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### Cross-watershed horizontal ecological compensation system : comparative examples from China and Germany

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**Lingnan** 嶺南大學  
**University** 香港 Hong Kong

**Master of Social Sciences in  
Comparative Social Policy (International)**

**Academic Year 2022-23**

**SOC 605 Comparative Social Policy Research Project**

**Cross-watershed Horizontal Ecological Compensation  
System: Comparative Examples from China and  
Germany**

**YANG Yanyao**

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## Introduction

The water pollution problem that affects people the most is the domestic water source problem. According to a United Nations report, decades of misuse, mismanagement, over-exploitation, and pollution of freshwater and groundwater supplies have exacerbated water stress and severely impacted watershed ecosystems. In turn, it affects human health, economic activity, and food and energy supplies ([United Nations, 2022](#)). In China, the Yangtze River is the longest river that spans east and west. It crosses 19 provinces and feeds one-third of the population in mainland China. It also plays a vital role in the economic and cultural development of the Yangtze River basin. However, in recent years, the ecological and environmental issues of the Yangtze River basin have become increasingly prominent. In particular, the Yangtze River Economic Belt occupies an important position in China's raw material industry. And its "heavy chemical" industrial structure and "heavy coal" energy structure features increase the consumption of resources. They also increase the difficulty of pollutant prevention and control. All these make the sustainable development of the regions face a serious challenge.

Therefore, river basin management is extremely important to protect the waters that people depend on. Today's basin management involves more players and is a multi-purpose and basin-wide approach. It is unlike the single management of shipping or hydropower in the past ([Ridder \*et al.\*, 2005](#)). Due to the transboundary nature of water, managing water pollution in the watershed has become an issue of widespread global concern. To solve the water problem, many scholars have sought solutions from such as international law ([Kamminga, 1995](#)) and discharge rights ([Amann, 2001](#)). However, the mismatch between the natural and administrative boundaries of watersheds usually exacerbates the problem of watershed management. The resulting violent conflict calls for greater attention to the need for consultation and cooperation in watershed management ([Mitchell and Zawahri, 2015](#)). For example, even India and Pakistan have conflicts. They are also interested in cooperating to reduce the expense of transboundary river management. The 1960 Indus Waters Treaty between the two countries not only reduced tensions between them but also improved their ability to manage the river ([Zawahri, 2009](#)). Unfortunately, it is not a simple for local governments to take unified action to address these water pollution because many areas with different interests are involved ([Peng and Zhang, 2014](#)). So, an entire ecological compensation mechanism is important to release the contradiction between the

environment and economic development in watershed management.

As a key component of the ecological civilization system, the ecological environmental compensation is a critical path to implementing the rights and responsibilities of ecological protection. Therefore, the Chinese government emphasizes the need to mobilize all parties to participate in environmental protection. The ultimate goal is to promote the construction of ecological civilization. (Xinhua,2021). Regarding the definition of ecological compensation, there are different perspectives in the academic. But these debates can broadly summarize into two views. The first view is that ecological compensation refers to natural ecosystem restoration by compensating for environmental damage caused by social and economic activities (Cao, 2002).

Zhuang (Zhuang, Gao, and Wang,1995) argues that the essence of ecological compensation is to compensate for the value of the eco-environment. And it makes the destroyers of the ecology bear the corresponding responsibility, thus playing a restraining role in the destruction of the ecological environment. For example, levying ecological compensation fees or taxes can solve the problems of ground collapse, soil erosion, mudflow, forest grassland, and arable land destruction caused by mining. Thus, the external diseconomies of ecological damage can be transformed into internal diseconomies of enterprises, which will prompt them to strengthen the protection of the ecological environment. The other viewpoint identifies ecological compensation as the means of adjusting the economy for conservation. This view suggests that it can increase the cost of environmental damages by levying a charge. This charge can reduce the external diseconomies associated with such behavior and thus serves the purpose of protecting natural resources (Lv and Xu, 2003). From the viewpoint of Wang (Wang, Wan, and Zhang,2006) and others, believe that ecological compensation is an institutional arrangement used to regulate the relationship of economic interests between ecological protectors, destroyers, and beneficiaries. Its purpose is to protect the ecology service function and promote harmony between humans and nature. The practical application of this view is most evident in implementing the system of paid acquisition and trading of emission rights in the field of environmental pollution prevention and control in China. It provides a systematic reference for the parallel establishment of an ecological compensation system in the field of environmental protection in China.

In the process of actual environmental protection in China, ecological compensation generally refers to appropriately compensating ecological protectors for the increased expenditures and costs incurred in fulfilling their environmental protection responsibilities through financial transfer payments or market transactions. Without compensation measures, developers may continue to destroy ecosystems because they do not have to pay for negative environmental externalities. Conversely, conservationists who want to stop the developers' behavior are less likely to receive the ecological protection benefit (Engel, Pagiola, and Wunder, 2008). As it were, ecological compensation is a kind of inspired institutional arrangement. To better protect the ecological environment and motivate environmentalists, ecological compensation mechanisms have been increasingly promoted in environmental conservation (Pascual *et al.*, 2014). In the case of China, ecological compensation has been widely used in conservation efforts in areas such as marine, agricultural land, and woodland.

