Vertical Embedded Governance and Oasis Ecological Space Production: A Postprint Study on Ecological Governance in the Ejina Oasis

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Abstract

Oases represent the essence of arid inland regions and constitute challenging areas for ecological civilization construction. Strengthening research on oasis ecological governance holds significant theoretical and practical importance for advancing regional ecological civilization construction. For a long time, research on oasis ecological governance has emphasized promoting oasis ecosystem restoration through technical means and economic measures, while paying insufficient attention to the role of actors in ecological governance, thereby affecting the effectiveness and sustainability of oasis ecological governance. This study takes the Ejina Oasis as a case study, and based on in-depth investigation, draws upon spatial production theory and regional governance theory to explore the production process of oasis ecological space under vertically embedded governance through policy tool portfolio analysis. The results indicate: (1) The institutional embedding of the central government broke the traditional water resource allocation orientation of "taking grain as the key link," transforming the basin water use system from a "grain production preference" to an "ecological protection preference." The oasis has been constructed as a national ecological conservation space, becoming an important ecological security barrier in northern China. (2) The administrative embedding of the central government reshaped basin water use relationships and water rights order, facilitating water quantity regulation in the main stream of the Heihe River and achieving increased water inflow to the oasis. The East Juyan Lake, which had been dry for many years, now has a stable water surface and has been developed as an eco-tourism scenic area, transforming from a Gobi desert lake wetland into an ecological sightseeing destination, thereby reconstructing the ecological space at the terminal of the Heihe River. (3) The rule embedding of the central government resolved the funding shortage problem in oasis engineering construction. Through artificial control of oasis irrigation and protected area-based governance of oasis ecology, it achieved the canalization of oasis river networks and the functionalization of

oasis space, transforming the oasis from a border pastoral production and living space into a national key ecological function space.

Full Text

Vertical Embedded Governance and the Production of Oasis Ecological Space: A Study of Ecological Governance in Ejina Oasis

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Abstract: Oases represent the essence of arid inland regions yet pose significant challenges for ecological civilization construction. Strengthening research on oasis ecological governance holds important theoretical and practical significance for advancing regional ecological civilization. For a long time, studies on oasis ecological governance have emphasized technical and economic measures to promote oasis ecosystem restoration, paying insufficient attention to the role of actors in ecological governance, which has affected the effectiveness and sustainability of oasis ecological governance. Taking Ejina Oasis as a case study and drawing on in-depth field research, this paper employs spatial production theory and regional governance theory to investigate the production process of oasis ecological space under vertical embedded governance through policy tool combination analysis. The results show that: (1) Institutional embedding by the central government broke the traditional "grain as the key link" orientation in water resource allocation, shifting the basin water system from a "food production preference" to an "ecological protection preference." The oasis was constructed as a national ecological conservation space, becoming an important ecological security barrier in northern China. (2) Administrative embedding by the central government reshaped basin water use relations and water rights order, facilitating unified water allocation in the main stream of the Heihe River and increasing water inflow to the oasis. East Juyan Lake, which had been dry for many years, now maintains a stable water surface and has been developed as an eco-tourism scenic area, transforming from a Gobi desert lake wetland into an ecological tourism destination and reconstructing the ecological space at the Heihe River' s terminus. (3) Rule embedding by the central government solved the funding shortage problem in oasis project construction. Through artificial control of oasis irrigation and zoned governance of oasis ecological protection areas, the canalization of oasis river networks and functionalization of oasis space were achieved, transforming the oasis from a border pastoral production and living space into a national key ecological functional space.

Keywords: vertical embedded governance; ecological space production; ecological governance; ecological civilization construction; Ejina Oasis

Oases are the essence of arid inland regions and also the most challenging areas for ecological civilization construction. They concentrate the vast majority of regional population and social wealth while bearing the heavy responsibility of maintaining regional and even national ecological security. Since the 20th century, rapid economic and social development has been accompanied by increasingly prominent ecological and environmental problems. How to coordinate oasis economic and social development with ecological and environmental protection and promote effective oasis ecological governance has become an urgent scientific and practical challenge.

