Discussion on the Basic Theory, Compensation Standards, and Regulatory Progress of Ecological Compensation

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Abstract. As an important means of promoting coordinated progress between ecological civilization construction and socio-economic development, ecological compensation can not only significantly improve the quality of the ecological environment to a certain extent, but also achieve sustainable socio-economic development. By exploring the concept and theory of ecological compensation, exploring ecological compensation standards in different fields, and exploring the current status of ecological compensation policies and laws, the core ideas and implementation principles of ecological compensation were elucidated. The research progress of ecological compensation calculation methods and systems in different sub fields (natural reserves, watershed ecology, and forests) was elaborated, and the existing problems of ecological compensation related policy systems and laws and regulations were analyzed, To provide effective references for subsequent theoretical research and work practice.

Keywords: Ecological compensation; Theoretical basis; Compensation standards; Comprehensive research; overview

1 Introduction

Global environmental pollution, ecological degradation, and resource scarcity have emerged as profound challenges that severely impact the prospects of socio-economic sustainability [1-9]. In response to these challenges, ecological compensation has gained widespread recognition as an effective economic and policy instrument [10-13], adopted on a global scale [14-16]. The core objective of ecological compensation is to integrate the value of ecological environments and natural resources into economic calculations, incentivizing enterprises and individuals to undertake proactive measures that offset the adverse consequences resulting from human activities on the natural environment and ecosystems. This approach plays a pivotal role in achieving a harmonious relationship between economic development and ecological preservation, thereby fostering global sustainable development [17-20]. Consequently, ecological

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compensation has emerged as a significant measure and pathway for the international community to collectively address global environmental issues.

Ecological compensation, as a method aimed at safeguarding and enhancing ecological environments by offsetting losses incurred during economic activities, has been widely implemented and yielded significant outcomes in developed nations. In contrast, China's scientific research and practical application in the field of ecological compensation started relatively late, but the country has since embarked on proactive exploration and implementation efforts [11-24]. With China's rapid socio-economic development and the growing environmental consciousness among its populace, ecological compensation has emerged as a pivotal agenda item. To advance the research and practical implementation of ecological compensation, it is imperative to draw upon the research accomplishments of both domestic and international scholars and experts, actively explore the future developmental trajectory of ecological compensation, and provide guidance and a reference framework for the establishment and implementation of ecological compensation mechanisms in China.

2 Basic Concept and Theoretical Foundation

As the process of globalization intensifies, the degree of cooperation and synchronization in economic and social development among different nations deepens. However, owing to substantial variations in economic development levels and cultural paradigms among countries, it becomes imperative to systematically explicate the fundamental concepts and theoretical underpinnings of ecological compensation. Such an undertaking assumes paramount academic and practical significance, as it fosters the scientific advancement of research and implementation endeavors in ecological compensation.

2.1 Conceptual Definition

Ecological compensation entails a system arrangement wherein conditional payments are made to providers of ecosystem services as a means to safeguard the ecological system. This concept gained widespread attention and discussion during the 1960s, referred to as "payment for environmental services" within scholarly discourse. Scholars abroad have predominantly classified their understanding of ecological compensation into three distinct types. The first type aligns with Coase's theory and defines ecological compensation as a voluntary transaction between environmental protectors and beneficiaries, intended to redress the costs associated with environmental preservation. Ecological compensation is viewed as an incentivizing measure designed to encourage the provision of ecosystem services. Successful implementation of an ecological compensation system necessitates the consideration of factors such as institutional diversity and the concept of additionality. The second type aligns with Pigouvian theory and broadens the definition of ecological compensation to encompass resource transfers among members of society, with the objective of incentivizing natural resource management and fostering land-use

decisions that align with societal interests. The third type encompasses viewpoints derived from other theoretical studies, defining ecological compensation as a transparent institutional framework that acquires supplementary ecosystem services through conditional payments made to voluntary participants engaged in providing ecosystem services. Ecological compensation must exhibit four essential characteristics: transparency, voluntariness, conditionality, and additionality. Thus, ecological compensation represents a significant institutional arrangement that facilitates the promotion of sustainable socio-economic development through incentivizing the conservation of natural resources. A comprehensive understanding of the definition of ecological compensation and its associated theoretical foundations paves the way for further comprehensive research and the refinement of ecological compensation mechanisms.

