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Study on the Long-term Mechanism of "Ten-Year Fishing Ban" In The Middle and Lower Reaches of the Yangtze River from The Perspective of Intergenerational Equity

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Abstract: Starting from the background of the "ten-year fishing ban" policy in the Yangtze River, this paper studies the long-term mechanism of the policy from the perspective of intergenerational environmental equity. From three dimensions of economic equity, social equity and resource and environmental equity, the AHP method is used to explore the intergenerational ecological equity coefficient in the middle and lower reaches of the Yangtze River basin. By tracking and calculating the longitudinal changes of ecological equity before and after the "ten-year fishing ban" from 2007 to 2021, it is concluded that the "ten-year fishing ban" policy alleviates the intergenerational environmental conflicts, and finally puts forward the improvement countermeasures.

Keywords: Equity between generations, 10 years of fishing ban, Long acting mechanism, AHP method.

1. Introduction

For a long time, due to the impact of overfishing, water pollution and other high intensity human activities, the ecological environment of the Yangtze River has been deteriorating, and the biodiversity of the Yangtze River has continued to decline. The 10-year ban on fishing along the Yangtze River is a major decision made by the CPC Central Committee and The State Council for the overall situation and for future generations. It is an important measure to promote high-quality development of the Yangtze Economic Belt and restore vitality to the Yangtze River. How to actively respond to the call of "ten-year fishing ban" and how to make this mechanism more long-term has become one of the difficult problems to be solved. It is one of the most effective ways to analyze and solve this problem from the perspective of intergenerational equity. Therefore, many cities in the middle and lower reaches of the Yangtze River not only "ban fishing" but also provide security for fishermen.

From the perspective of foreign evaluation systems, Jacobson[1] et al. used Lorenz curve and Gini coefficient to compare the distribution of energy consumption in five countries. In China, environmental justice is mainly measured by Gini coefficient, environmental intergenerational equity model and ecological equity coefficient. Wang Jinnan (2006) [2] proposed China's environmental Gini coefficient based on GDP, and took the green contribution coefficient as the basis for judging the inequity factor. Chen Daowei (2013) [3] conducted a comprehensive evaluation of environmental justice in domestic provinces and cities from the perspectives of GDP and ecological capacity respectively. Qiao Lixia (2016) [4] made a longitudinal analysis of domestic environmental equity based on the comprehensive Gini coefficient constructed by GDP, ecological capacity and population. Cao Wanlin (2019) [5] analyzed China's ecological justice vertically and horizontally from three dimensions: economic justice, social justice, and resource and environmental justice, and looked for key factors affecting ecological justice. On the basis of previous research results, this study intends to use AHP method to discuss the intergenerational ecological equity coefficient in the middle and lower reaches of the Yangtze River basin, in order to put forward relevant suggestions for the long-term development of "ten-year fishing ban" policy.

2. Research Methods and Principles

2.1. Research principles

The AHP method[6]Also known as analytic hierarchy process (AHP), its principle is to classify the problems studied in different levels according to different principles, then construct a judgment matrix according to the logical relations of each level, and calculate the single ranking structure of a certain level factor relative to each factor of the upper level and the total ranking weight relative to the upper level. It is a decision analysis method that combines qualitative and quantitative analysis.

2.2. Research methods

Step 1: Build a hierarchical model, that is, the classification of each influencing factor at the next level.

Step2: Construct the judgment matrix.According to the consistency matrix check method, the matrix is constructed, but all matrix elements are compared in pairs, and finally through the consistency check to determine whether the matrix construction is correct.The judgment matrix A(αijIs the element of the matrix, i represents the row, j represents the column), the value of each element in the judgment matrix reflects the importance of one element to another element judgment, innovative value method, αij It is not mandatory to select the data in Table 1. Any score in the above data can be used for judgment. Each value represents a different relationship between them, as shown in Table 1.

Table 1. Value assignment meaning table of analytic hierarchy process

The assignment	instructions
1	Both are equally important
3	i is slightly more important than j
5	i is important than j
7	i is more important than j
9	i is absolutely more important than j
2,4,6,8	The median of two adjacent judgments The middle of the two adjacent judgments needs further subdivision
The bottom	If the ratio of the importance of i to j is, then the ratio of the importance of j to i is$\frac{1}{a_{ij}}$

