



Theoretical Origins, Practical Experience, and Policy Recommendations of Watershed Ecological Compensation

Yongliang XU

China Institute of Geo-Environment Monitoring, Beijing 100081, China

E-mail: xyongliang@163.com

Abstract. With the rapid development of the economy and society, environmental issues have become increasingly prominent. The establishment and improvement of watershed ecological compensation mechanisms are of significant importance in promoting integrated watershed management, enhancing watershed environmental protection, and advancing the construction of an ecological civilization that fosters harmonious coexistence between humans and nature. This paper attempts to analyze the fundamental connotations of the concept of watershed ecological compensation from different perspectives. It explores the stages of its theoretical development, conducts a comprehensive analysis of existing watershed ecological compensation models and methods for setting compensation standards, and, based on China's practical experience in watershed ecological compensation, identifies the existing issues within the watershed ecological compensation mechanism. Furthermore, the paper proposes recommendations for the enhancement of China's watershed ecological compensation mechanism.

Keywords: construction of ecological civilization; watershed ecological compensation; policy recommendations

1 Introduction

Ecological compensation aims to comprehensively regulate the interests of relevant stakeholders through economic means to achieve ecological environmental protection and promote the sustainable development and utilization of ecosystems ^[1]. As an important branch of ecological compensation, watershed ecological compensation serves as a policy tool and management mechanism for regulating the relationship between the environment and the economy. It plays a crucial role in resolving conflicts of interest among different regions within a watershed and achieving a coordinated and healthy development of the "economy-society-ecology" in the watershed. Consequently, examining the key content and connotation extension of watershed ecological protection in academia, and reviewing related theoretical developments and practical research, can not only promote the development of

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watershed ecological compensation but also steadily advance the pace of ecological civilization construction. This research holds significant theoretical value and practical significance.

2 Concept of Watershed Ecological Compensation

The nationwide and regional attributes of ecological environments are important features that distinguish them as public goods or services from other market products. Ecological compensation is a concept that has emerged from the interdisciplinary integration of disciplines such as ecology, environmental science, and economics [2]. Watershed ecological compensation involves multiple disciplinary domains, including ecology, water resources, resource and environmental economics, environmental hydraulics, management, and law [3]. Due to differences in disciplines, knowledge backgrounds, and research perspectives, scholars have different understandings of watershed ecological compensation, resulting in variations in its connotations.

Ecological compensation relies on the support of pricing ecological products in the market, and ecological foundations and economic foundations are two important theoretical bases for market-based pricing of ecological products. Watershed ecological compensation, utilizing specific resources as carriers, effectively addresses compensation issues caused by economic imbalances among different regions within a watershed. It is an important economic method for reconciling the interests of upstream and downstream stakeholders in the watershed due to real activities, and it is also an economic method that can promote ecological environmental protection and ensure fair and equitable benefit distribution [4-5]. From a legal perspective, watershed ecological compensation aims to restore and enhance the ecological functions of ecosystems. It involves the imposition of charges by the state on developers who exploit natural resources and damage the ecological environment, as well as economic and non-economic compensation from beneficiaries of ecological services who make special sacrifices to improve ecological service functions [6]. From a policy perspective, ecological compensation aims to promote harmonious development between humans and nature. It is based on the costs of ecological protection and the value of ecological services, and it employs government and market mechanisms to mediate the interests of stakeholders involved in ecological protection [7-12]. The aforementioned concepts encompass the purpose, scope, subjects, and methods of ecological compensation. However, due to differences in disciplinary backgrounds and perspectives, variations in their connotations exist.

