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Construction of Diversified Ecological Compensation Mechanism for Water Environment Control in Zhejiang Province: A Case Study of Beitang River

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Abstract. Focusing on the need to build a diversified ecological compensation mechanism for water environment governance, the Beitang River pilot project was sorted out and analyzed, with research conducted from aspects such as the improvement of the ecological environment of the Beitang River, public awareness of ecological compensation policies, and public willingness to participate in ecological compensation, to analyze obstacles to the implementation of the system. On the basis of defining the relationship between government, market, and society, this paper proposed a basic framework for diversified ecological compensation mechanisms for water environment governance and advocated an ecological compensation model featuring coordinated operation of six mechanisms, namely, government guidance, market operation, social participation, communication and connection, system operation, and scientific management.

Keywords. Ecological compensation, diversification, water environment governance, compensation subject

1. Introduction

Marketization and diversification of ecological compensation mechanisms are considered to be effective ways to establish long-term ecological compensation mechanisms [1-3]. The state attaches particular importance to diversified ecological compensation mechanisms. In October 2017, the report of the 19th National Congress of the Communist Party of China proposed "establishing market-oriented and diversified ecological compensation mechanisms". In September 2021, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued "Opinions on Deepening the Reform of the Ecological Protection Compensation System", a landmark document on the reform of the ecological protection compensation system in the opening year of the "14th Five-Year Plan", which clearly played the role of market mechanisms, accelerated the

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promotion of diversified compensation, and made the path of market-oriented and diversified ecological protection compensation clearer [4, 5].

During the "13th Five-Year Plan" period, Zhejiang Province started with the "Ten Water Articles" and "Five Water Treatment", and the ecological compensation mechanism gradually covered the eight major water systems. The water environment quality continued to improve at a high level. The implementation of ecological compensation work in Zhejiang Province has been fully recognized by the Ministry of Finance and the Ministry of Environmental Protection, but there were problems such as formalized understanding of ecological compensation in various regions, inadequate scientific and reasonable formulation of compensation standards and indicator systems, compensation methods still focusing on financial compensation, and the need to accelerate exploration of diversified ecological compensation models. The effect of improving the quality of the province's water ecology and environment was unstable. Only by drawing on domestic and foreign experiences and establishing a relatively complete long-term mechanism for ecological compensation for water environmental governance, we will solve the problem and truly complete the deployment of water environmental protection work during the "14th Five-Year Plan" period [6].

To sum up, based on the shortcomings of research on diversified ecological compensation for water environment governance and in combination with the actual development background, this paper discussed the basic framework for establishing a diversified ecological compensation mechanism for water environment governance, clarifies the composition and responsibility sharing of multiple entities, compensation standards, and multiple compensation methods, and explored the experience and practices of attracting social entities to participate in practice and the realization path of market-oriented introduction of social capital [7-9], with a view to providing reference for scientifically promoting the construction of diversified ecological compensation mechanisms for water environment governance in Zhejiang Province.

2. Sample Characteristics and Descriptive Analysis

2.1. Basic Information of Survey Samples

The Beitang River is a major river channel that traverses the Binjiang and Xiaoshan districts of Hangzhou City, Zhejiang Province. It not only carries the main functions of water diversion and distribution, flood discharge, and shipping in the Binjiang and Xiaoshan districts but also witnesses the vigorous development of the social economy in the two districts. The Beitang River began excavation in December 1977. It starts from the Qiantang River drainage and irrigation station in the west and ends at Sanguanbu straight bay in Dangshan Town in the east. It has a total length of 20 km, a river surface width of 30 meters to 35 meters, and a riverbed height of 3.5 meters to 4 meters. It flows through eight town streets along the way, radiating a cultivated area of 600000 acres. The overall terrain of the Beitang River is high in the west and low in the east, with water flowing from west to east. There are several tributaries along the route, and 24 bridges are built along the whole route, which can pass 100 t class ships.