Step3: Hierarchical singleness and consistency check. Normalize matrix A according to column vectors:

$$A=\begin{bmatrix} 1 & \alpha_{12} & \cdots & \alpha_{1j} \\ \alpha_{21} & 1 & \cdots & \alpha_{2j} \\ \cdots & \cdots & \cdots & \cdots \\ \alpha_{i1} & \alpha_{i2} & \cdots & \alpha_{ij} \end{bmatrix}=\begin{bmatrix} \frac{\alpha_{11}}{\sum_{k=1}^{k=i}\alpha_{k1}} & \cdots & \frac{\alpha_{1j}}{\sum_{k=1}^{k=i}\alpha_{kj}} \\ \vdots & \ddots & \vdots \\ \frac{\alpha_{i1}}{\sum_{k=1}^{k=i}\alpha_{k1}} & \cdots & \frac{\alpha_{ij}}{\sum_{k=1}^{k=i}\alpha_{kj}} \end{bmatrix}$$

The vector normalized by the above normalization treatment can be obtained:

$$\overline{W}=\left\{\left(\frac{\alpha_{11}}{\sum_{k=1}^{k=i}\alpha_{k1}}+\cdots+\frac{\alpha_{1j}}{\sum_{k=1}^{k=i}\alpha_{kj}}\right)\ (\cdots)\ \left(\frac{\alpha_{i1}}{\sum_{k=1}^{k=i}\alpha_{k1}}+\cdots+\frac{\alpha_{ij}}{\sum_{k=1}^{k=i}\alpha_{kj}}\right)\right\}^{T}$$

$$W=\left(\overline{W_1}/n\cdots\overline{W_n}/n\ \right)T$$

Step4: After the normalized sum of matrix A column, find the maximum feature root and consistency check.

$$Aw=\lambda w$$

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

n is the matrix dimension, and its corresponding RI is shown in Table2.

Table 2. Average random consistency index RI

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

When C.R.<0.1, it indicates that the consistency of the judgment matrix A is considered to be within the allowable range. At this time, the feature vector of A can be used for weight vector calculation.If C.R.≥0.1, the judgment matrix A should be considered for correction.

Data standardization processing:In order to facilitate the comparative analysis of data, it is necessary to conduct standardization processing. This paper adopts the range standardization method, and the calculation formula of the positive correlation factor of the final score is (1), and the calculation formula of the negative correlation factor is (2).

$$X'_{ij}=\frac{x_{ij}-min\{x_{ij}\}}{max\{x_{ij}\}-minx_{ij}} \quad (1)$$

$$X'_{ij}=\frac{max\{x_{ij}\}-x_{ij}}{max\{x_{ij}\}-min\{x_{ij}\}} \quad (2)$$

Step5: Adjust the situation that does not conform to the consistency check and recalculate.

2.3. Data sources

There are 9 index layers in this paper, and the evaluation data are obtained directly or indirectly from the statistical yearbooks published by municipal authorities and China Fishery Statistical Yearbook from 2007 to 2022.

3. Results and Discussion

3.1. Evaluation system

Intergenerational ecological justice is rich in connotation. Before the evaluation, A relatively complete evaluation index system of ecological justice should be built first. The evaluation index system of urban competitiveness is composed of three levels, which are target layer (A), criterion layer (B) and index layer (C), among which, the target layer is intergenerational ecological justice. The index layers are economic equity, social equity and resource and environment equity respectively.

Table 3. Ecological justice index system

Target layer (A)	Criterion layer (B)	Index layer (C)
Ecological Equity A	Economic fairness B1	GDP C1
		Freshwater fishing value C2
		The output value of freshwater aquaculture is C3
	Social justice B2	Total population C4
		Number of fishery employees C5
		Per capita net income of fishermen C6
	Resource and environmental equity B3	Total water resources in the middle and lower reaches of the Yangtze River basin C7
		The proportion of fish in the catch C8
		Freshwater fishing output C9 in the middle and lower reaches of the Yangtze River Basin

Table 4. Weight of criterion layer of ecological justice evaluation index system

indicators	B1	B2	B3
The weight	0.3196	0.1219	0.5585

Table 5. Weight of index layer in ecological justice evaluation index system

indicators	The weight	indicators	The weight
C1	0.071	C6	0.0658
C2	0.2131	C7	0.1726
C3	0.0355	C8	0.3248
C4	0.0199	C9	0.0611
C5	0.0362		

3.2. Indicator description

The index system sets a total of 9 indicators from the three dimensions of "economic equity, social equity and resource and environmental equity". The index scores of the criterion layer are shown in Table 6, and the evaluation results are shown in Figure 1 and Figure 2.