To thoroughly implement the thought of ecological civilization and further deepen reforming the ecological protection compensation system, China put forward the reform goal, i.e., the essential completion of the ecological protection compensation system is compatible with the state of economic and social development in 2025. By 2035, the basic shape of the ecological protection compensation system to adapt to the requirements of the new era of ecological civilization construction. And while combining the effective market and productive government, it will establish a classified compensation system and a comprehensive compensation system. By promoting vertical ecological compensation and horizontal ecological compensation systems, realizing the final goal is to set up a coordinated compensation system for ecological protection (Xinhua, 2021). The Chinese central government divides ecological compensation systems into two categories: vertical ecological compensation (payments from the central government to local governments) and horizontal ecological compensation (direct transfer payments between local governments). The former focuses on its role as the central government, while the latter looks at compensating beneficiaries (Xie *et al.*, 2015).

To further promote the payments for watershed services, China has conducted inter-provincial cross-watershed horizontal ecological compensation (HEC) trials. China's HEC system has already

yielded remarkable results in watersheds such as the Xin'an River. From pilot to promotion, the Chinese government hopes to bring the successful experience of the cross-watershed ecological compensation mechanism all over the country. As an important river in China, the Chinese government attaches great importance to the Yangtze River's ecological environment. And it is committed to establishing an ecological compensation mechanism for the holistic Yangtze River basin. To promote the environmental protection and restoration of the Yangtze River economic belt, local governments in the Yangtze River basin adopt cross-watershed horizontal ecological compensation mechanisms to achieve synergistic management of ecological environment problems in the Yangtze River. In contrast, the Yangtze River basin involves multiple provinces, meaning that tremendously involved actors join the cross-watershed horizontal ecological compensation policy for the Yangtze River. Without a coordination structure, the large number of participants (Governments at all levels, relevant enterprises, individuals, etc.) can lead to excessive diversity of information and knowledge, which can have inconsistency with national policies (Valujeva *et al.*, 2023). The emergence of multiple participants makes the cross-watershed horizontal ecological compensation get into a difficult situation. Therefore, this study introduced a method to solve the environmental governance problems: social network analysis (SNA).

SNA is a widely used research method in the social and natural sciences. And networks of links between social actors have become "powerful and practical tools" for studying environmental governance issues (Alexander, 2015). Applications of SNA in the field of environmental governance have been: (1) society-to-society, (2) society-to-ecology, (3) ecology-to-ecology, and (4) ecology-to-society (Bodin and Tengo, 2012). However, the existing studies on cross-watershed horizontal ecological compensation as part of environmental governance are less integrated with SNA. Even the research on payment for ecosystem services (PES), which is similar to HEC, is currently focused on conceptualization, compensation criteria, compensation effects, and evaluation.

Furthermore, it is noteworthy that the existing literature has paid little attention to using ecological compensation mechanisms such as PES in authoritarian states such as China. Due to its strong central power and limited political freedom (Cerutti, 2017), China is considered the largest centralized state in the world (Spires, 2011). As Salzman *et al.* (2018) argue, China's unique political system allows it to implement ecological compensation

strategies at a scale and speed. And it is unattainable in other countries. However, in practice, vertical ecological compensation brings unimaginable pressure. At the same time, the uniqueness of its political system brings horizontal ecological compensation obstacles and makes it slow to spread nationwide. Take the Yangtze River basin as an example. With the introduction of policies related to the ecological compensation mechanism, its ecological benefits, economic benefits, and social benefits have gradually formed a multi-win situation. However, the ecological compensation mechanism in the Yangtze River basin still suffers from an insufficient supply of special legislation on ecological compensation, the imperfect establishment of an integrated compensation mechanism, a single ecological compensation method, and inconsistent application standards for ecological compensation.

Therefore, this study uses SNA to visualize the keywords in the ecological compensation policies of the river basin. Then, it obtains the policy formulation priorities and their development trends. This study will facilitate the comparison of policies in countries with successful experience in cross-basin horizontal ecological compensation in the Yangtze River basin. And by revealing the differences between the relevant policies in China and the excellent international ecological compensation policies and identifying the main problems, it systematically adjusts the policy system. Ultimately, it will support optimizing the cross-watershed horizontal ecological compensation policy system in the Yangtze River basin and improving the synergy of environmental protection in the Yangtze River.

## **Literature Review**

### **Payment for ecosystem services**

Research on PES began in the 1970s ([Schomers and Matzdorf, 2013](#)), and PES is widely recognized as a pre-market conservation approach to solving ecological problems ([Hausknost, Grima, and Singh, 2017](#)). By transforming ecosystem services into tradable commodities, PES helps to create new independent markets for purchasing so-called ecosystem services directly ([Wegner, 2016](#)). It is also widely used to internalize positive environmental externalities. As a result, PES is used as a direct and effective conservation tool to transform uncompensated externalities into economic incentives to protect ecology ([Moreno-Sanchez et al., 2012](#)). And ultimately, voluntary transactions between suppliers and buyers of good ecological system services are achieved.

The concept of PES is further delineated from different research perspectives. Wunder (2008) studied the conceptual framework of PES based on Coase's theory (Hurwicz, 1995). He argues that PES is a voluntary transaction established through buyers and providers of trading environmental goods and services. And based on Pigou's study (Beaudry and Portier, 2004), Muradian et al. (2010) define PES as a voluntary transfer between participants in ecological compensation.

From the perspective of PES system design, scholars have studied it in terms of stakeholders, influencing factors (Engel, Pagiola, and Wunder, 2008), compensation criteria (Pagiola et al., 2007; Kosoy et al., 2007), compensation conditions, and ecological compensation methods (Zabel and Roe, 2009). Take the studies of Engel et al. (2008) as an example. They argue that ecological compensation is the search for the lowest-cost service provider for ecological service needs. The resource owner is the most appropriate compensation recipient if the property rights of the resource are clear. However, it also incurs higher transaction costs when there are many participants. Differ from the above studies, scholars studying the effects and evaluation of PES have focused on the added benefits (García-Amado et al., 2012; Sánchez-azotemia et al., 2007) and poverty reduction effects (Pagiola, Arcenas and Platais, 2005; Kemkes, Farley and Koliba, 2010) of PES.