3 Watershed Ecological Compensation Models and Standards

3.1 Watershed Ecological Compensation Models

The watershed ecosystem, as a public good, is characterized by externalities and asymmetry, which to some extent constrain the effective allocation of this resource in the market. Currently, in China's ecological compensation, the government-led public

payment compensation model remains dominant. The government, through the formulation of laws, regulations, institutional arrangements, provision of projects, and policy funding support, utilizes means such as transfer payments and fiscal subsidies to regulate the relationship between different resource users. The aim is to align the rights and obligations of ecological protection investors and beneficiaries, thereby achieving the goal of ecological environment protection. This watershed ecological compensation model can typically be divided into three stages: the fundraising stage, which involves raising funds through tax collection; the payment stage, which provides project funding compensation through fiscal transfers; and the allocation stage, which ensures the effective implementation of compensation schemes according to procedures and compensation standards. Taking the Minjiang River Basin ecological protection as an example, the Fuzhou government provides an annual subsidy of 5 million yuan to the governments of Sanming and Nanping to address water pollution issues and ensure water quality standards are met. According to the comprehensive governance plan for the watershed's ecological environment, river water quality is dynamically monitored and compared with assessment indicators to conduct comprehensive evaluations. Compensation standards for upstream cities are calculated based on pollution compensation factors for out-of-city sections. Due to the difficulty in clearly defining property rights for natural resources in the watershed, the ambiguity and decentralization of their interests make it challenging to fully leverage market mechanisms. Currently, the government-led watershed ecological compensation model still dominates in China, while market compensation mechanisms are still in the exploratory stage ^[12-15].

3.2 Watershed Ecological Compensation Standards

The research and practice of watershed ecological compensation are still in the nascent stage, and there is insufficient legal basis to support the determination of the scope of compensation subjects, compensation standards, and other aspects. Currently, the calculation methods for widely recognized watershed ecological compensation standards primarily revolve around three dimensions: input costs, environmental benefits, and compensation willingness. (1) At the level of input costs, calculations are based on the overall cost of the ecological environment ^[16]. The input costs mainly encompass direct costs, opportunity costs, and compensation for the interests of the affected population. Direct costs primarily refer to the management of watershed water resources, water pollution control, costs of ecological migration, and other expenses. Opportunity costs refer to the value losses incurred due to the restriction of agricultural production and industrial development in the upstream watershed, as well as the loss of benefits resulting from the impact on ecological construction projects such as public welfare forests and nature reserves. (2) At the level of environmental benefits, calculations primarily rely on the assessment of the value of ecosystem services provided by the watershed, thereby facilitating the "monetization" of ecosystem services ^[17]. For instance, in the case of Lake Mangco in Tibet, the overall economic value of watershed ecosystem services is directly calculated based on the unit price of ecosystem services within the respective

ecological region ^[18]. (3) At the level of compensation willingness, questionnaire surveys are commonly conducted to determine the maximum amount residents are willing to pay or the minimum compensation they expect to receive ^[19]. In conclusion, the key to achieving the objectives of ecological compensation lies in the identification and analysis of compensation subjects and recipients, as well as the establishment of scientifically rigorous and operationally feasible compensation standards.

4 Experience in Watershed Ecological Compensation

4.1 Government Compensation Practices

watershed ecological compensation is primarily implemented by the government through vertical transfer payments. This government-led approach, where the government bears the cost of compensation, indicates its dominant role in ecological compensation. Relatively speaking, this compensation method is relatively simple to implement and highly feasible.

"Jiangxi Model" of Beautiful China

In order to further improve and enhance the ecological environment of watersheds in Jiangxi Province and ensure ecological balance in the middle and lower reaches of the Yangtze River, Jiangxi Province has fully utilized its financial functions, coordinated financial resources, and established innovative mechanisms. It has taken the lead nationally in adopting a new approach to watershed ecological compensation characterized by "vertical coverage and horizontal multilevel" and has created the distinctive "Jiangxi experience" of watershed ecological compensation [20]. To protect the ecological security of the entire watershed in Jiangxi, the provincial finance department considers the five major rivers and Poyang Lake as an integrated whole. They promote the overall governance of the entire watershed through the "Five Rivers, Two Banks, One Lake, One River" approach. Based on the overall principle of "polluter pays and beneficiary compensates," at the provincial level, they have established a compensation mechanism for ecological restoration of surface water sections, with horizontal compensation at the city level as the main component and vertical compensation at the provincial level as a supplement, to ensure that clean water flows from the lake into the Yangtze River [21].