Table 6. Scores of criterion layer

year	2007	2008	2009	2010	2011	2012	2013	2014
B1	0.3196	0.3788	0.3929	0.4192	0.4316	0.4976	0.5945	0.6101
B2	0.1219	0.1318	0.1364	0.1429	0.1531	0.1662	0.1872	0.1996
B3	0.5585	0.5583	0.5517	0.6075	0.5508	0.5457	0.5791	0.5940
Z	1	1.0689	1.0810	1.1696	1.1355	1.2095	1.3608	1.4036
year	2015	2016	2017	2018	2019	2020	2021	
B1	0.6296	0.6437	0.7164	0.7611	0.7036	0.7473	0.7145	
B2	0.2125	0.2257	0.2374	0.2449	0.2540	0.2589	0.2751	
B3	0.6006	0.6327	0.5432	0.5067	0.5242	0.5502	0.5059	
Z	1.4427	1.5021	1.4970	1.5126	1.4818	1.5563	1.4955	

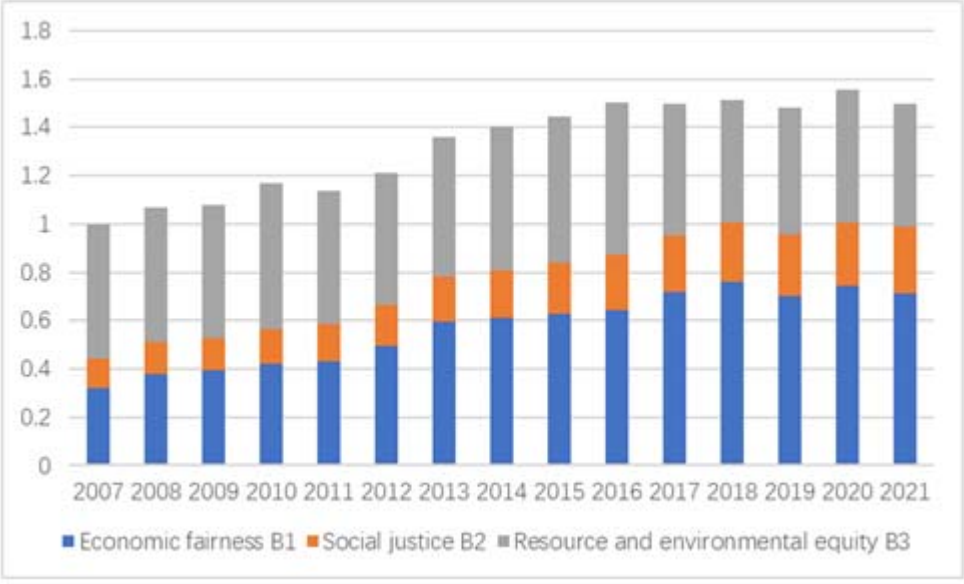

Figure 1. Ecological fairness assessment results in the middle and lower reaches of the Yangtze River Basin

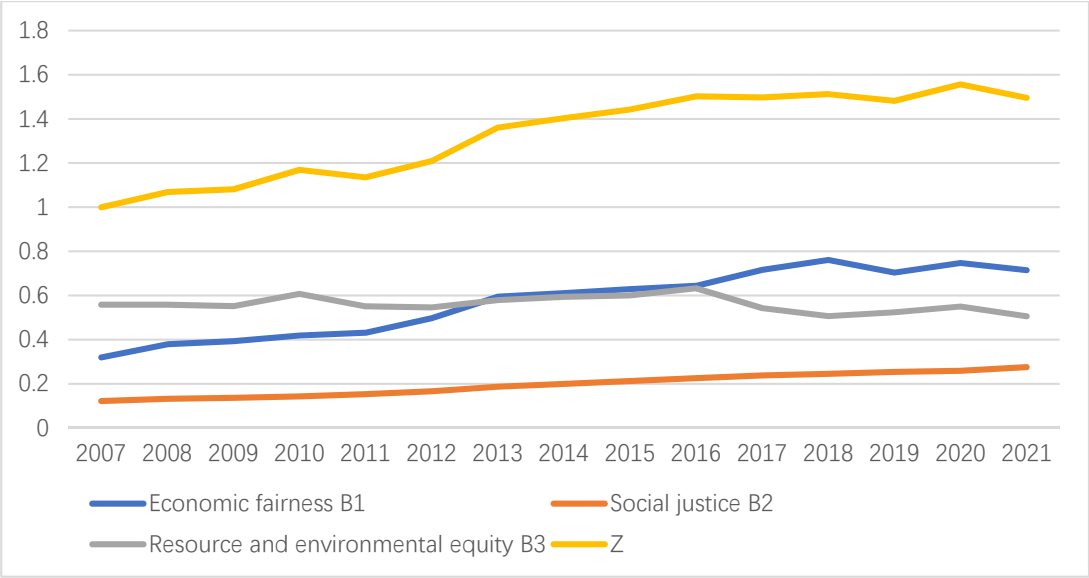

Figure 2. Trends of ecological equity indexes in the middle and lower reaches of the Yangtze River Basin

4. Conclusions and Countermeasures

Based on the AHP method, this paper obtained the vertical changes of ecological equity before and after "ten-year fishing ban" in the middle and lower reaches of the Yangtze River from 2007 to 2021, and finally proposed the optimal path of long-term development of "ten-year fishing ban" policy and improved the long-term policy mechanism.

