Research on River Governance Index System in the Big Data Era

Chengzhi Niu¹, Yougan Zhu^{1,*}

¹Beijing Institute of Fashion Technology, Chaoyang District, Beijing, 100020, PRC

Abstract. Realizing the ecological health and sustainable development of rivers has become a worldwide research hotspot. Sustainable development is a large system with multi-system, multi-level and multi-index. In the era of big data, data science methods have made great changes in water resources governance methods. We can obtain more detailed data through big data methods to comprehensively and scientifically measure river governance. Based on the analytic hierarchy process, this paper invites experts in related fields to construct and score the river governance index system, and establish a river governance index system in the era of big data. We hope that the river governance index system will achieve advanced river governance in the era of big data.

1 Introduction

The sustainable development of rivers also reflects the sustainable development of mankind. Therefore, the sustainable development of human society cannot be separated from the sustainable development of the ecological environment. [1] Rivers are an important part of the ecological environment, as well as important natural resources, economic resources, social resources and ecological basic elements for regional development. If the river is polluted, the entire system of the water cycle will be destroyed, causing it to lose social, economic, and environmental benefits.[2] However, due to our irregular activities, the health of the river has been damaged to a large extent, which may be detrimental to the sustainable development of society.

The governance and protection of rivers is of great significance to the improvement of our living environment and the development of social economy. In general, rivers are of high value for the sustainable development of human society. [3] Therefore, it is the general trend for us to establish sustainable and circular development of river governance. We must adhere to sustainable development and change the traditional concept of pollution first and treatment afterwards.

Governing water resources from the perspective of sustainable development and protecting and repairing the healthy circulation of river water bodies are the current focus of river governance. River governance has attracted people's attention, but due to the limitations of the times, people's methods for river governance in the past were often limited to the construction of a single indicator.[4] In the context of the era of big data, it is possible to build a comprehensive integrated river governance system. Therefore, this paper studies the river governance index system in all aspects from the

four dimensions of river safety, river resources, river ecology, and river management.

2 Construction of River Governance Index System in the Big Data Era

The river is an important place for ecological maintenance and the main channel for drought and flood control. It is a complex system including organisms, water bodies, river beds, river bottoms and other structures. With the development of economy and the increase of population, the ecological environment protection of rivers is becoming more and more important, and people's research on river governance is becoming more and more in-depth.

Fig. 1. Number of papers published of river governance in China

Sustainable water resources management is a hotspot of research on water issues in the world today, and it is also a major demand issue for the sustainable development of water resources in China. Chinese

* Corresponding author: macrov@yeah.net

scholars have carried out relevant research on water and sustainable use since the 1990s. The research on the sustainable development of water resources mainly focuses on maintaining the sustainable development of water resources and ecology, and raising people's awareness. In the 21st century, Chinese scholars' research on river governance has reached a new high level. After 2010, China's river governance research continued to heat up, and the number of papers published of river governance in China was at a historical high point. Figure 1 shows the number of papers published of river governance in China after 2005.

2.1 Principles for constructing a river governance index system

When constructing the river governance indicator system in the era of big data, we follow the following principles, which can ensure that our indicator system is comprehensive, comprehensive and feasible.

2.1.1 Principle of integrity and hierarchy

The establishment of the evaluation index system is a general description of the river morphology construction. All indicators should be set around the evaluation goals, forming a systematic and comprehensive organic overall system, and comprehensively and objectively evaluating the research goals. [5] Since the evaluation index of a water ecological civilization city is a complex system, it is required to have a certain level. Researchers usually refine the indicators layer by layer by dividing the target layer, criterion layer, and indicator layer to reflect the development status of water ecological civilization in the study area from different perspectives.

2.1.2 Principles of scientific and operability

The establishment of the evaluation index system requires that each index must be reasonable, scientific and accurate. In the process of construction, it is necessary to fully understand the research target object in order to truly and objectively reflect the internal mechanism of aquatic ecology.[6] It is necessary to ensure the scientific and standardized measurement and statistical methods to ensure the authenticity and objectivity of the evaluation results. The indicator data should be connected with the current statistical methods. Under the premise of meeting the purpose of monitoring and evaluation, relatively mature and recognized indicators should be used as much as possible, and there should not be too many indicators to ensure the efficiency of the evaluation results.