Ecological governance is an interdisciplinary research issue that has attracted widespread attention from scholars both in China and abroad. Oasis ecological degradation is mainly characterized by land degradation, particularly desertification, and research on its governance has primarily focused on desertification control. International research on desertification control began relatively early, initially concentrating on ecology. In the 1930s, the "Black Storm" in the United States had a significant impact on global desertification control, leading to the development of desertification control technologies that were widely applied. Western developed countries such as the United States, Israel, and Australia have developed and accumulated numerous ecological governance technologies through implementing large-scale ecological construction projects and protection programs. After the 1970s, as surface ecological processes were increasingly affected by human activities, social sciences gradually became involved, and the importance of social, economic, and cultural factors in ecological governance processes gained attention. The interaction between stakeholders and ecological governance has attracted researchers' strong interest. Debra reviewed the perspectives of social science scholars on environmental governance, pointing out the need to pay more attention to the role of state and social forces in environmental governance. From a multi-level environmental governance system, researchers explored how multiple actors influence environmental governance through different levels of power, authority, and action. Thorunn et al. noted that the effective restoration of large-scale ranch ecosystems depends on the functions of relevant policies, stakeholder groups, and the surrounding socioeconomic and political environment. Heidi et al. found that in an era of increasing emphasis on voluntary non-regulatory approaches to natural resource management, government still plays a fundamental role in water resource management.

Domestic oasis desertification control developed based on China' s sand prevention and control work in the 1950s. With the launch of major national ecological projects such as the "Three-North" Shelterbelt System Project, the Grain for Green Project, and the Beijing-Tianjin Sand Source Control Project, research on oasis desertification control gradually deepened. During this period, researchers also developed a series of internationally leading technical systems based on different types of experimental research stations and demonstration areas, and actively carried out research on multi-technology collaborative application, exploring Xinjiang' s Hotan model, Gansu' s Linze model, and Inner

Mongolia' s Dengkou model, which are suitable for desertification prevention and control in extremely arid regions and oasis areas in northwest China. Since the 21st century, with the deepening and expansion of oasis desertification control research, domestic scholars have combined desertification control with rural economic development, proposed eco-economic models for desertification control, and conducted detailed analyses of policy systems affecting desertification control, pointing out that institutional factors have become key to successful desertification control. In recent years, scholars have gradually realized the role of actors in oasis ecological governance, emphasizing interaction and cooperative governance among different actors, and believing that multi-actor governance models are effective paths for oasis desertification control. However, in the process of multi-actor cooperative governance, especially in cross-regional cooperative governance, collective action dilemmas often arise, requiring the combination of vertical embedding of higher-level governments with horizontal coordination of local governments to solve ecological and environmental collaboration dilemmas.

Overall, scholars at home and abroad have achieved rich research results in oasis ecological governance, but there are still some shortcomings. First, existing research has focused on engineering technical means and economic measures for oasis ecological governance, as well as policy and institutional arrangements, with limited attention to the role of actors in ecological governance. Second, existing research has not given sufficient attention to the spatial dimension of ecological governance, ignoring both the fundamental and constraining role of space in oasis ecological governance and the role of ecological governance as an important force in the production and reconstruction of oasis space.

After the outbreak of the oasis ecological crisis, under the vertical embedded governance of the central government, unified water allocation in the Heihe River officially began. The water diversion target was achieved in 2002, and emergency water allocation was transferred to normal allocation in 2004. After more than a decade of water allocation, the trend of sharp ecological deterioration in the oasis has been curbed and the ecological environment continues to improve. However, the oasis ecosystem remains fragile, and how to promote coordinated watershed ecological protection and achieve effective oasis ecological governance remains a major issue facing the advancement of oasis ecological civilization construction. Therefore, this paper takes Ejina Oasis as a case study, using hydrological monitoring data, engineering construction data, and social interview data, and employing field investigation, in-depth interviews, and data analysis methods to analyze the production process of oasis ecological space since the outbreak of the ecological crisis, revealing the relationship between oasis ecological governance and spatial production. The aim is to provide theoretical and case support for enriching and expanding ecological governance research and promoting the transformation of oasis ecological governance from technological governance to actor governance in the new era.