The field investigation and questionnaire survey of the Beitang River were conducted along the main stream of the Beitang River, from the source and the townships flowing through the upper, middle, and lower reaches. The sample selection was based on the shortest linear distance between the administrative villages of each township and the Beitang River, using a stratified sampling method. The field survey of the Beitang River Basin focused on investigating the water quality, water content, ecological environment, and industrial and agricultural production conditions in the surrounding areas; the questionnaire survey took stakeholders of ecological compensation in Beitang River as the respondents, covering their basic information, ecological compensation awareness, policy understanding, and participation, as well as participation needs, willingness to pay or receive compensation, and participation methods. The survey was taken in the form of "face to face" by entering the household, with the investigator giving a certain explanation before helping the interviewees or filling out the questionnaire by themselves. This survey visited more than 10 townships (towns) and sub-district offices in Changhe, Xixing, Chengbei, Changshan, Xinjie, Guangming, Kanshan, Guali, Changsha, Dangshan, etc. A total of 625 questionnaires were distributed and 616 valid questionnaires were returned, meeting the expected requirements.

The questionnaire first surveyed the basic characteristics of the interviewees, and the statistical data were shown in Table 1.

Туре	Option	Number of samples	Scale (%)
Sexuality	Male	345	56.01
	Female	271	43.99
Age	19-30	53	8.60
	31-40	132	21.43
	41-50	144	23.38
	51-60	168	27.27
	Above 60	119	19.32
Education level	Primary school and below	107	17.37
	Junior high school	180	29.22
	High school	151	24.51
	Bachelor degree	132	21.43
	Master's degree or above	46	7.47
Annual household income level	Up to 20000 yuan	20	3.25
	20000 yuan to 50000 yuan	84	13.64
	50000 yuan to 100000 yuan	199	32.31
	100000 yuan to 150000 yuan	164	26.62
	150000 yuan to 200000 yuan	104	16.88
	Above 200000 yuan	45	7.31
Career field	Student	35	5.68
	Farmer	89	14.45
	Individual business	139	22.56
	Staff and workers	230	37.34
	Personnel of government institutions	98	15.91
	Social organization personnel	25	4.06

Table 1. Basic characteristics of survey samples.

As can be seen from the table, among the 616 respondents, men accounted for 56.01%, slightly higher than women; 72.08% of them were aged between 30 and 60, which was in line with the reality of young and middle-aged people going out to work

in towns and rural areas; the education level was dominated by junior high school, technical secondary school, or high school, accounting for 53.73%, while those with a college degree or above account for 21.43%, and the respondents can better understand the content of the questionnaire; the proportion of households with annual income levels between 50000 yuan and 200000 yuan accounted for 75.81%; The occupational fields included farming, self-employed business, enterprise employees, government and public institutions personnel, and social organization personnel, accounting for 14.45%, 22.56%, 37.34%, 15.91%, and 4.06%, respectively. In addition, over 80% of the respondents lived within 2000 m of the Beitang River. Therefore, the data obtained in this survey were highly representative and reliable.

2.2. Analysis of the Current Situation of Ecological Environment in Beitang River

In July 2015, Xiaoshan District issued the "Beitang River Water Environment Management Plan" (one river, one plan), proposing the concept of "eco-managing rivers and highlighting culture", and continuously improving the quality of the water environment through water ecological treatment. In order to better maintain the governance achievements of the Beitang River and effectively enhance the sense of gain and happiness of the people in the two districts, Binjiang District and Xiaoshan District jointly drafted a framework agreement on "joint governance of the Beitang River basin" at the end of 2020, implemented the upgrading and reconstruction project for the Beitang River and its surrounding areas, and simultaneously developed ecological pollution interception, greening landscape, and cultural excavation. The quality of the Beitang River has been significantly improved. According to the water quality monitoring data of multiple monitoring sections of the Beitang River, all monitoring sections have reached the standard. The dissolved oxygen, potassium permanganate index, ammonia nitrogen, and total phosphorus of the Beitang River were about 6.0 mg/L to 8.0 mg/L, 3.0 mg/L to 4.6 mg/L, 0.31 mg/L to 0.39 mg/L, and 0.08 mg/L to 0.15 mg/L, respectively, stably meeting the requirements of Class III surface water quality standards. The appearance improvement of the Beitang River was shown in Figure 1.