2.1.3 Principle of comparability

The construction and selection of the entire evaluation index system should be comparative and can be used for horizontal comparison between different rivers and vertical comparison between the same river at different

points in time. By analyzing the horizontal and vertical trends, the role of the indicator system can be improved.

2.1.4 The principle of Dynamic index

As a developing system, the state of the river is a process of constant change. At different stages of development, the development of aquatic ecology has different focuses. The selection of indicators should proceed from reality, and strive to make each indicator reflect the characteristics and future orientation of the development of water ecological civilization. The entire evaluation index system should have a certain degree of expansion. With the development of water environment and water resources, some indexes will be introduced or eliminated, and this process does not affect the entire system framework.

2.1.5 The principle of combining qualitative and quantitative

In the whole system index selection process, we should choose as many quantitative indexes as possible. Qualitative description and quantitative feedback methods should be adopted for important indicators that are not easy to quantify in the indicator system. Combine qualitative and quantitative, and reflect the indicators as clearly and objectively as possible.

2.2 Construction of River Governance Index System in the Big Data Era

The Based on previous research results, we construct the water resource governance index system in the era of big data from the following four perspectives. These four dimensions reflect different aspects of our river governance results. At the same time, in view of the data characteristics of the big data era, we are bolder in selecting subdivision indicators, because in the big data era our data acquisition is more flexible and more real-time data acquisition becomes possible.

The essence of water security is whether the supply of water resources can meet the reasonable demand for water resources, which generally involves social security, economic security and ecological security. The river ecosystem should have the ability of system stability and virtuous cycle, and it should not cause harm to other systems. Water resources must not only meet the daily needs of people, but also ensure the sustainable development of society, as well as economic and ecological water.

Water resources system can be divided into water resources situation and water efficiency. The amount of water resources is a basic indicator for measuring water resources, and it is also a prerequisite for the existence of various water ecological, social, and economic systems. It is the basic requirement of river management to make the amount of water resources meet the needs of water ecology, society and economy. The efficiency of water use includes water demand guarantee rate, per capita water supply, and water supply guarantee rate.

Water environmental protection requires us to protect the natural water system ecological environment, control pollution, improve water quality, and improve the ecological environment of water resources. The water environment has certain requirements for the development of social open space and green space system, the existing rivers in the area, and the improvement of the water quality of the rivers in the planned area. Protecting the water environment to achieve harmony between humans and water and sustainable social and economic development is an effective way to achieve harmonious coexistence between humans and rivers. 2.2.4 River management system

Management system refers to various activities that use legal, administrative, economic, technical and other means to manage the distribution, development, utilization, dispatch and protection of water resources. Effective management methods can sustainably meet the needs of economic and social development and improve the environment for water.

3 Calculation of index weights based on the Analytic Hierarchy Process

The analytic hierarchy process is a complex multi-objective decision-making system. It decomposes the goal into multiple goals or criteria, and further decomposes the goal into multiple indicators. It uses the quantification method to calculate the hierarchy order to optimize decision-making.

We construct the analytic hierarchy process model as follow. There are 3 layers in this model, which are the target layer, the criterion layer and the indicator layer. The hierarchical model of the construction is shown in Table 1.

Table 1. The hierarchical model of River Governance Index System

Target layer	Criterion layer	Indicator layer
River Governance Index System A	River safety system B1	Riparian stability score C1
		Flood control project compliance rate C2
		Bottom mud pollution C3
		Reasonable degree of sewage outlet C4
	River resources system B2	Drinking water quality level C5
		Water quality C6
		Water function zone compliance rate C7
		Variation degree of flow process C8
	River environment system B3	Microbenthic Invertebrate Biological Integrity Index C9
		River Vertical Connectivity Index10
		Riparian vegetation coverage C11
		The degree of artificial disturbance in the riparian

	River management system B4	zone C12
		System integrity score C13
		Early warning monitoring scoring C14
		Inter-basin governance synergy C15
		River ecological restoration degree C16

We have invited many experts to revise the indicator system and give scores. When experts provide opinions and scores, in order to ensure the quality of the scores, we use the Delphi method to collect expert opinions.

The Delphi method is a method of soliciting opinions from experts in the form of questionnaires, and then summarizing the opinions of experts and drawing conclusions. As a subjective and qualitative method, the Delphi method can not only be used in the field of forecasting, but also can be widely used in the establishment of various evaluation index systems and the determination of specific indexes. Because in the process of using the Delphi method, the opinions of different experts can be fully solicited, and a certain accuracy is ensured on the basis of brainstorming.