Today, PES has been frequently used in several environmental management areas worldwide (May, Hobbs, and Valentine, 2017). For example, it has been applied to land compensation (Higgins et al., 2014), forest compensation (Locatelli et al., 2014), biodiversity conservation (Hein, Miller, and Groot, 2013), and watershed compensation (Muño, Hollaendera and Pined, 2013). PES has the advantage of being able to address transboundary pollution through a cooperative and consultative approach by bringing together different administrations as a whole. As a result, PES has gained wide acceptance in many countries. In practice, however, most PES cases do not meet all the criteria of the PES definition. According to Wunder's (2007) definition: PES program design should incorporate the following principles: "(1) voluntary transactions in which (2) well-defined environmental services (or land use that may ensure that service) is (3) provided by a buyer (at least one) buyer (4) from a supplier (5) on an ongoing basis (condition)." While many programs can meet some of these principles, it is hard to find one that meets all of the above-defined principles (To et al., 2012). The truth is that PES programs are not a self-regulating



marketplace that spontaneously brings together potential buyers and sellers of environmental services to connect them. Instead, PES programs typically focus primarily on how to pay those who generate external benefits. Instead, compensation programs that use donor funds or are government subsidies are included as part of the equation (Muñoz-Piña et al., 2008). So, they are more correctly referred to as "PES-related" cases (Suhardiman et al., 2013).

### **Chinese ecological compensation system**

The so-called "ecological compensation" that China started in 2007 is a PES-related program (Wang et al., 2016). And Chinese central ecological compensation system can be divided into vertical ecological compensation and horizontal ecological compensation.

Horizontal ecological compensation is part of horizontal fiscal transfers, which are part of the fiscal transfer system. Since China's tax distribution reform implementation, the fiscal level between the central and local governments has been uneven. It means the imbalance in China's economic development. The transfer includes vertical and horizontal transfer payments (Yang, 2014). Vertical fiscal transfer payments have been widely implemented in China's practice. But horizontal fiscal transfer payments refer to the transfer of finance funds between local governments at the same level. A horizontal fiscal transfer payment is an important part of the finance transfer payment system, which can cooperate with vertical fiscal transfer payment to form a synergy. Also, it is an inseparable part of the finance transfer payment system. China has a vast territory. But there are many differences in the economic development of different localities. The horizontal fiscal transfer payment system is more conducive to balancing the development of the regional economy than the vertical fiscal transfer payment.

Horizontal ecological compensation (HEC) in China was first proposed in 2013 as a complement to vertical ecological compensation to relieve pressure on vertical ecological compensation (CPC central committee, 2013), mainly between ecological system providers and buyers without sectoral linkages. For example, it includes local transfer payments in the same rank areas (Eaton and Kostka, 2018). Thus, HEC in China is closer to the PES concept than vertical ecological compensation. And HEC is an important component of the

ecological civilization protection system. It is applied to ecological elements such as rivers, seas, and woodlands. Therefore, the watershed horizontal ecological compensation can be called the extension and practical application of the theoretical horizontal ecological compensation basis.

HEC in the river basin can be defined as the mutual transfer of finance funds between local governments at the same level. And pecuniary compensation can be given to the victims who pay the price of protecting the ecological environment in the river basin. The core is to let the government bear the primary responsibility for river basin governance. And through the cooperation of upstream and downstream governments, the use of fiscal funds is a guarantee for river basin governance. In general, the system mainly compensates units and individuals for the costs and sacrifices spent on the ecological protection of the river basin through the mutual transfer of finance funds from upstream and downstream governments. Therefore, two governments are encouraged to carry out river basin governance to promote the river basin governance effectively.

As far as China is concerned, the implementation of the watershed ecological compensation system can stimulate the upstream government that has insufficient financial resources to undertake the task of maintaining the river basin protection and take measures to control the river basin by using the relatively economically developed downstream government to compensate the economically less developed upstream government. It can not only effectively solve the river basin governance issues, but also promote balanced development between upstream and downstream while protecting the ecological environment of the river basin (Li et al.,2010). For another, the complexity

of watershed governance requires long-term funding. Horizontal transfer payments have expanded China's single vertical-based compensation model and eased the financial pressure on the central government (Yuan,2022). It also helps to coordinate and negotiate between upstream and downstream governments to solve the problems of fiscal equalization and environmental externalities. The market exchange relationship between the cost and benefit of ecological services in the river basin ecological reserve reduces the central government burden. And it increases the efficiency of its river basin governance.

## **Methodology**

This paper uses quantitative and qualitative research methods as watershed eco-environmental policy comparison methods to compare HEC policies in the Yangtze River basin and the Elbe River in Germany. This study has five key steps: ① Collecting horizontal ecological compensation policies of the main streams in the Yangtze River basin and payment for ecosystem services in the Elbe River using text collection technology, then sorting out and analyzing the basic features of the policy systems of each region. ② Using the policy comparison framework to divide the relevant policies' textual content into three-period stages. Keywords are extracted using algorithms to analyze the focus on ecological compensation policies according to the frequency of keywords. ③ Constructing a three-dimensional framework of "policy objectives-policy instruments-policy implementers" for comparing watershed ecological compensation policies. ④ The keywords and related core text contents were used to analyze the correlation of keywords of horizontal ecological compensation policies in each mainstream of the Yangtze River basin by using the social network analysis method. ⑤ Comparing the analysis results with the ecological compensation policy of the Elbe River in Germany by content analysis, the problems of HEC in the Yangtze River basin are derived, and countermeasures propose to optimize the policy system systematically.