Yellow River Basin Ecological Protection Mechanism

In recent years, rapid economic and social development in the Yellow River Basin has led to persistent issues such as water resource scarcity, severe environmental pollution, and fragile ecological environment, which have not been fundamentally transformed ^[22]. The pursuit of Chinese-style modernization has placed new demands on the ecological compensation mechanism in the Yellow River Basin, requiring the construction of a comprehensive watershed ecological compensation mechanism with product value as the main consideration, achieving upstream-downstream benefit

sharing, product mutual assistance, and cost sharing [23]. Provinces (autonomous regions) in the Yellow River Basin have actively engaged in cooperation and created a cross-provincial ecological compensation model known as "sharing, governance, and sharing" across the entire basin. For instance, preliminary horizontal ecological protection compensation mechanisms have been established separately by Shandong Province and Henan Province, as well as Sichuan Province and Gansu Province, along the main stream of the Yellow River, yielding certain results. An example is the "Yellow River Basin (Yulu Section) Horizontal Ecological Protection Compensation Agreement" signed between Shandong Province and Henan Province, which uses water quality standards as an indicator to evaluate the effectiveness of water pollution prevention and control in upstream provinces. Based on the water quality at the Liu Zhuang national control section, if the annual average falls within the standard category, no compensation is exchanged between the two provinces. If the annual average water quality exceeds the standard by one category, Shandong Province provides Henan Province with a compensation fund of 60 million yuan. Conversely, if the water quality is one category below the standard, Henan Province compensates Shandong Province with 60 million yuan.

4.2 Market Compensation Practices

The market compensation model originates from the commodification concept of ecosystem services [24]. It refers to a voluntary compensation mode achieved between the resource protectors and beneficiaries in the upstream and downstream of a watershed under government guidance. Market-based compensation involves multiple entities such as downstream governments, individuals, enterprises, and social organizations. The compensators are the direct beneficiaries who enjoy high-quality ecosystem services in the watershed, while the compensated are the upstream governments, farmers, and relevant resource-conserving enterprises who directly provide ecosystem services in the watershed.

Water Rights Trading in Zhangye Area of Gansu-Heihe River Basin

Zhangye City in Gansu Province is located in the middle reaches of the Heihe River Basin, serving as the primary water source for local residents' domestic and industrial water use. However, the development and utilization of water resources in the Heihe River Basin have resulted in a series of prominent conflicts in Zhangye City, such as unclear water rights, water overuse, and water scarcity. To address these issues, Zhangye City implemented the "water rights ticket system." Water consumers pay water tickets to water management units based on their water rights certificates, and water management units supply water in exchange for these tickets. Surplus water tickets can be mutually traded at a mutually agreed price. Water tickets serve as a comprehensive carrier of water rights, quantity, and price, becoming a channel connecting the government, farmers, and the market, reflecting the usage rights, operational rights, and transaction rights of water users [25]. The water rights trading model in Zhangye City is an exploration and innovation of the watershed ecological

compensation system based on water rights property theory, combined with regional characteristics. It enables the rational allocation of ecological and environmental resources in the watershed, promoting the optimization of the city's industrial structure and economic development.

Cross-Regional Water Rights Trading between Dongyang and Yiwu in Zhejiang Province

After five rounds of negotiations, Dongyang and Yiwu in Zhejiang Province officially signed the "urban water rights transfer" agreement. The agreement clearly stipulates the rights and obligations of both parties. Water-rich Dongyang City transferred the permanent use rights of 49.999 million cubic meters of water from its Hengjin Reservoir to water-scarce Yiwu City for a price of 200 million yuan. Yiwu City pays a comprehensive management fee of 0.1 yuan per cubic meter of water supplied annually [26]. The water rights trading between Dongyang and Yiwu is a typical practice in China that utilizes a market-based approach for ecological compensation in watersheds. This water rights trading model requires analyzing the actual ecological and economic conditions of both areas, clarifying their supply-demand relationship, and using the market's role to allocate watershed water resources reasonably and scientifically, achieving the rational utilization of water resources. The successful implementation of this project not only greatly alleviates Yiwu City's water shortage problem but also maximizes the development of water supply capacity from Dongyang's reservoir.