Beitang River full of garbage

Beitang River after treatment

Figure 1. Comparison of Beitang River before and after treatment.

Of the 616 respondents, 57.32% believed that the ecological environment of the Beitang River has greatly been improved, 19.23% believed that there has been a significant improvement, 13.49% believed that there has been partial improvement,

5.09% believed that the improvement was very limited, and 4.87% believed that there was no improvement. Among them, respondents who believed that there was no improvement were mostly based on the evaluation of the tributaries of the Beitang River.

When asked about their satisfaction with the water quality of the Beitang River, 5.43% were very satisfied, 46.31% were relatively satisfied, 32.02% were generally satisfied, 12.36% were not very satisfied, and 3.88% were not satisfied. When asked about their satisfaction with the situation of the Beitang River, 7.08% of the people were very satisfied, 27.43% were relatively satisfied, 43.97% said they were generally satisfied, 17.09% were not very satisfied, and 4.43% were not satisfied, as shown in Figure 2. Overall, people's satisfaction with the water quality of the Beitang River was better than their satisfaction with the water content.





Figure 2. Respondents' satisfaction with the water quality and content of the Beitang River.

2.3. Policy Impact Analysis of Ecological Compensation in Beitang River

In a cognitive survey of the Beitang River ecological compensation policy, respondents had a low level of awareness of the concept of "multiple ecological compensations for water environment governance", with 25.74% saying they did not understand, 33.23% not quite understand, and only 27.01%, 11.84%, and 2.18% respectively expressing general, comparative, and very understanding.

In the survey conducted by respondents, only 11.13% of them knew about the Beitang River ecological compensation policy implemented in 2022, while 88.87% did not. These data indicated that although most respondents working and living around the Beitang River, they had a low level of awareness of the Beitang River ecological compensation that began to be implemented in 2022, which precisely validates the characteristics of the Beitang River upstream and downstream ecological compensation agreement as a government-led ecological compensation. How much to compensate, and how to compensate, as well as the ecological and environmental goals after implementing compensation, were all stipulated by the government. Suggestions from other stakeholders have not been widely sought. When compensating, special funds were also transferred and paid by upstream and downstream governments. There was a lack of publicity and mobilization of watershed ecological compensation policies, and the awareness and participation of other stakeholders were extremely low, failing to form a joint force of government, market, and social participation, which was precisely the problem that needs to be overcome in establishing a diversified ecological compensation mechanism for water environment governance.

2.4. Analysis of the Obstacles of Diversified Ecological Compensation in Beitang River

Based on the above analysis, the implementation of the Beitang River ecological compensation agreement has improved the ecological environment of the basin and gained recognition from stakeholders. However, some ecological and environmental issues still existed, and there were still certain obstacles to the operation of the ecological compensation mechanism. When it came to the causes of the problems. 55.31% of the 616 respondents believed that the government has not played an organizational and regulatory role, 13.15% believed that enterprises have not assumed corresponding social responsibilities, 15.37% believed that residents have not taken a high initiative in protecting the ecological environment, 11.06% believed that there was a lack of sustained and stable long-term ecological compensation mechanism, and 5.15% believed that the publicity and supervision of public opinion were insufficient, as shown in Figure 3. Therefore, to establish a diversified ecological compensation mechanism for water environment governance, it was necessary to play the role of the government as an organizational guide and regulator, enhance the social responsibility of enterprises, mobilize the enthusiasm of residents to participate in ecological compensation and environmental protection, coordinate various forces to jointly compensate, and form a long-term mechanism for ecological compensation for water environment governance [10-12].



Figure 3. The causes of ecological and environmental problems in Beitang River.