## **Selection of comparative objects**

The fiscal transfer system is widely used. And most countries implement the vertical fiscal transfer model in their fiscal transfer legal system and practice. Germany has carried out horizontal fiscal transfer legislation and practice compared to other countries. And its institutional model is adequate and systematic. It also forms a combined vertical and horizontal fiscal transfer legal system (Liang and Zhang, 2008). Germany's horizontal fiscal transfer system plays an important part in balancing the financial levels of the states and achieving the goal of equalizing public services for the population. This system even influences the practice of ecological compensation in German watersheds.

In addition, in Europe, Germany has been carrying out ecological compensation in watersheds from an early stage, and its most important feature is the horizontal fiscal transfer. The most classic case is reflected in the environmental management of the Elbe River. The reason for choosing the Elbe River is that it is one of the largest river basins in Europe that crosses national borders. And it has important ecological and economic values. At the same time, there are significant differences between regions along the river. The river basin covers

an area of 148,000 km<sup>2</sup>, of which 65.54% is located in Germany, 33.68% in the Czech Republic, and the two smaller shares are in Austria (0.62%) and Poland (0.16%) (ICPER, 2016). Most of the Elbe rivers are located in Germany, so the water environment of the Elbe is said to be quite important for Germany. However, the ecological degradation of the Elbe River accelerated in the 1980s due to the negligence of the German and Czech governments, which are the two main flowing rivers, to manage the Elbe.

In the 1990s, Germany sought cooperation with the Czech Republic to establish a joint upstream and downstream cooperation group to protect the environmental management of the river basin and the integrity of the river ecosystem. The Czech economy lagged behind Germany and lacked financial support for watershed management. For these reasons, the two governments had multiple times of negotiations and reached an agreement in the late 1990s. The International Committee for the Protection of the Elbe Agreement signed the Convention of the International Committee for the Protection of the Elbe River in Magdeburg on October 8, 1990, which realized the co-regulation of the Elbe River. Based on the agreement, the parties clarified their rights and obligations, objectives, and other contents. The principal objectives include a permanent strategy to promote the retrieval of drinking water, achieve the most natural ecosystem possible, and decrease the burden imposed on the North Sea by the Elbe River basin. The basis for all contents is to improve the ecological value of the Elbe riparian zone (ICPER, 2015).

The most direct manifestation of horizontal financial transfers for ecological compensation in the Elbe River basin is the German government's direct payment of DM 9 million to the Czech government to promote the construction of sewage treatment infrastructure in the Czech Republic. With the help of German financial resources, the Czech government has become more proactive in protecting the ecology of the Elbe River basin (Zhu, 2010). Although Germany has adopted various ways to raise funds in the transfer process, horizontal financial transfer still plays a pillar role. Therefore, the most important features of ecological compensation in the Elbe River in Germany and the Czech Republic are summarized as they have available funds and accounting fairness (Zhu, 2016). The availability of funds is due to the main role of horizontal financial transfers and other market-based instruments to ensure the adequacy of ecological compensation funds in the Elbe River. Accounting fairness means that Germany and the Czech Republic reached an

agreement based on negotiation, and the horizontal financial transfers are carried out according to strict procedures, such as calculation methods and criteria, which guarantee the fairness and interests of both parties.

Germany and the Czech Republic carried out cross-watershed ecological compensation horizontal financial transfers in the Elbe River by agreement to improve the Elbe River water environment and sustainable development. Ultimately they also achieve the harmonization of economic imbalance development between regions. It is a successful case of transnational river basin cooperation governance, which is more difficult to compare with trans-provincial river basin governance. Therefore, the trans-provincial river basin cooperation governance in China can learn from this successful case of the Elbe River. It can be said that although there are not many successful cases of watershed management with the same cross-watershed ecological compensation. However, Germany takes the leading position in the horizontal transfer payment as an ecological compensation method.

### **Data source and collection**

This study uses Python to crawl the texts of ecological compensation policies on the official websites of various local governments and related institutions passing through the Yangtze River mainstems and the Elbe River. And it also supplements manual search to form a policy alternative library. Based on the content relevance, this study screens the policies in the policy alternative library to analyze the policy supply quality of ecological compensation in the Yangtze River basin and the Elbe River. These policies have the following policy characteristics: ①Policy sources. To ensure the collected policies' accuracy and authority, the official websites of the local governments and relevant institutions such as the Department of ecological environment, and Department of water conservancy are selected as the main sources of policies. ②Policy keywords. This study identifies terms such as ecology, ecological compensation, and sewage as keywords. ③Policy type. To ensure the collected policies' comprehensiveness, the policy types involve local regulations, working documents, normative documents, administrative license approvals, local government regulations, etc.