4.1. Conclusions and Countermeasures

Calculate the ecological equity coefficient according to the above index weights, and draw the line chart of the ecological equity coefficient over the years.As shown in the figure, the ecological equity coefficient has been on a slow spiral upward trend since 2007 and reached the highest value of 1.56 in 2020.This indicates that with the rapid economic growth and increasing population, the intergenerational inequity of fishery resources and water quality environment in the middle and lower reaches of the Yangtze River is becoming increasingly prominent, and the intergenerational environmental conflict is deepening. In 2020, the "ten-year fishing ban" plan was launched in the Yangtze River, and the ecological equity coefficient began to decline, indicating that the environmental fairness of the middle and lower reaches of the Yangtze River increased and the environmental conflicts between generations eased during the implementation of the ten-year fishing ban policy.

Furthermore, the degree of intergenerational economic equity, social equity and resource and environmental equity in the middle and lower reaches of the Yangtze River basin is further analyzed, and the economic equity coefficient, social equity coefficient and resource and environmental equity coefficient from 2007 to 2021 are calculated for horizontal and vertical comparison.It can be seen from the figure that the changing trends of the three fairness coefficients are similar.

From 2007 to 2020, the coefficient of economic equity showed an upward trend, reaching more than 0.4 in 2010 and the highest value of 0.76 in 2018, exceeding the international warning line. Although the Gini coefficient of economic equity began to decline from 2018, it rebounded in 2019, showing an inverted triangle in the overall trend.The social equity coefficient is stable between 0.1 and 0.3, which is relatively average.The equity coefficients of resources and environment are all greater than 0.4.Since the implementation of the "ten-year fishing ban" plan in the Yangtze River in 2020, both the economic equity coefficient and the resource and environmental equity coefficient have shown a downward trend. Although the social equity coefficient has increased slightly, it is still below the warning line of 0.4.This indicates that although intergenerational inequality in the middle and lower reaches of the Yangtze River basin was greatly affected by economic growth and resources and environment from 2007 to 2020, intergenerational economic inequality and resources and environment inequality in the middle and lower reaches of the Yangtze River basin were alleviated to a certain extent during the implementation of the ten-year fishing ban policy.

4.2. Suggestions for long-term development of "ten-year fishing ban" policy in the middle and lower reaches of the Yangtze River Basin

(1) Increase financial support to protect the interests of fishermen who have returned from fishing and promote their reemployment.After the implementation of the fishing ban, whether the disembarked fishermen can find jobs again is the key to the sustainability of the fishing ban policy, and increasing the income of the disembarked fishermen is the key. Therefore, the government should increase the compensation for the disembarked fishermen and promote the re-employment of the fishermen.It is suggested that governments at all levels coordinate the efforts of all departments and introduce various encouragement and preferential policies to promote the re-employment of fishing fishermen.In light of the actual needs, we will make every effort to create jobs suitable for fishermen and provide free job training. This will not only ensure their livelihoods, strengthen their trust in the government, but also facilitate the effective implementation of the fishing ban.

(2) Establish matching principle and implement tradable quota.Due to intergenerational externality, that is, the time span causes artificial inequality between different generations in the opportunity to enjoy resources. It is suggested to implement tradable quota according to the matching principle, which can not only reduce the exploitation and consumption of public renewable resources, but also overcome the

intergenerational allocation failure.

(3) Strengthen the law enforcement supervision after the arrest ban.The no-catch policy is a strong binding policy, which needs effective law enforcement supervision.It is suggested that the government strengthen the work of legislating rules and regulations, and crack down on all kinds of illegal acts in violation of the fishing ban, so that the management of the fishing ban in the Yangtze River can be based on laws, strictly enforced and punished.At the same time, the government should play a leading role in the formulation and implementation of the no-catch policy and improve the driving and guiding role of the prescriptive norms for fishermen to quit fishing.

(4) Strengthen the publicity of ecological protection of waters and the ban on fishing. Improve fishermen's awareness of the importance of ecological protection in the Yangtze River Basin, enhance the popularity of the ban on fishing, make the public truly understand the green development concept of "clear waters and lush mountains are gold and silver mountains", realize that ecological protection is the process of adding ecological value and ecological capital, achieve the purpose of the whole society to pay attention to environmental protection, and take the road of sustainable development. We should not sacrifice the interests of future generations because of the development of the current generation, so as to create a good ideological basis for the comprehensive implementation of the Yangtze River no-catch policy and actively participate in the social atmosphere of no-catch.

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