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Towards a Better Understanding of Social-Ecological Systems for Basin Governance: A Case Study from the Weihe River Basin, China

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Abstract: Promoting sustainable development of the river basin ecosystem is important for improving human ecological environment. Thus, prior knowledge of natural and social sciences on the integration of natural, economic, and social factors related to rivers should be assimilated to improve river basin governance. This study uses a social-ecological systems (SES) framework to diagnose key factors affecting the governance of the Weihe River Basin, ranging from the social, economic, and political context to related ecosystems, watershed resource systems, watershed management system, and watershed governance actors' five subsystems. Further, corresponding countermeasures are proposed for the problems found during our diagnosis. The results of this study show that applying an SES framework to the diagnosis and analysis of river basin governance integrates the research results of different disciplines and fields. Thus, this study is helpful in identifying and proposing the key impact variables related to river basin management to establish a comprehensive management counterplan.

Keywords: diagnose; social-ecological systems; watershed environmental governance; Weihe River Basin

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1. Introduction

With climate change and rapid population growth, governments should consider the interaction between river basins and socio-economic development. A river basin is a complete "nature–society–economy" complex system composed of natural factors such as water resources, land, and plants and human factors such as population, society, and economy [1]. The water resource is an important basic link between different units of this complex system [2]. However, with rapid economic development and population growth, the economic functions of river basins have been overexploited by human beings, while the protection of ecological functions has been neglected. This resulted in a series of eco-environmental problems, including water pollution, water ecological damage, water shortages, and frequent floods. The water eco-environmental crisis has become an important challenge to the sustainable development of human beings [3]. Therefore, river basin eco-environmental management has become an important task of ecological environment governance and should be improved to realize the coordinated and sustainable development of the economy, society, and ecological environment in the entire basin.

At present, the actual management process of river basins in China is mainly to divide the entire river according to administrative regions, which are managed by each administrative region through administrative means [4]. However, the river basin is a complex social-ecological system that involves water resources, ecological environments, and socio-economic factors. Hence, it is difficult for a single department or a single element of administrative management to solve complicated problems associated with it. Further, natural dimensions and social dimensions interweave and influence each other, making it difficult to adapt to the protection of ecological function and sustainable development of the social economy. Thus, it is urgent that we innovate and solve related problems to determine the basic function, management goal order, and feasible path of the basin from the perspective of the entire nature and society. The social-ecological system (SES) framework has been put forward [5], which provides a new direction for the solution of complex problems in river basins. Through the use of common human language, the SES framework enables researchers to more deeply analyze the interaction between variables in the complex social ecosystem so as to form a systematic knowledge accumulation of research results in different fields. The SES framework has been applied in the management of the Ganges [6]. Based on the holistic perspective between basin system and socio-economic system, this study applies the SES framework to diagnose the potential variables that affect river basin eco-environmental governance from different subsystems, combined with a case study of the Weihe River Basin (WRB), a diagnostic analysis of the WRB's eco-resources, and environmental governance to explore the optimal path to river basin governance.

2. Literature and Theoretical Analysis

The basin is a special multi-dimensional natural region linked by rivers, which has strong integrity and relevance. The global water resources management cooperation organization defines watershed governance as management to promote the coordinated development of water, land, and other related resources and to maximize economic and social welfare within the affordability of the ecosystem. The ecology regards the watershed as a complete natural unit and considers that the main content of watershed management is to plan the agriculture, forestry, animal husbandry, and fishery scientifically and to exploit natural resources such as water and land reasonably [7]. From the perspective of public management, watershed management is mainly carried out in the form of multi-agent cooperation with the participation of government, society, and the public, that is, a multi-center management process and action network with the interaction of government, society, and the market [8]. This multi-center management model will inform the development direction of watershed management in the future.

