemented reasonable irrigation management measures in agricultural water resource management, promoting the sustainable use of agricultural water and providing crucial support for achieving agricultural modernization and rural revitalization.

In conclusion, the construction of the leadership cadres' water resource asset leaving office audit evaluation system is presented in Table 1.

Table 1. Evaluation index system for leaving office audit of water resource assets of leading cadres.

Target Layer	Criterion Layer	Indicator Layer
Utilization and protection of water resource assets of leading cadres	Resource	Total water resource (billion cubic meters) Groundwater resource (billion cubic meters) Water reuse (million cubic meters) Water resource area growth rate (%) Year-on-year increase rate in water resource (%) Utilization rate in water resource development (%) Diversion and displacement difference in the Yellow River irrigation area (billion cubic meters)
	Environment	Industrial wastewater treatment rate (%) Urban sewage centralized treatment rate (%) Ammonia nitrogen emission (ton) COD emissions (10,000 tons) The sewage treatment capacity of sewage treatment enterprises (million cubic meters) The amount invested in pollution prevention and control of old industrial enterprises in the same year (10,000 yuan)
	Social	Per capita water resource (m^3) Population density (population/square kilometer) GDP per capita (RMB/person)
	Economic	Water consumption for ten thousand yuan of industrial added value (Cubic meter/10,000 yuan) Water consumption per ten thousand yuan of GDP (Cubic meter/10,000 yuan) Urbanization rate (%) Agricultural per mu water consumption rate (%) Effective utilization coefficient of irrigation water

2.2. Comprehensive Evaluation Model

2.2.1. Analytic Hierarchy Process

The AHP originated in the mid-1970s, proposed by American operations researcher Thomas L. Saaty [32]. It divides decision-making problems into different components based on the objective's requirements. By decomposing, comparing judgments, and synthesizing, AHP ensures that the impact of different factors at different levels can be quantified, making the analysis results clear and distinct. It finds wide application in the analysis and decision-making processes of complex systems [33,34]. In this study, the AHP method is employed to determine the weights of the evaluation indicators, and the specific steps are as follows [35]:

Step 1: establishing the hierarchical structure. The core of the AHP is to reasonably and appropriately hierarchize the evaluation target object. This study divides the evaluation index system into four levels: Level A indicators represent the overall evaluation results of leadership cadres' water resource assets' outgoing audit. Level B indicators consist of four dimensions, namely resource, environment, society, and economy, representing specific conditions in each aspect. Level C indicators are specific indicators composed of several primary indicators from each criterion. The hierarchical structure model constructed in this study includes one goal, four key dimensions, and twenty-one specific indicators. The hierarchical structure model is shown in Table 1.

Step 2: constructing judgment matrices. Based on the evaluation judgments provided by experts for each element in the hierarchical system, pairwise comparisons of the relative importance of each element are made. In this study, the 1–9 scale method is used to quantitatively specify the scale values, which allows experts to adopt a unified evaluation standard for determining the relative weights of each element. The 1–9 scale method used in this study is shown in Table 2.

Table 2. Scale value.

Scale	Meaning Description
1	Both indicators are of equal importance
3	The former is less important than the latter
5	The former is more important than the latter
7	The former is demonstrably more important than the latter
9	The former is more important than the latter
2, 4, 6, 8	The scale of the compromise between two standards
Reciprocal	The scale of the importance of the latter over the former

Step 3: calculating indicator weights and consistency. Testing: we obtained the weight vectors by solving and normalizing the judgment matrices. AHP uses the consistency ratio (CR) to assess the consistency of judgments. The calculation method is to divide the consistency index (CI) by the random consistency index (RI), with the value of RI typically fixed when the dimensions of the decision matrix are determined. CR < 0.1 indicates that the consistency test is passed, and the smaller the CR value, the better the consistency. When CR $\geq$ 0.1, it indicates that the consistency test failed and the model needs to be adjusted. The CI value can be calculated using the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (1)$$

where λ_{max} is the average of the ratios of weighted sum and criterion weight for all criteria, and n is the number of criteria involved in the AHP.