5 Existing Issues in Ecological Compensation Mechanisms

Currently, nationwide efforts related to watershed ecological compensation have been progressing well and have achieved certain effectiveness. However, due to the involvement of various factors such as ecological security, stakeholders' interests, compensation vehicles, compensation scope, and standards, there are still many pressing issues that need to be resolved regarding legislative systems, public participation, and measures and mechanisms in watershed ecological compensation.

5.1 Need for Improvement in Legislative Systems

The establishment of a watershed ecological compensation mechanism holds significant significance for improving China's ecological environment. However, both at the national and local levels, there is an issue of inadequate legislation. Presently, the watershed ecological compensation mechanism in China primarily relies on government compensation, lacking comprehensive laws, regulations, and compatible systems. Although some provinces have made beneficial explorations in horizontal compensation system development, the lack of top-level design results in agreements lacking unified principles and standards, limiting their operational feasibility. Particularly in the case of cross-regional watershed ecological compensation, most local laws pertaining to watershed ecological compensation are specific to their

respective regions and lack comprehensive legal regulations for watershed ecological compensation mechanisms, thus lacking joint legislation across regions [27-28]. Insufficient legislation leads to fewer institutional norms for watershed ecological compensation, coupled with a lack of robust legal safeguards, resulting in perpetrators of ecological environmental damage harboring a sense of impunity and making it difficult to protect the rights and interests of ecological compensation beneficiaries. These factors hinder the development of the watershed ecological compensation mechanism and fail to meet the current requirements of environmental protection.

5.2 Lack of Foundation for Citizen Participation

In the process of establishing and developing watershed ecological compensation mechanisms, the government plays a dominant role, while the role of public participation mechanisms is not sufficiently evident. On one hand, there is inadequate emphasis by the government on public participation, with ineffective government propaganda and guidance. Citizens have limited knowledge of ecological issues concerning their own interests, and corresponding mechanisms for citizen participation have not been established. On the other hand, as environmental protection is a long-term endeavor, citizens may not immediately perceive the impact of environmental protection on the regions they inhabit. This results in low willingness among citizens to participate in watershed ecological compensation practices and a lack of interest in ecological compensation. Additionally, due to differing understandings of ecological compensation among various stakeholders, significant disparities exist in rights, obligations, and opinions regarding compensation methods related to water resources development, utilization, and protection. This impedes the establishment of effective negotiation mechanisms.

5.3 Insufficient Regulatory Framework

In China's watershed ecological compensation, there are situations where multiple departments simultaneously manage, cross-manage, or excessively involve various authorities, leading to unclear effectiveness of watershed ecological compensation [29]. The management framework for watershed ecological compensation is inadequate, and coordination between regions and departments is insufficient, resulting in a failure to implement specific provisions of the management framework. This is primarily manifested in the following aspects: First, there is a lack of horizontal consultation mechanisms among governments within the watershed, making it difficult to achieve efficient and effective communication and cooperation. Municipal and county governments within the watershed, driven by their own interests and short-term benefits, often result in wastage of resources such as manpower, finances, and materials in policy implementation. Second, there is ambiguity in the functional positioning and unclear rights and responsibilities of various management agencies, a lack of systemic, holistic, and comprehensive perspectives, and coexistence of multiple management systems. This hampers the overall effectiveness of integrated watershed governance.

6 Strategies and Recommendations

Constructing and improving the watershed ecological compensation mechanism aims to effectively alleviate the contradictions faced by upstream and downstream stakeholders in ecological conservation and economic development within the watershed, and to establish institutional arrangements to achieve "win-win" outcomes and promote coordinated development within the watershed ^[30]. Based on existing theories, practical experience, and identified deficiencies, the following strategies and recommendations are proposed.