When natural science studies ecological environmental problems, it usually takes the natural ecosystem as its main research object and treats humans simply as external, neglecting the relationship between human and ecological environmental communities [9,10]. However, when social science studies ecological environmental problems, it emphasizes the importance of human social interaction, and it is relatively easy to ignore the natural background of this human interaction [11]. In fact, the watershed system is a composite system dominated by humans, resources, and ecology, including social subsystems, economic subsystems, and natural subsystems, that is, a watershed social-economic-natural composite system [12]. When any discipline studies the watershed ecological environment, it is inadequate to focus only on the specific problems within that research field. The reasons behind the watershed ecological problems are complex and diverse. The relationship between human society and the water environment is not a simple linear relationship; rather, there are complex effects, such as nonlinearity, circular feedback, heterogeneity, and mutation [13]. Based on these explorations of the relationship between human society and eco-environmental systems, also known as a human-environmental system (HES), SES has gradually developed and formed. SES regards the human social system and the ecological environment system as a multi-dimensional interactive coupled whole, the constituent parts of which are closely related and interdependent; all the natural resources used by human beings are embedded in them, whether in the form of organization or in time and space [5].

From the perspective of SES coupling, the deterioration of water ecological environments is caused by the disharmony among the population, economy, politics, science, and technology. As a part of the broader SES interaction chain, to formulate an institution suited to the local situation and to achieve success in watershed ecological environment governance, it is necessary to clarify the complex relationship between human social systems and the natural ecosystem in the organizational category, as well as in space and time [14]. This requires a common analysis framework that can not only integrate a variety of knowledge concepts in social, economic, ecological, and geographical disciplines but also accommodate multi-scale, nonlinear key variables across time and space in the social ecosystem [15]. To this end, Elinor Ostrom developed a new diagnostic method (multi-level nested framework), namely, the SES diagnostic framework, based on the common-pool resources governance theory and the institutional analysis and development framework [16]. The SES framework can integrate interdisciplinary related knowledge and provide a path for different disciplines to identify, diagnose, and analyze the sustainable development of social ecosystems. In this analysis framework, resource systems, resource units, governance systems, and actors are considered first-level variables (Figure 1). Under the regulation of the governance system, actors carry out a series of interactions around the use and maintenance of the resource system and produce corresponding results, thus forming a feedback effect on the resource system. This process closely connects human social systems and natural resource systems, constituting the action situation of ecological environment governance, and can be considered the core of the SES diagnostic analysis framework. As nodes nested in social-ecological systems, resource systems and governance systems are also affected by a wider range of social, economic, political, and ecological environmental background variables. Therefore, the SES diagnostic analysis framework is composed of eight construction units.