As a crucial instrument for ecological environmental governance and sustainable development, ecological compensation exhibits diverse definitions within the domestic context. On the one hand, the domestic definition of ecological compensation can be broadly categorized into two main types: narrow ecological compensation and broad ecological compensation. Narrow ecological compensation refers to the compensation, restoration, and remediation of damages inflicted upon ecosystems and natural resources, aimed at addressing behaviors that squander resources and degrade the environment [25]. Broad ecological compensation encompasses the narrow definition and further includes compensating residents who have foregone development opportunities due to environmental protection efforts, be it through financial, technological, or material means. The objective is to enhance residents' environmental awareness and ultimately achieve environmental protection [26]. This definition reflects the growing environmental consciousness and the demand for ecological civilization construction in China, emphasizing the social value and environmental benefits associated with ecological compensation.

On the other hand, the definition of ecological compensation in China can be elucidated from the perspectives of economic instruments and punitive measures. From an economic instruments perspective, ecological compensation is defined as charging or compensating for actions that harm or protect ecological and natural resources, with the aim of increasing the costs or benefits associated with such behavior. This approach seeks to stimulate a reduction or increase in harmful or protective actions, thereby achieving the objectives of environmental protection and resource conservation [27-29]. This definition emerges from an economic viewpoint on ecological environmental issues, emphasizing the economic significance and environmental benefits of ecological compensation.

From the perspective of punitive measures, ecological compensation is defined as the utilization of specific punitive methods to enhance ecological environmental quality, address the imbalance between ecological protection and economic development, and serve as a significant means of environmental governance. This definition arises from the synthesis of practical experiences in environmental governance, highlighting the significance of the rule of law and the environmental benefits of ecological compensation.

Therefore, as an eminent instrument for environmental governance and sustainable development, the diversity in the definition of ecological compensation reflects its utmost significance and intricate nature across diverse domains and disciplines. Comprehending and amalgamating the distinct characteristics and merits of these definitions assume paramount importance in the scientific and efficacious advancement of establishing and implementing ecological compensation mechanisms. Hence, ecological compensation serves as a pivotal policy instrument that is geared towards safeguarding, ameliorating, and rehabilitating the ecological milieu. It necessitates the reformation of economic interest allocation systems pertaining to individuals and collectives, wherein perpetrators of environmental degradation are obliged to provide suitable redress to environmental custodians or beneficiaries based on well-defined ecological compensation standards. Through this course of action, the policy endeavors to rectify the multifaceted losses incurred and bridge the disparity resulting from their actions.

2.2 Theoretical Foundations

From the perspective of public goods theory, ecological compensation can be viewed as a form of public good due to its non-rivalrous and non-excludable characteristics. Natural resources and ecosystems, being public goods, possess value that extends beyond market transactions and significantly impacts overall societal well-being. However, the costs associated with conserving and restoring natural resources and ecosystems are often borne by specific collectives or individuals, without necessarily receiving equitable societal recognition for their efforts. Consequently, governments can establish ecological compensation policies to provide recompense to these contributors, ensuring the provision of public goods related to natural resources and ecosystems while enhancing overall societal welfare.

From an externality theory standpoint, ecological compensation can be seen as a means to address negative externalities. Conservation and restoration efforts related to natural resources and ecosystems have positive effects on societal welfare. However, those who contribute to these efforts often fail to internalize the associated benefits, leading to a discrepancy between their actual contributions and the benefits received. Moreover, ecosystem degradation and pollution often generate negative externalities that inflict harm upon society. To rectify this, governments can implement ecological compensation mechanisms to mitigate these negative externalities and incentivize contributors who generate positive externalities, fostering continued commitment to ecological conservation.

Within the framework of sustainable development theory, ecological compensation can be regarded as a means to achieve the sustainable utilization and management of ecosystems. By integrating environmental costs into economic activities and harmonizing ecological conservation with economic development, ecological compensation mechanisms facilitate environmentally friendly economic growth. These mechanisms not only ensure the sustainable utilization of natural resources but also provide support for economic development. Additionally, they incentivize enterprises to adopt environmentally friendly measures in their production and

operations, thus promoting their own sustainable development. Consequently, ecological compensation mechanisms play a pivotal role in realizing the sustainable utilization of ecosystems and fostering socio-economic sustainability.