By using the policy text library as the analysis object, this study divides the policy contents into three dimensions: policy goals, policy implementers, and policy tools. The keywords of the policy text of ecological compensation in the Yangtze River basin in different

dimensions are extracted and compared using Jieba algorithms. Jieba algorithm is a Chinese natural language processing segmentation library. And it can divide Chinese sentences into individual words and achieve functions such as lexical annotation and keyword extraction. In this study, based on the extraction results of each critical dimension and the basic features of policies, the policy texts are analyzed by using social network analysis. The co-occurrence network mapping of high-frequency keywords in policy texts is drawn based on the co-occurrence matrix. And deep features such as linkage relationships among keywords are analyzed using the structural hole index. According to our structural hole indices of effective size ( $ES_i$ ), efficiency ( $E_i$ ), restriction system ( $C_{ij}$ ), and hierarchy ( $H$ ), this study describes the attributes of association, influence, and control of policy keywords and the characteristics of policy networks by Ucient (Liu, 2019).

## Results

This paper collects 44 publicly available horizontal ecological compensation policy texts on each province and municipality directly under the central government in the Yangtze River basin from 2008 to 2023. In contrast, it collects a total of 12 policy documents for the period from 1991 to 2021 related to the Elbe River Basin. Using these policy documents as the object of this study, the essential characteristics of the policy systems of the two countries include ①In terms of policy types, ecological compensation policies in the Yangtze River basin cover local laws and regulations, government regulations, and notes, with the maximum number of normative documents. In contrast, the policies of the German Elbe River are mainly derived from the action plans or programs of the Elbe River Protection Committee. Regarding policy focus, the Yangtze River and the Elbe River's ecological compensation policies involve water quality improvement and healthy ecosystem development. However, due to the different conditions of the two waters and the various stages of policy development, they differ in terms of policy priorities. ③In terms of policy release time, the publication of ecological compensation-related policies in the Yangtze River area is mainly concentrated from 2021 to the present. This phenomenon is closely related to the policy implementation of the Implementation Plan for Supporting the Establishment of Horizontal Ecological Protection Compensation Mechanism in the Yangtze River Basin. In contrast, the publication time of the Elbe River is more even, basically developed along the time of the promulgation of the EU Water Framework Directive.

### **Development of relevant policies of the two countries**

This study counts the keywords of the Yangtze River ecological compensation policy in three dimensions- policy objectives, policy tools, and policy implementers. Since the HEC policy in the Yangtze River basin is still relatively new, based on the understanding of the economic and social development process in the Yangtze River basin, using the promulgation time of important policy documents as the critical time, the policy development process can be divided into three main stages: In the first stage (1990-2017), the State Council issued the Decision on Further Strengthening Environmental Protection in 1990, which established the ecological compensation policy for the first time. In the second stage (2018-2020), the Ministry of Finance issued the Implementation Plan for the Central Financial Promotion of Ecological Protection and Restoration Incentive Policy for the Yangtze River Economic Belt in February 2018. And it established the incentive guidance mechanism for ecological compensation through comprehensive incentive measures. In December of the same year, the Ministry of Ecology and Environment and the National Development and Reform Commission issued the Action Plan for the Protection and Restoration of the Yangtze River, pointing out that it is necessary to improve the ecological compensation mechanism of the Yangtze River Basin. The document also indicates that every related department should implement the Yangtze River basin's ecological conservation and restoration incentive policy in depth. And 11 provinces and cities along the river should promote the implementation of market-oriented and diversified HEC. In this context, environmental policies related to ecological compensation in the Yangtze River basin have been introduced one after another. And the systematic nature of the policies has been strengthened. In the third phase (since 2021), to consolidate the achievements of the construction of HEC mechanisms in existing river basins along the Yangtze River Economic Zone and further enhance the systemic and synergistic nature, the Ministry of Finance and other departments formulated and issued the Implementation Plan for Supporting the Establishment of Horizontal Ecological Protection Compensation Mechanisms in the Whole Yangtze River Basin in 2021.

In contrast, the policy development stage of ecological compensation in Germany follows the development of the EC Water Framework Directive, which can also be roughly divided into three stages: in the first stage (1991-2014), although ecological compensation in the Elbe River started as early as 1990, subsequent policy development and modification were based on the 2000 EC Water Framework Directive, and with its development were

continuously further improved. In the second phase (2015-2021), with the promulgation of the updated International Management Plan 2016-2021 of the Water Authority 2000/60/EG in December 2015, the Elbe policy is more oriented towards the achievement of the objectives of this document. In the third phase (2022-present), the management plan for the Elbe for 2022-2027 was developed based on the policy objectives of the EU's Water Framework Treaty, as the river assessment results within most international river boundaries within the EU in 2021 did not reach good status.

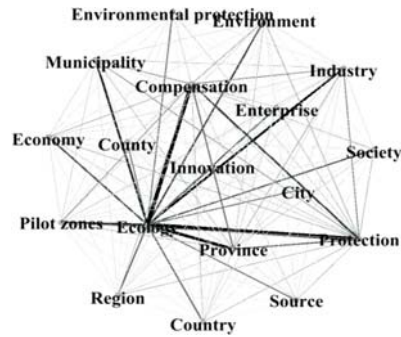
### **SNA Research on HEC policies for the Yangtze River**

Based on the three stages, this study extracts high-frequency keywords from the policy documents of the Yangtze River. And it conducts keyword co-occurrence mapping using Gephi to social network analysis. SNA is an analytical tool for describing, visualizing, and investigating mathematical approaches to the network of connections between social actors. And SNA is based on modeling social actors as nodes. And they are connected by relating that represent the relationships between these behaviors. Nodes and links combine to form a unique network structure ([Alexander, 2015](#)).