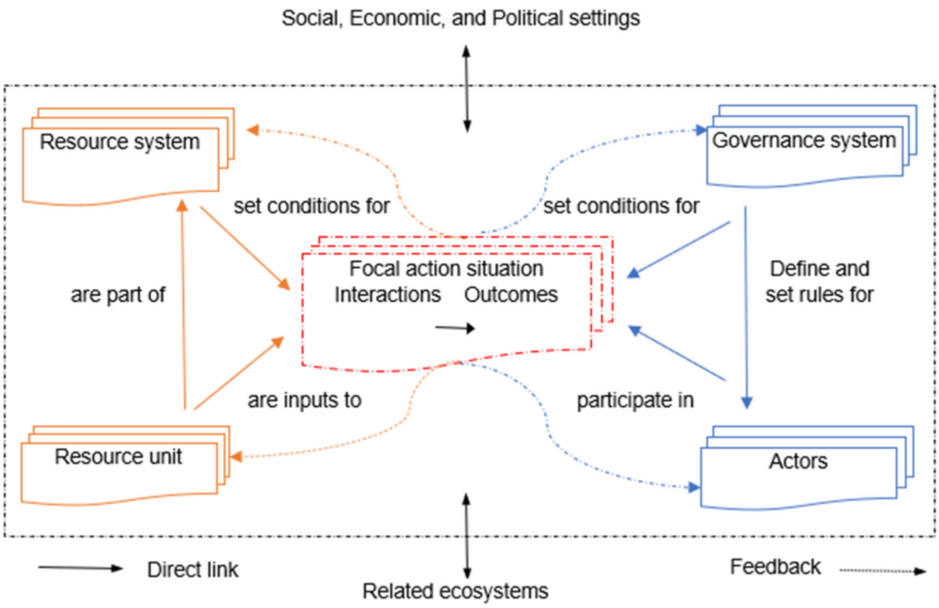

Figure 1. SES framework concept diagram. Source: Adapted with permission from Ref. [Social-ecological system framework: Initial changes and continuing challenges]. 2014, McGinnis and Ostrom.

Ostrom summarized previous research results and further subdivided the eight primary variable groups of the SES framework into several secondary variables [17]. Researchers can also continue to subdivide these secondary variable groups according to specific research needs. The application of the SES framework to diagnose the complex watershed ecological environment and identify the key factors and variables affecting the sustainable development of the watershed ecological environment is a new methodology for the study of watershed ecological environment governance. Based on the existing research literature, this paper uses the SES framework to bring complex potential variables affecting the ecological environment of the river basin into a systematic and multi-level analysis framework (Table 1) to find the key factors affecting the sustainable development and governance of the ecological environment of the river basin.

Table 1. Second-tier variables of an SES.

<table>
<tr><td colspan="2">Social, Economic, and Political Settings (S)
S1—Economic development. S2—Demographic trends. S3—Political stability. S4—Other governance systems. S5—Markets. S6—Media organizations. S7—Technology.</td></tr>
<tr><td>Resource Systems (RS)</td><td>Governance Systems (GS)</td></tr>
<tr><td>RS1—Clarity of system boundaries
RS2—Scarcity
RS3—Predictability of system dynamics</td><td>GS1—Nongovernmental organizations
GS2—Operational-choice rules
GS3—Degree of local autonomy</td></tr>
<tr><td>Resource Units (RU)</td><td>Actors (A)</td></tr>
<tr><td>RU1—Resource unit mobility</td><td>A1—Number of relevant actors
A2—Leadership
A3—Social capital
A4—Knowledge of SES/mental models</td></tr>
<tr><td>Activities and Processes (I)</td><td>Outcomes (O)</td></tr>
<tr><td>I1—Conflicts
I2—Lobbying activities</td><td>O1—Social performance measures</td></tr>
<tr><td colspan="2">Related Ecosystems (ECO)
CEO1—Climate patterns. ECO2—Pollution patterns. ECO3—Flows into and out of focal SES.</td></tr>
</table>

Source: Adapted with permission from Ref. [Social-ecological system framework: Initial changes and continuing challenges]. 2014, McGinnis and Ostrom. Note: Variables in the table are affect watershed governance analyzed and identified in this paper.

Rivers have transboundary characteristics, and the implementation of the entire watershed management plan depends on whether the watershed boundary can be clearly divided [18]. The continuous growth of the global population makes the scarcity of water resources more and more prominent [19]. The dynamic prediction of the water resources system is an important link to preventing ecological risks and water quality risks in the river basin [20]. Therefore, for the resource system, clarity of system boundaries, scarcity of water resources, and predictability of system dynamics are the key variables affecting river basin governance. Because of the mobility of water resources, the pollution of rivers presents randomness, fuzziness, and wide distribution, making it difficult to determine the restoration range of river basins [21]. Therefore, for the resource unit system, resource unit mobility is the key variable affecting river basin governance. Concerning the governance system, nongovernmental organizations (NGOs), operational-choice rules, and degree of local autonomy are the key variables affecting river and lake watershed governance. By establishing extensive cooperation with governmental organizations in river basin ecological environment governance, nongovernmental organizations directly or indirectly assist the local government in the form of research, training, publicity, and education [22]. Under the bureaucratic basin management system, the local government's basin management operating rules and the local degree of autonomy are important factors affecting the success of river basin governance measures [23]. With regard to actors, the number of relevant actors, leadership, social capital, and social-ecological cognition are the key variables affecting watershed governance. The higher the number of watershed-governance-related actors, the higher the potential scale benefit of watershed governance will be, but correspondingly, transaction costs will also increase [24]. The ecological awareness, social capital, and leadership of river basin governance participants will affect their sense of responsibility and initiative and ultimately determine the effect of public participation in river basin governance [25]. In the analysis of specific cases, the identification of key variables may be far more than these, and researchers need to make their own judgment.