Regarding the implementation process of ecological compensation for water environment governance, 47.14% of respondents believed that legal system protection should be given the most attention, 25.37% believed that the most attention should be paid to whether compensation methods were suitable, 13.42% believed that the level of compensation standards was relatively important, and 14.07% believed that who compensates was the key. Therefore, the establishment of a diversified ecological compensation mechanism for water environment governance should reconstruct and establish a sound legal system to clarify the rights, responsibilities, and obligations of the compensation subject and object, allowed more stakeholders to participate in ecological compensation, achieved multi-channel compensation, and improved the efficiency of ecological compensation [13].

3. Analysis of Public Participation Willingness for Multiple Ecological Compensation in Beitang River

The eight variables that affect the public's willingness to participate were selected as explanatory variables, including gender, age, education level, family income level, the necessity of ecological governance, understanding of environmental protection policies, and the importance of ecological compensation. And the willingness to participate was defined as the dependent variable. The definition and expected action direction of each variable were detailed in Table 2.

Variable name	Variable definition		
Willingness to participate (y)	Unwilling=0		
winnighess to participate (y)	Willing=1		
Convolity (v.)	Male=1		
Sexuality (x_1)	Female=2		
	19-30=1		
	31-40=2		
Age (x_2)	41-50=3		
	51-60=4		
	Above 60=5		
	Primary school and below=1		
	Junior high school=2		
Education level (x_3)	High school=3		
	Bachelor degree=4		
	Master's degree or above=5		
	Up to 20000 yuan=1		
	20000 yuan to 50000 yuan=2		
Annual household income	50000 yuan to 100000 yuan=3		
level (x ₄)	100000 yuan to 150000 yuan=4		
	150000 yuan to 200000 yuan=5		
	Above 200000 yuan=6		
	Student=1		
	Farmer=2		
	Individual business=3		
Career field (x_5)	Staff and workers=4		
	Personnel of government		
	institutions=5		
	Social organization personnel=6		
	Uncalled-for=1		
NT '' C 1 ' 1	Not necessary=2		
Necessity of ecological	Indifferent=3		
governance (x_6)	Necessary=4		
	Quite necessary=5		
	None understanding=1		
	Not quite understanding=2		
Understanding of	General understanding=3		
environmental policies (x_7)	More understanding=4		
	Well understanding=5		
	Unimportant=1		
Immontance of c11	Less important=2		
approximation (r)	Indifferent=3		
compensation (x_8)	Important=4		
	Very important=5		

Table 2. Variable definition.

Logit econometric model is used to study the selection process of behavioral

agents, and its regression analysis model is an ideal model for analyzing individual decision-making behavior and influencing factors [12]. The functional form of the Logit model is as follow:

$$y = F(\alpha + \sum_{j=1}^{n} \beta_j x_{ij}) = \frac{1}{1 + e^{-(\alpha + \sum_{j=1}^{m} \beta_j x_{ij})}}$$
(1)

where y represents the willingness of the public to participate in ecological compensation for water environment governance, x_{ij} represents the *j*th explanatory variable that affects the public's willingness to pay for ecological compensation for water environment governance, β_j represents the regression coefficient of the explanatory variable, *n* represents the number of explanatory variables, and α is a constant term.

Stata17.0 statistical software was used for performing logit regression on the data, and the results were shown in Table 3. The regression results and analysis were as follows: (1) The age of the public (x_2) was significant at the level of 1%, and the coefficient was positive, indicating that the younger the age, the more willing they were to pay a certain fee for ecological environment protection. (2) The household income level (x_4) , the awareness of the necessity of ecological governance (x_6) , and the awareness of the importance of ecological compensation (x_8) were significant at the levels of 1%, 5%, and 1%, respectively, with a positive coefficient, indicating that the higher the household income level, the more necessary ecological governance, and the more important ecological compensation was, the stronger the willingness of the public to pay a certain fee for the ecological services of the Beitang River governance. (3) The gender (x_1) coefficient of the public was negative, indicating a negative impact on willingness to participate. The coefficients of public education (x_3) , professional field (x_5) , and understanding of environmental policies (x_7) were positive, indicating a positive impact on participation willingness, but none of them passed the significance test.