2.2.2. Initial Comparison Scoring Method

The initial comparison scoring method considers the time factor, allowing for dynamic observation of the direction and magnitude of indicator changes. Therefore, this study adopts the initial comparison scoring method to evaluate each indicator. The initial comparison scoring method involves calculating the average values of various indicators during the tenure of the leadership cadre and comparing them with the values at the beginning of their tenure. Based on the differences, scores are assigned. Due to the absence of uniform evaluation standards for each score among professional auditors, this paper adopts the semantic difference method to compare the annual average value of the indicator data during their tenure with the initial value. The comparison results are then categorized into five evaluation ranges: "inadequate", "relatively poor", "intermediate", "relatively good", and "excellent". The corresponding score ranges are 60–70, 70–80, 80, 80–90, and 90–100, respectively. The final score for each indicator is derived by taking the average value of the evaluation scores provided by each auditor. Combining the results of expert consultation, Y City in the Yellow River Basin was assessed as being in an "intermediate" state at the beginning of 2018. Considering the comparability of data, this study assigns a score of 80 for each indicator at the beginning of the leadership cadre's tenure. If the average values of various indicators during the tenure outperform those at the beginning, 80 is taken as the base score for addition; otherwise, 80 is taken as the base score for subtraction.

Based on the determined weights and scores of each indicator in the previous section, to comprehensively evaluate the ecological performance of the leadership cadre's water resource management, this study introduces a comprehensive evaluation model to calculate the final score of the leadership cadre's water resource audit. The specific model is as follows:

$$S = \sum_{q=1}^{n} \sum_{i=1}^{\infty} P_q X_{iq} \times Z_{qi} \quad (2)$$

Among them: S, the final score of the leadership cadre's water resource audit.

P_q, the weight of the criteria layer dimension indicators;

X_{iq}, the weight obtained from the hierarchical single sorting test of the indicator layer below the criteria layer;

Z_{qi}, the scores of each evaluation indicator in the indicator layer;
q, criterion layer dimension;
i, indicator layer number of dimension indicators.

2.3. Obstacle Degree Model

In order to further reveal the obstacle factors affecting the comprehensive evaluation results of the audit of water resource assets of leading cadres leaving office, the obstacle degree model was introduced to analyze the impact degree of the four dimensions of resource, environment, society, economy and various indicators on the audit results [36]. The specific model is as follows:

$$L_i = (100 - Z_i) \times W_i / \sum_{i=1}^{n} (100 - Z_i) \times W_i \quad (3)$$

Among them: L, obstacle degree of a single index to the coupling coordination degree of the system;
Z, score value of a single index;
W, weight;
n, the number of indicators.

2.4. Data Source

The primary data for the evaluation comes from the scoring by expert professionals. The invited professionals include experts and scholars engaged in audit research from universities, government audit department personnel, and social audit organization staff. The distribution of professional participants is 40% from university audit experts, 40% from government audit department personnel, and 20% from social audit organization staff. The raw data provided for the scoring experts include the average values of various evaluation indicators during the tenure of the former mayor of Y City (2018–2020) and the values of these indicators when he assumed office (early 2018). The raw data are sourced from the Ningxia Statistical Yearbook and the Ningxia Water Resource Bulletin [37,38].

3. Case Study Area and Data

3.1. Regional General Situation

Y City is situated in Ningxia's central plain region and is traversed by the Yellow River, serving as its primary water resource supply. According to international standards, a per capita water resource quantity below 500 cubic meters signifies extreme water scarcity. In 2020, Y City recorded a per capita water resource quantity of 129 cubic meters, significantly lower than the national average of 2239.8 cubic meters, highlighting its classification as an area facing severe water scarcity [38,39]. Due to water resource scarcity, its management and distribution has become critical, and regional leaders play a crucial role in resource allocation and protection. Conducting a water resource asset audit for the departing leaders in Y City can effectively oversee their responsibility in protecting water resources and help alleviate the water scarcity in the region, promoting the sustainable development of water resources, vital for protecting the water resource assets of Y City.

3.2. Comprehensive Evaluation Results

3.2.1. Determination of Indicator Weights

The weight assigned to each index is a quantitative representation of its influence on the evaluation results, and it significantly affects the overall evaluation outcomes [40]. In this study, a questionnaire survey was conducted to invite experts to assess the weights of various elements in the structural system. The survey was distributed among experts and scholars from universities engaged in water resource research (60%), government officials from the Water Resource Bureau (30%), and the general public (10%). University experts, with their extensive academic qualifications and research experience, possess in-depth knowledge of theoretical, practical, and cutting-edge research concerning water

resource management. Government officials from the Water Resource Bureau have abundant practical experience in water resource management and are well-versed in related policies and regulations, providing a higher-level strategic perspective. The participation of the general public represents the interests and viewpoints of the wider population, offering diverse perspectives and insights, thereby ensuring that the assessment reflects public demands and expectations. To ensure the independence of the evaluation process, the questionnaire distribution was conducted anonymously. A total of 30 questionnaires were distributed, and 21 valid questionnaires were collected, demonstrating the data's practicality and validity. The resulting judgment matrix is shown in Tables 3–7.