3. Weihe River Basin (WRB) Introduction and Governance Process

3.1. Data Collection

The basic overview information of WRB comes from the materials provided by the Shaanxi Provincial Department of Water Resources and the Department of Natural Resources. The hydrological information of the WRB comes from the statistical data set of natural conditions of WRB (1999–2017), the environmental status bulletin of Shaanxi province (2018), and the Annual Hydrological Data of the Yellow River Basin (2001–2016).

3.2. Overview of the WRB

The WRB, an important part of the Loess Plateau, is the largest tributary of the Yellow River. It originates in Gansu province, flows through Shaanxi province, and flows into the Yellow River at Tongguan County of Shaanxi Province. The WRB covers an area of 135,000 km^2, and the total length of the main stream is 818 km, among which Shaanxi province covers an area of 67,600 km^2, and the length is 512 km (Figure 2). The annual average runoff in the Shaanxi section of the Weihe River is 4.424 billion m^3, the annual average flow is 140 m^3/s, and the annual average sediment discharge is 118.5 million tons [26]. The farmland irrigation area of the Weihe River is nearly 93,300 hm^2, and 65% of Shaanxi's GDP is concentrated in the WRB. Weihe River is the only sewage and wastewater receiving and discharging channel in the Guanzhong area of Shaanxi Province, receiving 78% of industrial wastewater and 86% of domestic sewage in the province.

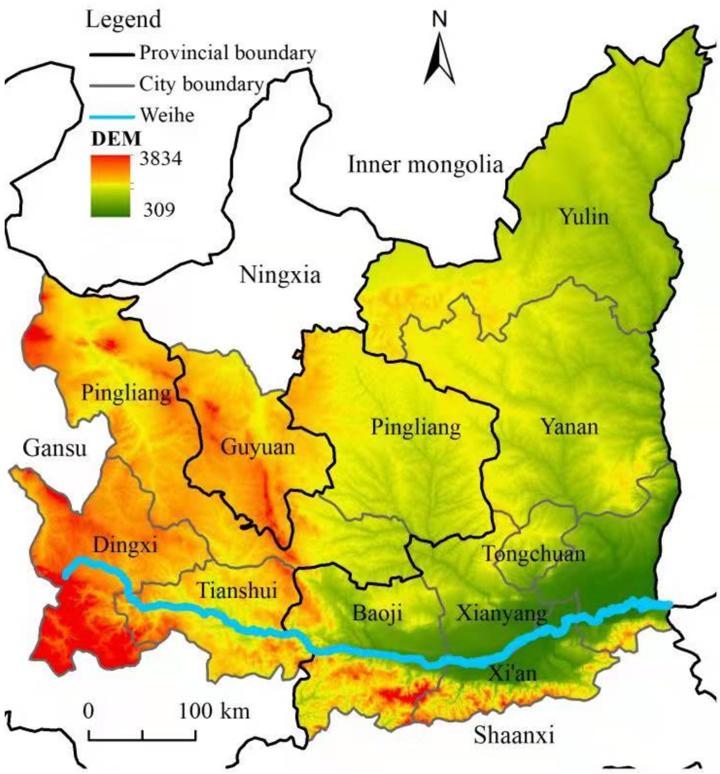

Figure 2. Schematic diagram of Weihe River Basin Governance process concerning the WRB.