Ecological compensation mechanisms represent a vital practical approach that combines the theories of public goods, externalities, and sustainable development. Within the framework of public goods theory, ecological compensation can be regarded as a non-rivalrous and non-excludable public good. Natural resources and ecosystems, being public resources, hold value not only in terms of market exchange but also in their impact on the overall societal well-being. However, the costs associated with their protection and restoration are often borne by specific individuals or groups, with uncertain prospects for receiving fair societal rewards in return. To address this disparity, governments can establish ecological compensation policies that aim to compensate these invested efforts, thus ensuring the provision of natural resources and ecosystems as public goods and enhancing overall societal welfare. From the perspective of externalities theory, ecological compensation can be seen as a means to internalize negative externalities. While the preservation and restoration of natural resources and ecosystems yield positive societal benefits, those who contribute to these efforts often fail to internalize these effects, leading to their returns falling below their actual contributions. Simultaneously, the destruction and pollution of ecosystems frequently generate negative externalities, causing harm to society. Through ecological compensation mechanisms, the adverse externalities can be mitigated, and those responsible for generating positive externalities can be encouraged to continue contributing to ecological preservation. Within the context of sustainable development theory, ecological compensation serves as a means to achieve the sustainable utilization and management of ecosystems. By combining ecological conservation with economic development and integrating environmental costs into economic activities, the ecological compensation mechanism promotes environmentally friendly economic growth. It not only ensures the sustainable utilization of natural resources but also provides support for economic development. Moreover, it incentivizes businesses to adopt environmentally friendly measures in their production and operational activities, facilitating their own sustainable development. Hence, the ecological compensation mechanism is of significant importance in realizing the sustainable utilization of ecosystems and promoting socioeconomic sustainability. The diverse definitions of ecological compensation reflect its significance and complexity within different fields and disciplines. Understanding and synthesizing the characteristics and advantages of these various definitions are essential for the effective establishment and implementation of ecological compensation mechanisms.

3 Researches on Ecological Compensation Standards

Ecological compensation is an innovative approach to resource and environmental management that addresses the inherent conflicts between environmental pollution, ecological degradation, and economic development [30-32]. At its core, ecological

compensation aims to restore and protect the ecological environment by providing economic restitution for damages inflicted upon it. In practice, the key to implementing ecological compensation lies in the formulation of scientifically and logically sound compensation standards. Specifically, careful consideration must be given to the relationship between the extent of ecological damage and the corresponding compensation amount. Furthermore, the assessment methods for determining the value of ecological public goods need to be further refined and optimized.

Tailoring appropriate ecological compensation standards requires the formulation of region-specific guidelines that accommodate different types of ecosystems and compensation recipients. This ensures the effectiveness and scientific rigor of ecological compensation measures. To achieve this, various approaches can be employed to assess the value of ecological public goods. Market-based pricing, replacement cost methods, and ecological benefit assessment are examples of techniques that can be utilized to evaluate the worth of diverse ecological products or services. By integrating these methods with local circumstances, well-founded ecological compensation standards can be devised, thereby optimizing ecological protection outcomes.

It is important to note that the establishment of ecological compensation standards should not solely consider economic factors but also incorporate social and environmental considerations. Consequently, when formulating these standards, careful attention should be paid to local culture, societal dynamics, and the ecological context. Adopting a multidimensional approach to comprehensively evaluate the value of ecological public goods will lead to the development of more scientifically grounded and rational ecological compensation standards. Such standards will effectively mitigate the conflicts between environmental pollution, ecological degradation, and economic development.

3.1 Ecological Compensation for Nature Reserves

Natural protected areas, as integral components of the ecological environment, play a pivotal role in determining the costs associated with ecological compensation, encompassing factors such as the service value of their ecosystems, conservation expenditures, and the costs incurred due to ecological losses. In order to uphold fairness in ecological compensation, it is imperative to prioritize both the willingness to pay and the willingness to be compensated, while employing market-based mechanisms for subsequent adjustments. Empirical studies investigating the ecological compensation mechanisms within protected areas through the utilization of survey methods can shed light on the varying degrees of impact that the establishment of such areas has on the economic losses and opportunity costs incurred by different local households. Moreover, factors such as educational attainment, ethnicity, and geographical location exert differential degrees of influence on the acceptance of ecological compensation among local residents.

To determine the specific compensation values for ecological compensation, a range of methods, including the direct cost approach, opportunity cost approach, and

ecological valuation approach, can be employed. These methods should be complemented by a thorough analysis and calculation that takes into account the actual circumstances of the context. Additionally, there exists substantial heterogeneity in the preferred modes of compensation among local residents, with the combination of financial compensation, technological compensation, and policy-based compensation being commonly observed. The selection of the most appropriate compensation method should be guided by the specific contextual factors, aiming to maximize fairness.

In summary, it is essential to acknowledge that different calculation methods exhibit their own strengths and limitations. Therefore, by adopting a comprehensive approach that minimizes errors, the scientific rigor, rationality, and practical relevance of ecological compensation can be effectively ensured.

3.2 Watershed Ecological Compensation

Watershed ecological compensation refers to the economic compensation for ecosystem services within a specific watershed, aiming to achieve the objectives of ecological environment protection and restoration. From the perspective of ecosystem service value, it is important to employ multiple quantitative research methods scientifically and develop well-founded watershed ecological compensation standards. The equivalent factor method is a commonly utilized approach that quantifies different ecosystem services into a common unit, enabling comparison and calculation. The contingent valuation method takes into account the diverse demands and values of different stakeholders regarding the same ecosystem services, determining compensation standards based on the analysis of demand elasticity and value elasticity. The water ecological footprint method measures water resource utilization by converting the impacts of ecosystems on water resources into economic value, thereby establishing watershed ecological compensation standards.