Explanatory variable	Coefficient	Standard error	Z-value	P> Z
Sexuality (x_1)	-0.107	0.154	0.31	0.437
Age (x_2)	-0.438***	0.007	-6.23	0.000
Education level (x_3)	0.079	0.112	0.79	0.419
Annual household income level (x_4)	0.216***	0.041	5.27	0.000
Career field (x_5)	0.337	0.769	0.39	0.643
Necessity of ecological governance (x_6)	0.218**	0.083	2.47	0.014
Understanding of environmental policies (x_7)	0.735	0.071	0.89	0.326
Importance of ecological compensation (x_8)	0.259***	0.088	2.86	0.004

Table 3. Regression results of logit model.

Note: The superscripts ***, **, and * indicate a significance level of 1%, 5%, and 10%, respectively.

Main conclusions and inspiration: based on a questionnaire survey of 616 members of the public in Beitang River, this article empirically analyzed the influencing factors of public participation willingness using the logit model on the basis of statistical analysis. The research results showed that 78.08% of the public was willing to pay a certain fee for the ecological protection of the Beitang River basin. The public's age,

family income level, awareness of the need for ecological governance, and awareness of the importance of ecological compensation affected the public's willingness to participate to a certain extent. Specifically, the younger you were, the higher your awareness and need for ecological protection, and the stronger your willingness to pay. The higher the household income level, the more willing they were to pay a certain fee for a high-quality ecological environment in the expenditure structure. The more necessary ecological governance was, the more urgent the demand for ecological services became, and the stronger the willingness to pay. The more important it was to consider ecological compensation, the stronger its desire to pay a certain fee to participate in ecological compensation, and the greater public participation. Therefore, in the process of coordinating the participation of multiple entities in ecological compensation, it was necessary to increase the publicity of diversified ecological compensation policies, so as to make the public aware of the need for ecological protection and governance. Through social public organizations, it was important to focus on raising public welfare funds for ecological compensation for people with relatively high household income levels [14-16].

4. Breakthrough Path of Diversified Ecological Compensation Dilemma in Beitang River Governance

The essence of diversified ecological compensation is to effectively absorb the participation of other beneficiary market entities and social public organizations while implementing the government's ecological compensation responsibilities to promote the transformation of government public financial compensation, and social compensation through coordinating the interests and responsibilities of multiple entities. The transition from a simple "transfusion type" compensation to a comprehensive "hematopoietic type" compensation should be adapted to the long-term, systematic, and comprehensive characteristics of ecological protection, and forming a prolonged, stable, and inclusive ecological compensation long-term mechanism [17-20].

From the above analysis, it can be seen that there were still certain problems in the operation of the diversified ecological compensation mechanism of Beitang River, especially in the sharing of the main responsibilities of the government and enterprises, and society, and the construction of a sustainable and stable long-term ecological compensation mechanism. Based on relevant domestic and foreign experience, the following suggestions for breaking through the plight of the Beitang River's diversified ecological compensation are proposed.

4.1. Determination of the Relationship between Government, Market, and Society

In a diversified ecological compensation system, the key to the transformation of the role of the government lies in a reasonable definition of the boundaries of the government's role, so that it can do something and not do something. When promoting the ecological compensation system, it is neither absent nor offside. The government should transform its past leading role into a guiding role. From a specific perspective, the guiding role of the government should be reflected in four aspects, namely, political support, legal and policy supply, financial support, audit, and supervision [21].

The market is a key force in diversified ecological compensation mechanisms. To

play the key role of the market in the ecological compensation system, breakthroughs can be made in both market entities and transaction models. Society should become the supervisor and active participant in ecological compensation. Society mainly refers to residents and social organizations [22].