Since 1949, the Chinese government has not stopped harnessing the WRB, having built a large number of embankment projects and a complete flood control system and having ensured the normal agricultural production of nearly 598,000 people on both sides of the river. In 2004, Xianyang city started the "Xianyang Lake" construction project. The Xianyang section of the Weihe River has built a water surface landscape of 720 hm^2 with a length of 13.4 km, a width of 500–700 m. In 2015, the Xi'an railway bureau built a new concrete face rockfill dam in the main channel of the Weihe River one km downstream of the railway bridge, effectively controlling the threat of the riverbed undercutting railway safety. In 2017, the 105 km flood control dike in Xianyang city was built, which significantly improved the flood control capacity of the WRB and became a new highlight of economic and social development along the river.

At the end of the last century, due to the general pollution of trunks and tributaries, the water quality of the Weihe River was poor. In 2000, class III water quality accounted for 37.2%, class IV water quality accounted for 12.2%, and class V water quality accounted for 50.6% in the main stream of the Weihe River. The water quality of the river section under the jurisdiction of Xianyang city is in class V all year round, which has lost the basic function of a water body, and its fish are extinct. In 2016, the water quality of the Xianyang city section of the Weihe River was at a class IV water standard. In recent years, the water conservancy department has carried out artificial proliferation and stocking activities in the Weihe River, successively built 337 hm^2 of aquaculture water surface dominated by intensive ponds, and its production capacity has reached 4644 tons, which has restored the fishery resources of the Weihe River to a certain extent

After years of treatment, especially the construction of a comprehensive restoration project, the basin environment of the Xianyang city section of the Weihe River has undergone fundamental changes compared with before. However, the ecological environment management of the WRB still poses many problems. The first is the lack of ecological river flow. According to the regulations, the ecological flow of the Weihe River is 15 m^3/s, and the good ecological flow is 20 m^3/s. According to the statistical data from 2004 to 2011, the ecological flow was still less than 15 m^3/s in some periods from December of that year to March of the next year, and the maximum occurrence days reached 76 days. The period for which there is less than 20 m^3/s of good ecological flow is mainly concentrated from June to August each year, and its maximum duration is 43 days. The second is the serious problem of main channel undercutting. In 2013, compared with 1999, the average channel thalweg point was cut down by 6.78 m, and the maximum cutting depth reached 8.69 m. The average undercut of the main channel in the Xianyang section of the Weihe River is about 7 m. The third is the difficulty of river management. In 2014, Shaanxi provincial department of water resources requested that the mining of the entire Weihe River be banned, resulting in a rapid rise in sand prices; some sand mining enterprises were driven by explosive profits to illegally mine.

4. Diagnosis and Countermeasures in Weihe River Governance

The case of the WRB is a typical representation of water resources shortage, serious pollution, and sediment-laden rivers in western China. In recent years, the government has formulated a large number of policies for the ecological environmental restoration of the WRB, which has improved the ecological environment of the WRB to a certain extent but has not effectively solved the problems existing in river basin governance from the perspective of sustainable development strategies such as regional ecological environment planning, regional ecological environment security, and improving the welfare of river basin populations. With the help of the SES framework, this paper diagnoses and puts forward countermeasures for the governance of the WRB from the perspective of watershed sustainable development strategies.

4.1. Social, Economic, and Political Settings

Banpo-xiyin culture bred in the WRB was the most powerful culture in the entire land of China at that time and the main root of the ancient culture of the Chinese nation. The upper reaches of the Weihe River had a primitive agricultural civilization as early as the Palaeolithic age. The profound historical and cultural heritage of the WRB plays an important role in the developmental history of Chinese civilization. Today, the WRB is still the main grain production base in western China. More than 9333 hm^2 of farmland in the entire basin feeds 64% of the population of Shaanxi Province. The WRB plays a vital role in Shaanxi's economic and social development. As the largest tributary of the Yellow River, the Weihe River also undertakes to protect the flood control safety of north

China, east China, and the Huanghuai plain. Its ecological change is closely related to the ecological environmental safety of the middle and lower reaches of the Yellow River and has an overall impact on the economic development and ecological environmental improvement of the entire country.