Table 3 shows the scaling values of the four indicators of criterion layer resource (A1), environment (A2), social (A3), and economic (A4).

Table 3. Judgment matrix of criterion layer.

M	A1	A2	A3	A4
A1	1	1/3	2	2
A2	3	1	4	2
A3	1/2	1/4	1	1/4
A4	1/2	1/2	4	1

Table 4 shows the comparative scale values of seven indicators under the criterion layer resource (A1), including total water resource (B1), groundwater resource (B2), repeated consumption (B3), water resource accumulation growth rate (B4), water resource co increase rate (B5), water resource development and utilization rate (B6), and difference in water inflow and outflow in the Yellow River irrigation area (B7).

Table 4. Judgment matrix of the indicator layer.

A1	B1	B2	B3	B4	B5	B6	B7
B1	1	1/2	1/4	1/3	1/3	1/2	1/5
B2	2	1	1/3	1/2	1/3	1/4	1/5
B3	4	3	1	3	3	2	1/4
B4	3	2	1/3	1	1/2	1/2	1/6
B5	3	3	1/3	2	1	1/2	1/5
B6	2	4	1/2	2	2	1	1/3
B7	5	5	4	6	5	3	1

Table 5 shows the scaling values of six indicators, namely, industrial waste treatment rate (B8), urban living sewage centralized treatment rate (B9), ammonia nitrogen emissions (B10), COD emissions (B11), sewage treatment capacity of sewage treatment enterprises (B12), and completed investment in pollution prevention and control of sewage enterprises (B13), under the condition of criterion layer environment (A2).

Table 5. Judgment matrix of the indicator layer.

A2	B8	B9	B10	B11	B12	B13
B8	1	2	1/3	1/3	1/2	1/4
B9	1/2	1	1/3	1/3	2	1/4
B10	3	3	1	2	5	1/2
B11	3	3	1/2	1	5	1/2
B12	2	1/2	1/5	1/5	1	1/6
B13	4	4	2	2	6	1

Table 6 shows the scaling values of the three indicators of average resource (B14), density (B15), and average GDP (B16) under criterion layer social (A3).

Table 6. Judgment matrix of the indicator layer.

A3	B14	B15	B16
B14	1	2	3
B15	1/2	1	3
B16	1/3	1/3	1

Table 7 shows the scaling values of five indicators under the criterion level economic (A4), namely the water consumption for industrial added value (B17), water consumption for GDP (B18), urbanization rate (B19), agricultural per mu water consumption rate (B20), and irrigation efficiency coefficient (B21).

Table 7. Judgment matrix of the indicator layer.

A4	B17	B18	B19	B20	B21
B17	1	1/2	3	2	1/3
B18	2	1	3	4	2
B19	1/3	1/3	1	2	1/3
B20	1/2	1/4	1/2	1	1/3
B21	3	1/2	3	3	1

We obtained the weight vector by solving the characteristic vector and standardizing the judgment matrices. According to the consistency test, the consistency index for the criteria layer concerning the objective layer is 0.089. The consistency indices for the indicator layers concerning each criterion layer are 0.0553, 0.0617, 0.0515, and 0.0539, respectively. All of these results are less than 0.1, indicating good consistency, making them suitable for comprehensive evaluation. The consistency test results are shown in Tables 8–12.

Table 8. Order and consistency test of each dimension of the criterion layer.

M	Weight	Consistency Test
A1	0.2352	λ_{max} = 4.2427
A2	0.4601	CI = 0.0809 RI = 0.9090
A3	00884	CR = 0.0890
A4	0.2163	Pass conformance test

Table 9. Sorting and consistency test of all dimensions of the indicator layer.

A1	Weight	Consistency Test
B1	0.0435	λ_{max} = 7.4513
B2	0.0521	
B3	0.1904	
B4	0.0749	
B5	0.1005	CI = 0.0752 RI = 1.3596
B6	0.1357	CR = 0.0553
B7	0.3028	Pass conformance test

Table 10. Sorting and consistency test of all dimensions of the indicator layer.