The judgement matrix was constructed by using the Delphi Method. The Delphi method will investigate the opinions of experts on the questions raised in the questionnaire in multiple rounds. This method is reliable in the research field.

Before analysing the indicators of Analytic Hierarchy Process, we need to check their consistency first.

We use the consistency index CI and the ratio CR to check the consistency. When $CR < 0.1$, it indicates that the judgment matrix has passed the consistency test; otherwise, the judgment matrix should be corrected.

The calculation process of the consistency index is as follows:

Table 2. The A-B Judgment Matrix

A	B1	B2	B3	B4
B1	1	3	3	1/3
B2	1/3	1	1/3	1/4
B3	1/3	3	1	1/3
B4	3	4	3	1

Table 3. The B2-C Judgment Matrix

B1	C1	C2	C3	C4
C1	1	1/2	2	1/4
C2	2	1	3	2
C3	1/2	1/3	1	1/2
C4	4	1/2	2	1

Table 4. The B2-C Judgment Matrix

B2	C5	C6	C7	C8
C5	1	3	2	1/3
C6	1/3	1	1/2	1/3
C7	1/2	2	1	1/3
C8	2	4	4	1

Table 5. The B3-C Judgment Matrix

B3	C9	C10	C11	C12
C9	1	4	2	1/3
C10	1/4	1	1/2	1/4
C11	1/2	2	1	1/3
C12	3	4	3	1

Table 6. The B4-C Judgment Matrix

B4	C13	C14	C15	C16
C13	1	3	1/2	3
C14	1/3	1	1/4	1/2
C15	2	4	1	2
C16	1/3	2	1/2	1

The maximum eigenvalues $\lambda_{\max}$ obtained in the A-B judgment matrix is 4.2106, test coefficient is $CR=CI/RI=0.0891<0.1$ we can see that the result has passed the test. The weight the matrix is $(0.494, 0.2697, 0.1544, 0.0818)^T$.

The maximum eigenvalues $\lambda_{\max}$ obtained in the B-C judgment matrixes are 4.2596, 4.1431, 4.1197, 4.1179, and the test coefficients CR are 0.0972, 0.0536, 0.0442, 0.0304. The four CR are less than 0.1, we can see that all the judgment matrix passes the consistency test. The weight of the indicator layer is shown in Table 7.

Table 7. River Governance Index System Weight Table

Criterion Layer	Indicator Layer	Relative Weight
River safety system 49.40%	Riparian stability score	21.12%
	Flood control project compliance rate	15.59%
	Bottom mud pollution	10.85%
	Reasonable degree of sewage outlet	8.78%
River resources system 26.97%	Drinking water quality level	8.04%
	Water quality	7.79%
	Water function zone compliance rate	4.65%
	Variation degree of flow process	4.24%
River environment system 15.44%	Macrobenthic Invertebrate Biological Integrity Index	4.01%
	River Vertical Connectivity Index	4.00%
	Riparian vegetation coverage	3.11%
	The degree of artificial disturbance in the riparian zone	2.32%
River management system 8.18%	System integrity score	2.05%
	Early warning monitoring scoring	1.32%
	Inter-basin governance synergy	1.29%
	River ecological restoration degree	0.85%

4 Conclusion

According to the water resources governance indicator system we have established, we draw the following conclusions and recommendations:

Vegetation restoration is the most common technical method in river restoration. Vegetation can slow down the flow of the river, promote the deposition of sediment, reduce the occurrence of soil erosion, and effectively shape the shape of the river. The reasonable distribution of vegetation can also help withstand flood disasters and improve the water quality of rivers.

The environmental protection department can use bio-enhanced technology to make the artificial river channel more unobstructed and increase the stock of organisms in the river, including plankton, benthic animals and fish. The physical factors that have the greatest impact on benthic animals are the stability and sediment composition of the river bed. The more stable the river bed, the more species there will be. River governance projects that promote the growth of aquatic organisms are very beneficial to purifying water quality and maintaining a good river ecology.

Habitat restoration Habitat restoration involves the growth environment of organisms. We should increase the habitats of organisms along the river, enhance the purification capacity of the river, and promote the improvement of the river ecosystem.

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