6.1 Enhancing the relevant laws and regulations for watershed ecological compensation

China's construction of laws and regulations regarding watershed ecological compensation lags behind and has not yet formed a relatively comprehensive legal framework. It is necessary to conduct in-depth research on the theories and methodologies of watershed ecological compensation, absorb research findings from domestic and international scholars, and combine them with the national context to construct policies, mechanisms, and measures at the implementation level. Firstly, there is a need to improve China's Environmental Protection Law. Although the latest revision of the Environmental Protection Law explicitly recognizes the importance of watershed ecological compensation and establishes ecological redlines to ensure sustained and effective ecological conservation ^[31], the provisions of the law are relatively abstract and do not consider specific practical situations, resulting in difficulties in implementation. Therefore, it is possible to address the shortcomings of the law by formulating corresponding legal interpretations, guidelines, etc., to define the specific content of watershed compensation, thereby remedying the deficiencies of the law and providing legal guarantees for practical work. Secondly, due to different understandings among regions regarding the subjects and objects of watershed ecological compensation, as well as the allocation of funds and technologies, differentiation arises in watershed ecological compensation. It is necessary to clarify the division of powers between watershed management institutions and local water resources management departments, coordinate national legislation and local legislation, and coordinate and promote legislation on watershed ecological compensation in various regions of China, minimizing conflicts and contradictions as much as possible.

6.2 Establishing a Mechanism for Citizen Participation in Watershed Ecological Compensation

Citizen participation is a crucial element in environmental governance, and the implementation of watershed ecological compensation in our country relies on the support and supervision of citizens. Active citizen participation is particularly needed, and it is essential to establish a sound mechanism for citizen engagement. Firstly, government departments need to ensure citizens' right to environmental information.

Various methods such as online platforms and public notices can be utilized to communicate the practical aspects of watershed ecological compensation to citizens, thereby further expanding the dissemination of relevant information on watershed ecological compensation. Secondly, it is necessary to standardize forms of citizen participation and establish a comprehensive system for public oversight and evidentiary requirements. This will ensure that citizen engagement goes beyond superficial forms and actively and effectively involves them in the practice of ecological compensation. Thirdly, through diverse promotional activities, citizens' understanding of ecological compensation should be deepened, and their comprehension of the work related to ecological compensation should be enhanced, making them aware of the immediate relevance of ecological compensation to their own interests. Additionally, it is encouraged to support community organizations in forming environmental knowledge dissemination groups, fostering a favorable environment throughout society that facilitates the advancement of watershed ecological compensation work and promotes the sustainable development of the watershed.

6.3 Strengthening the Coordinated Regulatory Mechanism for Watershed Ecological Compensation

The construction of the watershed ecological compensation mechanism relies on the scientific and systematic nature of the management system. Its core content involves the rational and appropriate delineation of the authority scope of the management institutions, as well as their supervision and coordination ^[32-36]. Firstly, it is crucial to clarify the responsibilities and powers of the management authorities through legally established norms, ensuring a clear division of authority and establishing management institutions within cross-regional management areas. This facilitates mobilizing relevant personnel responsible for various watersheds and establishing a coordinated resource allocation management institution to effectively address ecological conservation efforts across the entire watershed. Secondly, to a certain extent, it is necessary to expand the relevant management authority for watershed ecological compensation. By granting appropriate powers to the management institutions through legislative measures and other means, rights, functions, and management effectiveness can be defined. This encompasses not only the aspects of watershed ecological construction and restoration but also the overall improvement of the watershed's ecological system. Thirdly, it is essential to establish a systematic management framework among different regions, clearly defining the management powers and obligations of each region and strengthening the vertical and horizontal linkages. This facilitates the systematic development of watershed ecological compensation management.

7 Conclusion

As a geographically distinct unit that spans multiple administrative regions, the study of watershed ecological compensation mechanisms is closely related to various aspects such as economics, society, and the environment. The concept of watershed ecological compensation varies in ecological economics, law, and policy studies, encompassing its objectives, scope, stakeholders, and implementation methods. Throughout the evolution of research in the field of watershed ecological compensation, the theoretical foundation has been extended both in breadth and depth. The predominant approach to watershed ecological compensation is government-led, employing financial transfers as a means of compensation. It involves the standardized calculation of investment costs, environmental willingness, and compensation willingness from three dimensions. The combination of government-led initiatives and market-oriented approaches within a region has provided valuable insights for the enhancement and refinement of ecological watershed compensation mechanisms. However, in China, there still exist certain gaps in the legislative system, public participation, and regulatory aspects of ecological watershed compensation mechanisms. Further efforts are needed to improve the relevant legal and regulatory frameworks, establish robust citizen participation mechanisms, and enhance the integration of watershed and regional management systems and mechanisms.

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