A2	Weight	Consistency Test
B8	0.0765	λ_{max} = 6.3884
B9	0.0736	
B10	0.2463	
B11	0.1963	CI = 0.0777 RI = 1.2593
B12	0.0623	CR = 0.0617
B13	0.3451	Pass conformance test

Table 11. Sorting and consistency test of all dimensions of the indicator layer.

A3	Weight	Consistency Test
B14	0.5278	λ_{max} = 3.0536
B15	0.3325	CI = 0.0268 RI = 0.5048 CR = 0.0515
B16	0.1396	Pass conformance test

Table 12. Sorting and consistency test of all dimensions of the indicator layer.

A4	Weight	Consistency Test
B17	0.1725	λ_{max} = 5.2413
B18	0.3610	
B19	0.1006	CI = 0.0603 RI = 1.1187
B20	0.0762	CR = 0.0539
B21	0.2897	Pass conformance test

3.2.2. Determination of Indicator Scores

Due to the former mayor's tenure in City Y from 2018 to 2020, this article takes the water resource situation at the beginning of 2018, when the former mayor took office, as the baseline data. As the "Ningxia Statistical Yearbook" and the "Ningxia Water Resources Bulletin" are compiled only once a year, obtaining accurate data for the beginning of 2018 presented practical challenges. Considering data availability, a reasonable decision was made to use the data from the end of 2017 as a proxy for the beginning of 2018. Expert professionals were invited to compare the average values of various indicators during the former mayor's tenure in City Y (2018–2020) with the baseline (early 2018) indicator values. Based on the differences observed, scores were assigned, and the mean of the expert scores was taken as the final score for each indicator.

Based on the previously determined indicator weights and scores, the evaluation results of the outgoing audit indicators of water resources assets of the former mayor of Y City are shown in Table 13.

Table 13. Evaluation results of the audit indicators for the departure of water resource assets of the former mayor of Y City.

Hierarchy B	A1	A2	A3	A4	Each Level of Indicators Relative to the Sub-Target Weight	Index Score
	0.2352	0.4601	0.0884	0.2163		
B1	0.0435				0.0102	76.4
B2	0.0521				0.0123	78.3
B3	0.1904				0.0548	89.6
B4	0.0749				0.0176	77.4
B5	0.1005				0.0246	90.4
B6	0.1357				0.0319	78.4
B7	0.3028				0.0732	95.6
B8		0.0765			0.0352	80.2
B9		0.0736			0.0339	76
B10		0.2463			0.1163	88.3
B11		0.1963			0.0913	86.5
B12		0.0623			0.0287	80
B13		0.3451			0.1588	92.6
B14			0.5278		0.0467	72.3
B15			0.3325		0.0294	85.6
B16			0.1396		0.0123	85.5
B17				0.1725	0.0373	86.7
B18				0.361	0.0781	88.3
B19				0.1006	0.0218	83.4
B20				0.0762	0.0165	70.4
B21				0.2897	0.0627	84.5

According to

$$S = \sum_{q=1}^{n} \sum_{i=1}^{\infty} P_q X_{iq} \times Z_{qi}$$

the final score for the water resource asset audit of Y City's leadership is calculated as follows:

$$S = \sum_{q=1}^{n} \sum_{i=1}^{\infty} P_q X_{iq} \times Z_{qi} = 85.66$$

Based on the evaluation results, the final score of the water resource asset audit for the former mayor of Y City is 85.66, falling within the "relatively good" range. This indicates that the mayor has fulfilled the "entrusted responsibility" for water resource, but has not yet reached the "excellent" range, suggesting that more significant efforts are needed in water resource management.

Regarding resources, the scores for water reuse and the year-on-year increase rate in water resource are 89.6 and 90.4, respectively, representing an increase of 31.6% and 18.5% compared to the baseline values. This indicates that the leadership has made significant progress in promoting water resource reuse and controlling the rise in water resources. Additionally, the score for the difference in water intake and drainage in the Yellow River irrigation area is 95.6, showing an increase of 16.8% compared to the baseline, reflecting the importance the leadership places on the ecological protection of the Yellow River water resource. However, the scores for the total water resource and groundwater resource are 76.4 and 78.3, respectively, representing a decrease of 17.5% and 3.5% compared to the baseline values. This suggests there are still deficiencies in overall water quantity management and groundwater resource protection, indicating the need for further improvement in these areas.