Based on the social, economic, and political settings, the WRB is an important ecological barrier and key economic belt in China and plays an extremely important role in China's socio-economic development and ecological security. Ensuring the high-quality development of the Weihe River is the key link to ensuring the major national strategy for the protection and development of the Yellow River basin. The top-level design of the ecological environment governance policy mechanism of the WRB should adhere to the macro environmental perspective of sustainable development; develop a comprehensive, systematic, and appropriate governance policy mechanism from the national strategic level, ensuring the long-term stability of the Yellow River basin; promote the high-quality development of the Yellow River basin; improve the quality of people's lives near the basin; and inherit and preserve the Yellow River culture so that immediate problems and long-term interests in watershed governance can be well-coordinated and unified.

4.2. Related Ecosystems

Watershed systems are complex, open, dynamic, unbalanced, and nonlinear ecosystems connecting climate, vegetation, and biodiversity. The WRB is located in the transition zone between humid and arid areas. The climate is dry and cold in winter and hot and rainy in summer. The annual average temperature is maintained at 8–13 °C, the annual average rainfall is about 572 mm, and the annual average water surface evaporation is 660–1600 mm. The main land types of the entire basin include cultivated land, forestland, and grassland. The vegetation in the basin varies greatly; from south to north is the transition from a warm temperate zone and temperate broad-leaved deciduous forest zone to grassland vegetation, and the vegetation in some areas is affected by microclimates and topographic factors. The problem of water and soil loss caused by loose soil and strong rainstorm scouring in the WRB has been serious. Therefore, since 1999, the government has implemented the policy of returning farmland to forest and grassland, and they have carried out engineering projects such as returning farmland to forest and grassland status, closing mountains for afforestation, and natural secondary forest protection in the tributary areas of the Weihe River, which has significantly improved the vegetation coverage of the entire basin. The WRB is rich in biological populations, including 57 zooplankton, 11 protozoa, 33 rotifers, 7 cladocerans, and 6 copepods. These biological groups have special positions and functions in the river ecosystem, which can indicate any changes in the river's ecosystem.

Beginning with the overall situation of national ecological security, considering the integrity of the ecosystems in the WRB, we can improve the mechanism of ecological and environmental protection in the WRB. The ecosystem of the WRB is diverse and has good ecological functions, such as soil and water conservation, wind prevention and sand fixation, climate regulation, water resource supply, and biodiversity. The design of policies and systems related to watershed governance must involve the following: coordinating the protection and sustainable development of these ecosystem functions; canceling the single ecological construction project in the basin and comprehensively considering the protection, restoration, management, utilization, and development of the ecology in the entire basin; gradually turning tree planting, grass planting, mining, and grazing prohibition projects into an ecological restoration, protection, and long-term sustainable development projects; effectively combining ecosystem protection with the rational utilization of resources; and designing a restored ecosystem sustainable utilization scheme according to the ecological characteristics of different regions near the basin.