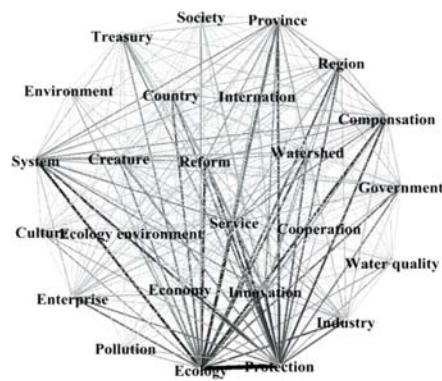
Therefore, this study derived keyword co-occurrence network diagrams for the three stages (Figures 1-3) by SNA. And it can be seen that the important keywords present in all three phases are mainly in ecology and conservation. It is consistent with the policy objectives of ecological compensation. But each stage also has differences. Specifically, the first stage has compensation in addition to ecology and protection. And these keywords link to province, city, environment, industry, pilot zone, and economy. In this stage, China has just proposed ecological compensation, so the pilot zone is to compensate economically for environmental pollution caused by industry. However, the second phase is linked to compensation, mechanisms, provinces, regions, and services. It is related to the first phase of the pilot. Based on the previous pilot, the government wanted to establish and improve the ecological compensation mechanism. It also requires the Yangtze River basin regions to implement ecological environment protection and restoration incentive policies. And it can promote market services to achieve diversified horizontal ecological compensation. Although the third phase is an important period for HEC in the Yangtze River basin, most of the provinces in the Yangtze River basin are still implementing HEC policies based on the previous ones because they are relatively close to the present. Thus, the keywords of this period are linked to several



words such as basin and innovation, but the relationship is not deep. However, it can also be seen from the figure that in this new phase, the provinces have made a further content breakdown of the policy content of HEC in the Yangtze River basin.



**Fig.1 The first stage of keyword co-occurrence network**



**Fig.2 The second stage of keyword co-occurrence network**



**Fig.3 The third stage of keyword co-occurrence network**

The keyword co-occurrence mapping shows that the mapping of each stage matches the essential characteristics of the policy development stage. It presents a tendency that the three-dimensional policy framework of "policy objectives-policy instruments-policy implementers" is gradually diversified and solid. And the policy objectives, policy instruments, and policy implementers are closely linked within each stage. The result of this analysis is that the policy objectives are the primary guide to setting the corresponding policy instruments and policy implementers, and the policy instruments and policy implementers influence each other and change.

Based on the above results, this study also uses Ucient to investigate the structural holes in the matrix of the established keyword co-occurrence network. Burt's structural hole theory can provide an important basis for the analysis of individual network location in this study, which can help identify the potential number of structural holes in the network of academic social individuals and the ability of the central individual to control the structural holes. This theory is important for understanding that central individuals have information advantages in scientific communication and can thus improve the effectiveness of information exchange in the whole network. The structural hole indicators include four aspects of  $ES_i$ ,  $E_i$ ,  $C_{ij}$ , and  $H$ . The effective size indicates the overall influence of the node. This value can measure the importance of structural hole nodes to some extent (Burt, 2004). This study mainly explores the focus of policy development. Therefore, by calculating the  $ES_i$  at each stage of this study, it is easy to find that the policy focus in the last two stages since the government introduced the HEC document about the Yangtze River basin is on the four dimensions of ecology, protection, compensation, and watershed. It implies that ecological protection and compensation have been given great importance as important policy objectives in the policy of HEC in the Yangtze River basin.

### **Policy Objectives**

The policy objective is the effect and purpose that policymakers hope to achieve by implementing the policy. It guides policymakers to choose appropriate policy instruments and provides judgmental benchmarks for subsequent policy evaluation (Fan and Tan, 2017). In general, macro policy objectives are the general goals of policies, which are more general and briefer. Specific policy objectives are refinements of macro-objectives, often divided into different indicators for portrayal, and are relatively detailed (Yang et al., 2021). The

macro-objectives of ecological compensation policies in China and Germany mainly focus on restoring water resources to a good state and enhancing the ecological functions of the basin. The specific policy objectives are related to the rational allocation and efficient use of water resources, water environment improvement, water ecology protection, etc., to promote the systematic improvement of the water environment in the basin. However, there are still differences in the related policies of the two countries:

From the perspective of macro policy objectives, China's HEC policy objectives in the Yangtze River basin are still in the initial stage, mainly to establish a sound compensation mechanism for HEC in the Yangtze River basin. Eventually, it will steadily improve the ecological environment quality of the Yangtze River basin through richer compensation content, more diverse approaches, and standards. It also means that the macro-objectives of China's watershed HEC policy still focus on establishing and improving ecological compensation mechanisms. For Germany, which became aware of the pollution problem of the Elbe River in the 1990s, the ecological compensation mechanism in the Elbe River basin has already taken shape. The issues that still need to be solved mainly focus on solving water quality problems and using water resources in the river basin.

However, from the perspective of specific policy objectives, the policy objectives for the Yangtze River basin focus on the steady improvement of ecological and environmental quality. Specifically, this means that the proportion of surface water of high quality in the Yangtze River basin will eventually increase. The ecological functions of rivers will also be gradually restored. And it will continuously improve the quality and stability of the ecosystem. The policy objectives for the Elbe River Basin focus on drinking water and agricultural water, although they also focus on achieving the most natural ecosystem possible. At the same time, its policy objectives include reducing the burden of the Elbe River Basin on the North Sea.

There are also significant differences between Germany and China in setting the level year for the policy objective setting. The achievement of the policy objectives for the Elbe River is part of a long-term plan, with targets planned from 2022 to 2027. But China has a more detailed set of milestones, with specific targets set for 2022, 2024, and 2025. In the process of ecological compensation governance of the Yangtze River and the Elbe River, there are some differences in the policy goals set due to the different environmental problems of the

basins and their causes in the two countries at different stages.