In the environmental aspect, the score for ammonia nitrogen emissions is 88.3, representing a decrease of 29.3% compared to the baseline value. The score for COD emissions is 86.5, indicating a decrease of 9.9% compared to the baseline value. This demonstrates that the leadership has taken adequate measures to control ammonia nitrogen and COD emissions, significantly improving water quality. Additionally, the score for the investment completion amount in pollution prevention and control by old industrial enterprises is 92.6, showing an increase of 19.6% compared to the baseline value. This reflects the increased efforts of the leadership in investing in pollution prevention and control for old industrial enterprises. However, the scores for urban domestic sewage centralized treatment rate, industrial wastewater treatment rate, and the sewage treatment capacity of sewage treatment enterprises have decreased by 5.3%, 0.3%, and 3.8%, respectively, compared to the baseline values. This indicates that the leadership still needs to strengthen the management and control of sewage treatment to enhance water quality and water pollution control further.

In the social aspect, the scores for population density and per capita GDP are 85.6 and 85.5, respectively, indicating that the leadership has considered the balance between social development and water resource protection in water resource management. Adequate measures have been taken in social planning to achieve moderate regulation of population density. However, the score for per capita water resource is 72.3, representing a decrease of 11.9% compared to the baseline value. This suggests that there are still deficiencies in the rational use and protection of water resource by the leadership, leading to a reduction in per capita water resources. The leadership needs to continue strengthening population control and urban planning while paying attention to water resource protection and rational utilization to achieve the sustainable development of society and water resources.

In the economic aspect, the score for water consumption per unit of ten thousand industrial value-added is 86.7, representing a decrease of 11.08% compared to the baseline value. The score for water consumption per unit of ten thousand GDP is 88.3, indicating a decrease of 5.51% compared to the baseline value. The irrigation water-use efficiency coefficient score is 84.5, showing an increase of 2.34% compared to the baseline value. This indicates that the leadership has effectively reduced the water consumption per unit of output and GDP while promoting industrial and economic development and has improved

the efficiency of irrigation water use. However, there are still some deficiencies in the urbanization rate and agricultural water consumption per unit of acre. The urbanization rate has increased by 3.0% compared to the baseline value, and the leadership needs to strengthen urbanization planning and management to achieve balanced development of urban and rural populations. The score for agricultural water consumption per acre unit is 70.4, representing an increase of 12.85% compared to the baseline value, indicating that there is still room for improvement in agricultural water-use efficiency. The leadership needs to take measures to improve agricultural water-use efficiency and promote the rational utilization of agricultural water resources.

Overall, the former mayor of Y City has achieved specific achievements in water resource management, especially in the environmental and economic dimensions, where performance is relatively good. They have played a positive role in improving water quality and promoting the rational utilization of water resource. However, there are relative deficiencies in the resource and social dimensions, which require further strengthening of overall water quantity management, water resource protection, and population control measures to achieve more comprehensive, efficient, and sustainable water resource management, providing a stable water resource guarantee for the region's economic and social development.

3.3. Analysis of Influencing Factors

To conduct an in-depth analysis of the main factors affecting the comprehensive evaluation of the leadership's water resource asset outgoing audit, we utilized the obstacle degree model to determine the obstacle degrees of each criterion layer and specific indicators, as shown in Figures 1 and 2.

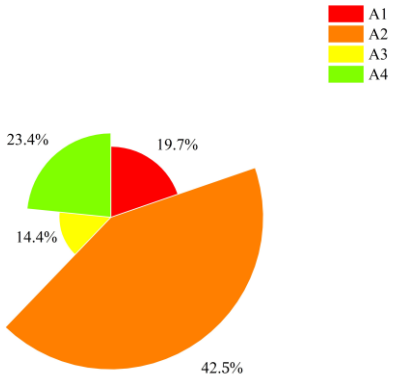


Figure 1. Criterion layer obstacle ratio.