4.3. Resource Systems

The area of the WRB accounts for 17% of the Yellow River, the total amount of water resources accounts for 17.3% of the Yellow River, and the river sediment content accounts for 35% of the Yellow River. The entire WRB crosses three geomorphic units: the Loess Plateau, the Guanzhong Basin, and the mountains at the northern foot of the Qinling Mountains. The main stream runs east-west across the Guanzhong Basin, and 16 tributaries with an annual runoff of more than $1 \times 108\ m^3$ are distributed on the north and south banks. The tributary on the south bank of the Weihe River originates from Qinling Mountains, with a short source and rapid flow, and abundant water. The tributaries on the north bank have far sources and long flows, and the sediment concentration of the river is relatively high here. The water quality and quantity of the Weihe River are regulated and influenced by the tributaries of the north and south banks. The distribution of water resources in the entire WRB has the characteristics of being more in the west and less in the east, and more in the south than in the north. The annual average flow in the Guanzhong area is $73.7 \times 108\ m^3$, and Baoji city in the west is $36 \times 108\ m^3$, Weinan city in the east is only $7.82 \times 108\ m^3$, Tongchuan city in the north is $2.06 \times 108\ m^3$. The WRB system has the geographical characteristics of self-production, self-use, and self-cultivation. The quality of the ecological environment of the basin is seriously dependent on the river water volume. The distribution of precipitation in the basin varies greatly throughout the year. The precipitation is mainly in summer and autumn. The precipitation in the flood season from June to September reaches more than 60% of the annual precipitation, which is prone to flood. Due to the limited capacity of reservoirs in the basin, and most of them are mainly used for farmland irrigation and urban water supply, the flood resources cannot be well utilized, which reduces the utilization efficiency of water resources in the entire basin.

According to the characteristics of the water resources system in the WRB, taking the sustainable socio-economic development and ecological environment improvement of the entire basin as the governance goal, and on the premise of ensuring that the water demand of the ecological environment is met, the water volume in the basin is reasonably allocated to improve the utilization efficiency of water resources in the basin. Owing to the spatial differences between the utilization of water resources and the level of socio-economic development, the imbalance of the regional socio-economic development, and the deterioration of the ecological environment caused by the uneven distribution of water resources in the WRB, the assignment rule and utilization model of water resources in various regions of the basin are formulated according to local conditions. Further, the surface water and groundwater, local water, and external water in the entire basin comprehensively mobilize. This makes the ecological, economic, and social values of water resources development and utilization in the basin reach the best state.

4.4. Governance Systems

The core departments involved in the WRB governance system are mainly water conservancy departments and environmental protection departments. In addition to the two core departments, agriculture, forestry, transportation, fisheries, and other departments undertake certain governance functions within their respective responsibilities. Although according to the provisions of China's environmental protection law, the environmental protection department implements unified supervision and management on the prevention and control of river basin water pollution, due to the lack of management authority of the environmental protection department, it is difficult for multiple departments to coordinate river basin governance affairs. Further, due to the problems incurred by unclearly defined responsibilities and coordination difficulties among various departments, there is a separation in systematicness between natural elements in the entire watershed, which is easy to make watershed governance fall into the dilemma of collective action. According to China's current water law, water resources management should implement the management system of combining river basins with administrative regions, emphasizing the integrity of river basins in water resources management. However, China's law on the prevention and control of water pollution also stipulates that administrative regions at different levels should implement river basin protection and pollution prevention and control in their own administrative regions at different levels and sections. This leads to the contradiction between the hierarchical and segmented management of the watershed and the integrity of the watershed. In view of these institutional obstacles and imperfect systems existing in river basin governance, the state has carried out the river chief system (RCS) governance policy. The purpose is to vertically integrate the fuzzy and decentralized governance responsibilities through a local chief executive responsibility system to avoid the dispersion of responsibilities among different governance departments and the contradiction between subsection governance and the entire river basin cross-regional governance.

RCS policy is an institutional innovation with distinctive Chinese characteristics, which gives full play to the coordination advantages of the party and government system in river basin governance. However, in the implementation of the RCS policy, there are also some problems, such as the lack of interest incentive between superior and subordinate river chiefs and the lack of an interest coordination mechanism between cross administrative regions. Introducing market mechanisms into RCS policy could effectively improve the endogenous driving force of watershed governance. As the main person in charge of the basin unit, the river chief has clarified the property right and responsibility boundary of governance, which provides a basis for using market mechanisms to solve the environmental externalities of the basin. Through the model of government guidance and market participation, the market mechanism plays a leading role in the ecological environment governance of the basin, and the government only plays the role of coordinating and supervising the meta governance function.