### **Policy Tools**

Policy tools are the techniques and tools used by the government to achieve policy objectives (Howlett,1991). Environmental policy tools are the total of a series of environmental measures such as prevention, and control. They are also introduced and implemented by government departments to achieve environmental quality improvement (Zheng and Luo,2017). As the most equitable public good, the ecological environment is subject to non-exclusivity and positive externalities of environmental governance. It makes government intervention effective and reasonable. Foreign scholars usually take the degree of government intervention as the classification criteria of environmental policy tools. The Organization for Economic Cooperation and Development (OECD) classifies environmental policy tools into three categories: command-and-control, economic incentive, and persuasive tools (OECD,1996). Sterner synthesizes environmental policy tools into three categories: market-based tools, command-and-control tools, and information dissemination tools (Sterner,2001). Chinese scholars use "degree of coercion" as a criterion to classify environmental policy tools. And scholars classify the degree of coercion as two, three, and four. In the two classifications, some scholars classify environmental policy tools into command and market-oriented tools (Ye et al.,2018). In the three classifications, some scholars classify environmental policy tools into command-and-control, market-incentive, and public participation tools (Gan,2014). Among the four classifications, some scholars classify environmental policy tools into four categories: command and control, the market economy, voluntary action, and public participation (Zhang, Wen, and Peng,2007).

In the classification of environmental policy tools, the tri-categorization approach is more consistent with the whole governance process of environmental policy. Command-and-control policies include source prevention, process regulation, and ex-post disposal. The economic incentive tool includes fiscal policy, price, financing, and technology. And the public participation type focuses on publicity, education, monitoring, and participation. Specifically, the command-and-control policy tool is the most widely used, with 32 policy documents containing this policy tool. It shows that there is a preference for authority and coercion in HEC in the Yangtze River basin, with a series of coercive policy tools to regulate

the behavior of institutions and individuals. The low level of application of both economic incentives and public participation policy tools, and the lowest frequency of public participation, suggest that the power of the market and the public in policy tools have not been fully utilized, which may affect the HEC process in the Yangtze River. And as a successful experience of ecological compensation policy in the watershed, the policy related to the Elbe River can be said to be based on public participation. Various NGOs are involved to assist the government in jointly protecting the ecological environment of the Elbe River basin.

Therefore, in general, among the existing effective policy documents to address ecological compensation in the Yangtze River basin, direct government regulation is still the main instrument, and the importance of economic incentive-based and public participation-based policy tools needs to be strengthened.

### **Policy implementers**

The main actors in implementing ecological compensation policies in the Yangtze River basin are various levels of government. And enterprises and society are supplementations. In contrast, the policy implementers in Germany are very different in the governance of the Elbe River. However, this is also due to the various focus of ecological compensation work in both basins. And there is a big difference in the proportion of the different types of policy implementers in the two river basins. Compared to Germany, the policy implementers of HEC in the Yangtze River basin in China are more inclined to various government departments in each province and municipality. In terms of a single type of policy implementer, the governments at all levels involved in the ecological compensation policy of the Yangtze River basin play a leading role. However, finance departments at all levels play a critical role in the specific policy implementation. The finance departments' involvement helps to provide fair and just ecological compensation calculation methods for HEC in the Yangtze River basin.

The ecological compensation of the Elbe River belongs to cross-border ecological compensation, which involves the governments of two countries, Germany and the Czech Republic. The ecological compensation method of the Elbe River basin also relies mainly on public financial payments from the government. In 1990, Germany and the Czech Republic signed the Convention on the Protection of the Elbe River, in which both

governments made public payments to protect the ecological environment of the river and to compensate for the protection of upstream water sources. However, the Elbe River Protection Committee, which was established as a result of the Elbe River Protection Convention, has been relied upon for the subsequent compensation of the Elbe River. The Commission consists of two signatory countries, Germany and the Czech Republic, as well as Austria, Poland, the European Union, the International Commission for the Protection of the Rhine, the Oder and the Danube, and NGOs as observers. In the Elbe River governance, the River Basin Community Elbe (RBC Elbe; in German “Flussgebietsgemeinschaft (FGG) Elbe”) is mainly involved in the management of the Elbe River pollution in Germany. Although various government departments play a role in the committee, the government is not the main implementer of the ecological compensation policy in Germany. Instead, the various river basin committees it involves are independent bodies accountable to the government but not statutory bodies of any one government whose functions are defined by the river basin management agreement.

The starting point of ecological compensation policy objectives in both China and Germany is to protect the ecological environment of the basin, but the specific contents are different. It is because China, as a developing country with its industrial structure and socioeconomic development needs, has had to focus on the economy to the detriment of the environment for a long time in the past. As a result, the ecological and environmental protection policy has been slower and more problematic than in Germany, a developed country. At the same time, the differences between the political systems of Germany and China have led to significant differences in the policy instruments and policy implementers of the two countries. The centralization of power in China puts more power in the hands of the government, thus limiting the role of the market and the public. With its federal system, Germany is relatively more liberal in this respect. At the same time, the favorable development of NGOs in Germany allows German companies and the public to be more involved in policymaking.

## **Conclusion and suggestions**

### **Conclusions**

Compensation mechanisms play an important role in ecological conservation. Integrating the above analysis, this study compares the theory and practice of ecological compensation

mechanisms in China and Germany. And by analyzing the characteristics of China's ecological compensation policy, it concludes that there are problems with China's HEC policy in the Yangtze River basin.