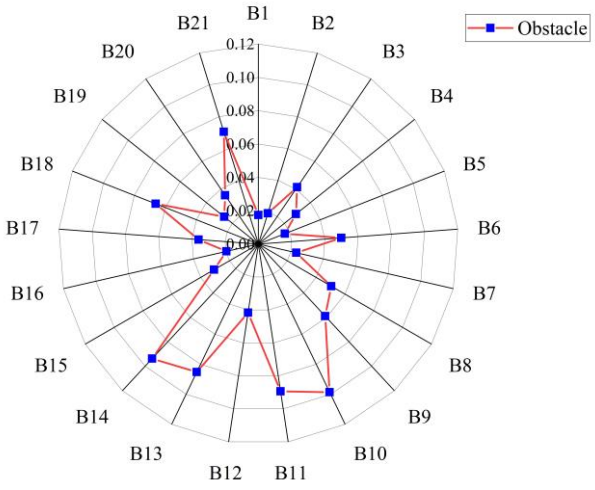


Figure 2. Indicator layer obstacle ratio.

Regarding the impact of indicators on the audit results, ammonia nitrogen emissions have emerged as the primary obstacle influencing the comprehensive evaluation of the former mayor's water resource management performance in Y City, with an impact degree of 9.86%. Additionally, per capita water resources account for 9.38%, COD emissions account for 8.93%, investment in pollution control of old industrial enterprises in the current year accounts for 8.52%, and irrigation water-use efficiency coefficient accounts for 7.04%. These factors significantly impact the comprehensive evaluation results and should be the key focus for the city's leadership in water resource management. Notably, ammonia nitrogen emissions, COD emissions, and investment in pollution control of old industrial enterprises are all environmental indicators, indicating that the environmental dimension significantly influences the audit results.

From the perspective of the evaluation index system's criterion layer on the audit results, the environmental dimension significantly impacts the comprehensive evaluation results, accounting for 42.43%. Therefore, the protection of water quality and water pollution control are crucial issues that Y City's leadership should be focused on. Leaders should strengthen their investment in water quality assurance, achieve sustained improvement in water quality, and provide stable water resource guarantees for the region's development, thus achieving sustainable water resource utilization. Next is the economic dimension, which accounts for 23.43% of the comprehensive evaluation results' impact. This indicates that Y City's leadership needs to pay more attention to the rational use and conservation of water resources while promoting economic development in order to reduce excessive water consumption and alleviate pressure on the water resource environment. However, examining only the environmental and economic dimensions cannot fully reflect the leadership's water resource management performance. The impact of resource and society on the comprehensive evaluation results should not be overlooked, accounting for 19.74% and 14.41%, respectively. To improve performance in the resource and social dimensions, leaders should formulate and implement water resource protection policies, plan and develop water resource rationally, and ensure the secure supply and optimal allocation of water resources. At the same time, optimizing social development planning, promoting balanced population distribution, and alleviating population water pressure are also essential measures.

4. Discussion

This paper is based on the concept of water resource management under the United Nations' Sustainable Development Goals and the green accounting of natural assets. It constructs a comprehensive evaluation index system for leadership water resource asset outgoing audits from four dimensions: resource, environment, society, and economy. This system covers key aspects of water resource management, and it closely links water resource assets with resource–environment and socio-economic development. Compared to existing research, this approach effectively addresses the issue of overly simplistic existing index systems.

Commonly used evaluation models for leadership natural resource asset outgoing audits include the PSR model, fuzzy comprehensive evaluation model, and the AHP model. The PSR model mainly focuses on pressure, state, and response aspects when considering natural resource management, but it may overlook critical factors influencing natural resource management, leading to incomplete and inaccurate evaluation results. The fuzzy comprehensive evaluation model can handle uncertainty and vagueness but requires high expertise from auditors due to the complex theory of fuzzy mathematics and cumbersome calculation processes, potentially increasing audit costs and time. On the other hand, combining the AHP method with the initial comparison scoring method offers a relatively simple mathematical model, reducing the expertise requirements for auditors. This not only helps improve evaluation quality but also lowers implementation costs, enhancing the practicality and operability of the model.