4.5. Actors

With the development of polycentric governance theory, the state's ecological environment governance is no longer one-dimensional but integrates various social forces for ecological environment governance from the perspective of public participation. The ecological environment is closely related to everyone and every social organization. It is not only the material basis for their common survival but also their common interests. Therefore, they have the goal of participating in ecological environment governance and enjoying a good environment together. In river basin governance, the government, social organizations, enterprises, and residents constitute the multiple subjects of governance and are the main governance actors. The government occupies the core position among these governance actors and is the core force of river basin ecological environment governance. It has absolute rights and has the most resources. It is not only the implementer of national ecological environment political will but also the aggregator of local social public environmental public opinion. Additionally, the government can take ecological environment governance actions in time. It is not only the designer and coordinator of watershed governance rules and governance patterns but also the ultimately responsible subject of watershed governance. Its concept, behavior, and mode of watershed governance determine the success or failure of watershed ecological environment governance. In fact, the government often passively participates in river basin governance under political pressure, and other participants passively participate in river basin governance only when their own interests are infringed or induced by interests, which makes it easy for river basin environmental governance to fall into the trap of pursuing short-term effects.

In the watershed ecological environment governance, local governments should break away from the conventional governance model and avoid the disadvantages of high governance cost, insufficient effectiveness, and legitimacy caused by maintaining their own authority. As the direct beneficiaries of the local river basin environment, social organizations, enterprises, and residents not only have a strong sensitivity to the local river basin's eco-environmental problems but have also formed, through their life practices, some experience and common sense regarding the river basin's environmental problems. Therefore, absorbing them into the framework of river basin eco-environmental governance actors can effectively improve the legitimacy and effectiveness of governance and reduce the cost of watershed environmental governance. As the core actor of the river basin eco-environmental governance, the government should adhere to the governance concept of openness, inclusiveness, mutual benefit, and cooperation. Further, it must provide a platform for all actors involved in river basin governance to make river basin eco-environmental governance an orderly and effective national endeavor.

5. Conclusions

How to diagnose the changes in the social ecosystem in complex river basins has been an important challenge for social scientists for a long time. Using the SES framework and the relevant archives of the WRB cases, a diagnostic analysis of the social ecosystem of the WRB was conducted in this study, and corresponding treatment countermeasures were proposed according to the diagnostic analysis results of the SES framework. When applying the SES framework to diagnose the eco-environmental governance of the WRB, we established that the application of the SES framework to identify the key influencing factors of watershed governance has good comprehensiveness and explanatory power.

The SES framework was used to diagnose and analyze the ecological environment governance of the WRB, which provides a path for systematically formulating and designing the governance policies of the WRB. From the social, economic, and political perspectives, the WRB is the main birthplace of China's agricultural civilization, an important ecological barrier, and a key economic belt, and plays an important role in socio-economic development and ecological security. Therefore, the top-level policy design from the perspective of sustainable development of the basin is the basis of the governance of the WRB. The WRB is also a complex ecosystem connecting climate, vegetation, and biodiversity. The integrity of the ecosystem is something that must be coordinated in the formulation of governance policies of the WRB. As the largest tributary of the Yellow River, the Weihe River water resources system has its own characteristics. Thus, the WRB governance policy should aim to formulate the water resource distribution rule and utilization mode in the basin according to local conditions and to ensure that the eco-environmental water demand is met. WRB governance involves multiple departments and spans multiple administrative regions. Introducing market mechanisms into the WRB governance system and solving the problems concerning lack of interest incentives and insufficient coordination mechanisms between different administrative departments and administrative regions in river basin governance are important contents of the WRB governance policy design. A watershed ecological environment is the common material basis for the survival of everyone and every social organization, which is directly related to their own interests. Absorbing them as governance actors in watershed ecological environment governance is also an important aspect of WRB governance policy design.

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