The current HEC mechanism of watersheds carried out by provinces and municipalities in the Yangtze River Basin has a low or insufficient level of administrative districts (local governments), i.e., some provinces and municipalities carry out horizontal ecological compensation of watersheds only among prefecture-level cities without including district and county governments in the horizontal ecological compensation system. In contrast, some other provinces and municipalities carry out horizontal watershed ecological compensation only among district and county governments within each prefecture-level city. Compared with the large number of cross-provincial rivers in the Yangtze River basin, the proportion of watersheds with HEC in inter-provincial watersheds is small.

The HEC in the Yangtze River economic zone basin is mainly paid by financial funds, with a single source of funds and compensation mode, and lacks a market-oriented and diversified compensation mode. The existing watershed HEC is led by the watershed government. And the source of funds is financial funds, and the upstream and downstream compensation is carried out in the form of "blood transfusion" financial subsidies and transfer payments (Xu,2020), and the "blood-making" function is seriously insufficient. Although the relevant stakeholders are encouraged to actively explore diversified compensation models such as counterpart support, industrial undertaking, skills education, and enclave economy, and support regions with a good foundation and mature conditions to actively pilot market-based instruments such as water rights and sewage rights, the actual situation is not satisfactory. Taking the compensation of inter-governmental fund transfer, a more easily operated and realized compensation method, is still mainstream.

The current compensation agreements and compensation programs signed around the implementation of the supporting supervision and assessment system are inadequate. And they do not play a true role in the HEC of the watershed. First, in some areas, there is a phenomenon of emphasis on form and light content. And the horizontal watershed ecological compensation policy in a few areas is not well integrated with the actual watershed and is a task-based compensation. Second, most compensation programs lack ecological compensation process supervision and compensation effect assessment systems.

And there is a phenomenon of emphasis on implementation and light results. The existing horizontal watershed ecological compensation mainly focuses on improving water quality at watershed cross-sections. Also, the costs of ecological compensation, economic and social environmental gains, and comprehensive goals are less considered (Yu,2018).

## **Suggestions**

### **Deepen and promote the consensus on cooperation**

Basin ecological and environmental management involves many departments such as finance, ecology environment, and water conservancy. And it requires cooperative consensus and consultation. It also calls for interaction between upstream and downstream governments in the basin. First, various governments should strengthen inter-provincial spatial planning synergy. And they should conduct policies to promote the cross-provincial main function areas and ecological compensation. Second, these governments can improve information sharing and joint law enforcement to build a cooperation platform. Second, they can achieve common sharing of monitoring water quality and quantity, pollutant concentration, and so on. Third, every government needs to focus on the functions of the river basin governance agencies. Establish an agency responsible for promoting and managing HEC in the Yangtze River basin. And the resident department can be set up at the Yangtze River Water Resources Commission. Finally, the government can rely on the multi-sectoral and multi-level government linkage mechanism of the river and lake director system to promote the implementation of specific measures for HEC in the basin.

### **Establish a mechanism to realize the value of ecological products**

Local finance for ecological compensation is not a long-term solution. New channels need to be explored to achieve new sources of economic compensation. ecological compensation linked to ecology can be achieved by accelerating the establishment of an ecological product value realization mechanism. So, it can make protection and restoration of the ecology reasonably rewarded. And the destruction of the ecology can pay a corresponding price. In this process, we should fully consider different ecological product value realization paths. And we need to focus on the government's leading role in system design, economic compensation, performance assessment, and creating a social atmosphere. We also should give full play to the decisive role of the market in resource allocation. It can



promote the effective transformation of the ecological product value. At the same time, it is necessary to establish a mechanism to investigate and monitor ecological products, promote the registration of natural resource rights, and monitor ecological product information.

And a standardized evaluation mechanism needs to be established for measuring the value of ecological products. In addition, the value realization path should be continuously enriched. Eventually, we can improve the ecological product protection compensation mechanism and the damage compensation system. These include improving the vertical ecological protection compensation system, the HEC mechanism, and the ecology damage compensation system.

### **Increase the publicity and guidance of the ecological compensation system**

To enhance the publicity and guidance of ecological compensation systems and related policies so that stakeholders can realize that HEC in watersheds is not only the responsibility of local governments. And we should enhance their enthusiasm to participate in HEC in watersheds. Firstly, we should strengthen the publicity and guidance of the news media, and carry out grounded explanations and propaganda on the connotation, role, and precautions of watershed horizontal ecological compensation in an easy-to-understand living language, enhancing their cognitive level and willingness to take action. Meanwhile, we should focus on the role of the grass-roots river and lake leaders in the knowledge and policy propagation of watershed ecological compensation. Secondly, through market-oriented reform means such as water rights and water resource tax, we should promote the importance of ecological compensation deeply felt by the stakeholders such as basin residents and enterprises. And we need to increase the enthusiasm of basin residents and enterprises to participate in basin ecological compensation (Zhang et al.,2019).

It is important to establish ways and mechanisms for third-party subjects to participate in water environment management in an institutionalized form, such as improving the water environment information disclosure mechanism and introducing third-party institutions. Also, we should promote enterprises to consciously take responsibility for water environment protection by using market-based methods and means such as user fees and property rights transactions. Last but not least, we need to encourage the whole society to participate in water environment protection by strengthening the standardization of volunteer services, building a

platform for volunteer services, increasing incentives and funding for volunteer services, enriching social information feedback channels, and strengthening publicity.

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