Indeed, the AHP and initial comparison scoring method involve a certain degree of subjectivity. However, professional evaluators consider the actual conditions of the audited leadership area and thoroughly consider natural factors that may influence indicator changes, such as climate variations, seasonal fluctuations, and natural disasters. They combine the direction and magnitude of these indicator changes to accurately assess the performance of the audited leadership in water resource management responsibilities. This approach prevents evaluation results from deviating from the actual situation, making the assessment more precise. This study has implemented several measures to ensure the reliability and quality of the audit results. Firstly, when selecting professional evaluators, individuals with extensive expertise in relevant fields were chosen, including audit research experts, government officials, and staff from social audit organizations. This diverse team enables a comprehensive evaluation process, leveraging different professional perspectives. Secondly, original data with authoritative and trustworthy sources were provided to the evaluators, sourced from government statistical yearbooks and official reports. Standardized data collection and processing methods facilitate data comparison and analysis. Additionally, to ensure evaluators' assessments are consistent and credible, the study employed the semantic difference method, defining five evaluation results with corresponding score ranges in the evaluation criteria. This approach helps minimize subjective bias. Finally, the feedback data provided by the experts underwent thorough verification and validation. Any abnormal data was removed to reduce the impact of individual evaluators' subjectivity on the evaluation results, thereby ensuring the overall data quality. These measures collectively contribute to the accuracy and reliability of the audit results in assessing leadership performance in water resource management responsibilities.

The evaluation indicator system proposed in this paper provides valuable insights for Y City and is a significant reference for the international exchange of water resource management experiences. The evaluation system considers not only the attributes of water resources themselves but also their socio-economic effects. Other countries and regions can adopt a similar approach, using the AHP to consider their local water resource endowments, selecting evaluation indicators accordingly. By developing evaluation systems with local characteristics, they can more comprehensively assess their leadership performance in water resource management. Moreover, other countries and regions can learn from the conclusions and experiences of Y City in the Yellow River Basin. By comparing different regions' situations, they can better identify potential problems and challenges in their water resource management, and therefore implement corresponding policy measures for improvement. Thus, they can effectively use this indicator system and draw from the research findings and experiences to enhance their water resource environment, positively contributing to global water resource management and sustainable utilization.

Through the in-depth study of specific cases, we can gain insights into the actual performance of the indicator system in a particular environment. However, we must recognize the limitations in terms of generalizability and representativeness in single-case studies. To overcome these limitations, future research could consider adopting multiple national or provincial case studies covering different regions and contexts. Additionally, the subjective limitations of the expert scoring method used in this paper should be acknowledged. Future studies may incorporate other evaluation methods, such as data mining and machine learning to continuously improve and optimize the evaluation process, enhancing objectivity and scientific rigor in the assessment results. Through such efforts, we can better enhance the applicability of the indicator system and provide more reliable evidence for its global application and implementation.

5. Conclusions

This paper is based on the concepts of water resource management under the United Nations' Sustainable Development Goals and natural asset green accounting. It constructs an evaluation indicator system for auditing the water resource assets of departing officials from Y City in the Yellow River Basin, covering four dimensions: resource, environment,

society, and economy. Utilizing the AHP and initial comparison scoring method, it assesses the performance of the former mayor in water resource management. Additionally, the study explores the main influencing factors using the Barrier Degree Model. The conclusions drawn from the study are as follows.

Firstly, the constructed indicator system in this paper covers critical aspects of water resource management and closely integrates the relationship between water resource assets, resource environment, and socio-economic development. It effectively evaluates leaders' performance in managing water resources, providing a basis for optimizing water resource management and promoting sustainable utilization and conservation of water resource.

Secondly, when applying this evaluation indicator system to Y City in the Yellow River Basin, the assessment results indicate that the former mayor received a final score of 85.66 in the water resource asset departing audit, falling into the "relatively good" range, indicating an essential fulfillment of the "entrusted responsibility" for the water resources. The former mayor achieved specific accomplishments in water resource management, particularly in the environmental and economic dimensions, contributing positively to improving water quality and the rational utilization of water resources. However, the overall score did not reach the "excellent" range, indicating that, although efforts were made in water resource asset management, the effectiveness of the management was not significant. There are management shortcomings in the resource and social dimensions, requiring further optimization of water resource allocation and population development planning to achieve more comprehensive, efficient, and sustainable water resource management, ensuring stable water resource support for the region's development and realizing sustainable water resource development.

Finally, utilizing the Barrier Degree Model for analyzing the main influencing factors, it was found that, at the indicator level, the top three factors influencing the comprehensive evaluation results of the former mayor's water resource management in Y City are as follows: ammonia nitrogen emissions accounting for 9.86%, per capita water resources accounting for 9.38%, and COD emissions accounting for 8.93%. At the criterion level, the environment dimension significantly impacts the comprehensive evaluation results, accounting for 42.43%. Therefore, leaders should strengthen their investment in water quality assurance to continuously improve water quality, ensuring stable water resource support for the region's development and promoting the sustainable utilization of water resources.

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