In the practice of diversified ecological compensation for the governance of the Beitang River, the governments of Xiaoshan District and Binijang District of Hangzhou City should play a guiding role in ecological compensation within the region, coordinate ecological compensation related work across regions, and coordinate the allocation and management of ecological compensation funds under the guidance of public policies for ecological environmental protection in Zhejiang Province, such as "Five Water Treatment", "Thousand Villages Renovation and Ten Thousand Villages Demonstration", and "Beautiful Countryside". At the level of neighborhood and village committees, the governments should actively mobilize resources at the corresponding level, and coordinate social organizations and the masses to participate in the project. Residents and social organizations can, on the one hand, monitor the fairness of bidding between the government and market companies through telephone, email, and active participation, provide opinions on the formulation of environmental compensation policies, and evaluate the effectiveness of ecological compensation. On the other hand, market-based means (such as investment), socialized means (such as donations), and public-private cooperation means (such as government and social capital cooperation) can be used to participate in ecological compensation.

4.2. Constructing a Diversified Ecological Compensation Operation Mechanism for Environmental Governance of the Beitang River

Guide market entities, social organizations, and citizens to participate in the construction of ecological compensation to achieve vertical and horizontal coordination among the government, market entities, and social public organizations. Promote the diversified transformation of ecological compensation for environmental governance of the Beitang River truly, and build a diversified ecological compensation operation mechanism for water environmental governance, as shown in Figure 4.



Figure 4. Diversified ecological compensation operation mechanism for the Beitang River governance.

The core of the government guidance mechanism is to play the role of the government as a guide in the multiple ecological compensation mechanism for water environment governance and to play a fundamental role in ensuring and supporting social participation mechanisms, market operation mechanisms, communication and connection mechanisms, scientific management mechanisms, and system operation mechanisms. In the government guidance mechanism, the government mainly promotes the ecological compensation construction of the entire river basin through policy support, financial security, coordinated management, publicity, and education.

The market operation mechanism aims to actively stimulate the vitality of market entities, adopt market-oriented ecological compensation methods, give full play to the role of market entities, and solve the problems of ecological environment damage and unreasonable allocation of ecological resources in the water environment through ecological resource market transactions. The application of market-oriented means of ecological compensation can be considered from the following aspects: first, developing new industries such as green agriculture, green industry, and green service industry; the second is to establish a water rights trading system and implement water rights trading; third, exploring green financial models such as water funds.

The social participation mechanism promotes the conscientization of multiple ecological compensations for water environment governance and improves the efficiency of ecological compensation by guiding social organizations, the public, and other social entities to participate in ecological compensation for water environment governance, providing financial and intellectual support in ecological compensation, and playing the role of external supervision in the field of supervision and feedback.

The communication and connection mechanism aims to improve communication channels and establish communication and exchange platforms, promote consultation and exchange between regions and various entities, eliminate the phenomenon of information asymmetry among all parties involved in ecological compensation for water environment governance, and play a role of communication and connection in ecological compensation for water environment governance.

The system operation mechanism refers to the overall design and arrangement of the related work and key project operation in the multiple ecological compensations for water environment governance from the perspective of systems science, which is embodied in the realization of the allocation of related resources for ecological compensation for water environment governance and the establishment of a complete water environment pollution prevention and control, ecological restoration, and disaster management system. The entire system operation mechanism relies on government management departments at all levels involved in water environment governance and ecological compensation to achieve systematic linkage operation of resource allocation, pollution prevention and control, ecological restoration, and disaster management throughout the entire basin.

Scientific management mechanism refers to the use of advanced management techniques and means under the guidance of advanced management concepts to achieve scientific management of ecological compensation for water environment governance, assist in supporting the efficient operation of multiple ecological compensation mechanisms for water environment governance, and promote the scientific construction of ecological compensation for water environment governance. The application of scientific management mechanisms in ecological compensation for water environment governance is mainly reflected in the following three aspects: information collection, emergency feedback, and dynamic supervision [23-26].

5. Conclusion

At present, there are still some problems in the operation of the Beitang River's diversified ecological compensation mechanism, especially in terms of the main responsibility sharing among the government, enterprises, and society, and the construction of a sustainable and stable long-term ecological compensation mechanism. To establish a long-term mechanism for diversified ecological compensation for water environment governance, it is necessary to play the role of the government as an organizational guide and regulator, enhance the sense of social responsibility of enterprises, mobilize the enthusiasm of residents to participate in ecological compensation, scientific management, and systematic operation among the government, market, and society.

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