By comprehensively applying the aforementioned methods, the appropriate level of watershed ecological compensation can be scientifically calculated. During the process of formulating compensation standards, negotiations among stakeholders play a crucial role. By effectively utilizing various quantitative calculations and research methods, support and assurance can be provided for negotiations among stakeholders, facilitating the smooth implementation of watershed ecological compensation. In the implementation of watershed ecological compensation, realistic scenarios such as multi-stakeholder interests and bargaining come into play. Thus, considering costs and values as criteria for watershed ecological compensation standards is of paramount importance to ensure fairness among stakeholders.

3.3 Forest Ecological Compensation

Forest ecological compensation refers to an economic compensation and incentive mechanism implemented during the process of forest conservation and management to ensure the sustainable development of the ecosystem [33]. Relevant research has transitioned from focusing solely on forest resource conservation management to

considering the valuation of ecosystem services and the marketization of ecological compensation, providing new perspectives and approaches to promote the ecological protection and restoration of forest ecosystems.

When formulating ecological compensation standards, it is crucial to comprehensively consider the economic costs associated with direct costs, opportunity costs, and the benefits derived from ecosystem services, aligning with the objectives of forest conservation and management. To establish a robust calculation framework for compensation standards, a comprehensive analysis integrating the benefit method and cost method provides scientific support by examining actual compensation standard data across different provinces. This approach enhances the scientific rigor, rationality, and applicability of compensation standards.

Relevant data indicate that the average values of ecological compensation standards in each province are consistent with the respective levels of economic development. This indirectly reflects the alignment between ecological location, forest quality, compensation standards, and the willingness of local residents to accept compensation, to some extent. It demonstrates the rationality of compensation standard design and supports the enhancement of the compatibility of the forest ecological compensation mechanism.

In terms of marketization of the ecological compensation mechanism and the reform of compensation taxation, marketization facilitates better engagement of social capital in forest resource conservation and management. Simultaneously, the reform of compensation taxation improves the fairness and sustainability of compensation standards, thereby fostering the protection and restoration of forest ecosystems.

4 Policy, Institutional Framework, and Legal Regulations

Ecological compensation serves as a remedial measure for the restoration and preservation of natural ecosystems. Establishing an effective ecological compensation mechanism requires the construction of a robust framework supported by relevant laws and regulations, encompassing fundamental laws, specialized legislation, and specific regulations, to ensure the smooth implementation of ecological compensation [34-36] Taking watershed ecological compensation as an example, its successful execution relies on adequate protection from pertinent national laws, which elucidate regulatory requirements and legal aspects, while also defining the statutory criteria for ecological compensation in a scientifically sound manner.

On one hand, challenges persist in refining the legislation associated with watershed ecological compensation. Efforts should be directed towards enhancing the incentive systems for all stakeholders involved in watershed ecological compensation through legal means. This entails optimizing compensation standards, diversifying funding sources for ecological compensation, and thereby bolstering stakeholders' intrinsic motivation to fulfill their legal obligations. On the other hand, regional legislation pertaining to watersheds exhibits imbalances, incomplete supervision mechanisms, and weak legal enforcement. Consequently, continuous improvements are required in the legal framework governing ecological compensation, tailored to

the specific policies and legislative realities of each locality. Emphasis should be placed on compensation methods, standards, and evaluation systems, in order to augment specialized legislation on ecological compensation across different regions.

Furthermore, laws and regulations pertaining to watershed ecological compensation are currently dispersed among environmental protection laws and specific regulations. Accordingly, it is crucial to promptly develop comprehensive regulations concerning the ecological compensation mechanism and utilize them as the foundation for specialized legislation. By doing so, the legal framework for ecological protection compensation in China can be swiftly enhanced, taking into account both national-scale macro considerations and regional-specific circumstances.

5 Conclusions

Ecological compensation, as an institutional arrangement for providing conditional payments to ecosystem service providers, exhibits four essential characteristics: transparency, voluntariness, conditionality, and additionality. It encompasses both narrow and broad definitions and can be implemented through economic and punitive measures. Serving as a crucial tool for ecological environment governance and sustainable development, ecological compensation not only addresses the negative externalities faced by ecosystem protectors and restorers but also incentivizes positive externalities from contributors who continue to contribute to ecological protection. Furthermore, it provides support for economic development and facilitates the achievement of sustainable development by promoting the sustainability of enterprises.

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