1 Study Area Overview

Ejina Oasis is one of the three ecological defense lines in Alxa League and the first ecological barrier in Northwest and North China. In spring 2000, North China, including Beijing, suffered five consecutive severe sandstorms, with frequency, intensity, and scope unprecedented since the founding of the People' s Republic of China. The sand source area, Ejina Banner, became the focus of news attention, and the oasis ecological crisis came to the surface. After more than ten years of water allocation in the Heihe River, the trend of sharp ecological deterioration in the oasis has been curbed and the ecological environment continues to improve.

Ejina Banner is located at 97°10 23 -103°7 15 E, 39°52 20 -42°47 20 N, in the lower reaches of the Heihe River basin in the westernmost part of Inner Mongolia Autonomous Region. It borders Alxa Right Banner of Alxa League to the east, Subei Mongolian Autonomous County and Jinta County of Gansu Province to the west and south, and reaches the China-Mongolia border to the north (Figure 1). The national border within the territory is 489 km long, making it an important border defense town in Northwest China. The banner extends 324 km from east to west and covers an area of 1.15$×10^{5}$ km^2, making it the largest banner (county) in Inner Mongolia Autonomous Region. Ejina Banner is deep in the hinterland of the Eurasian continent, with a typical temperate desert continental climate. The average annual precipitation is 40 mm, evaporation is 2500–4000 mm, and the average annual temperature is 8.6°C, making it an extremely arid region. In 2018, the registered population of the banner was $33.3\times10^{4}, with a GDP of 3.805\times10^{9}$ yuan and a three-industry structure ratio of 8:27:65.

The Heihe River is the only seasonal river entering Ejina Banner. After entering the banner, it is called the Ejina River. After passing Langxinshan, it divides into the East and West Rivers, eventually flowing into the terminal lakes of East and West Juyanhai. Oases developed along the river, forming the Ejina Delta surrounding the East and West Rivers (Figure 1). After the 1960s, with increased water use in the middle reaches of the Heihe River, the water volume flowing into the lower reaches decreased significantly. West Juyanhai and East Juyanhai dried up completely in 1961 and 1992, respectively, and the oasis ecological environment deteriorated sharply.

2.1 Theoretical Perspective and Analytical Framework

Spatial production theory, proposed by French thinker Lefebvre, posits that space is a social product. He constructed a three-dimensional theoretical framework for spatial production from the dimensions of perceived, conceived, and lived space: spatial practice, representations of space, and representational spaces. This theory treats material, social, and cultural space as a whole, deeply revealing the interaction between space and the social, political, and economic factors that shape it. It has been widely applied in urban studies, tourism stud-

ies, rural studies, and other fields, and has recently begun to permeate ecological governance research, demonstrating its profound insight and explanatory power and helping to examine ecological governance research more comprehensively and systematically.

Spatial production theory provides an important theoretical perspective and analytical framework for oasis ecological governance research. Oasis ecological governance is not only a process of oasis ecosystem protection and restoration but also a process of oasis ecological space production, a spatial governance practice jointly conducted by multiple actors. Oasis ecological space production is the process in which, under specific historical backgrounds, to maintain oasis ecosystem stability, enhance oasis ecosystem service functions, and ensure regional and national ecological security, multiple social actors use various means such as reforming watershed management systems, implementing comprehensive watershed management, and adjusting local development modes to reshape oasis space and form new oasis ecological space. Oasis ecological space production includes three dimensions: the perceived dimension of oasis ecological spatial practice, the conceived dimension of oasis ecological spatial representation, and the lived dimension of oasis representational ecological space.

Vertical embedded governance is an institutional arrangement adopted to solve problems in regional cooperative governance, such as lack of binding force in horizontal government coordination, simultaneous over-embedding and under-embedding of vertical governments, and relatively weak social organization forces. It requires embedding the central government into the regional cooperative governance network and organically combining vertical mechanisms with horizontal mechanisms to overcome regional cooperative governance dilemmas and form a vertical embedded governance mechanism. The key to applying the vertical embedded governance mechanism is to determine the timing and manner of vertical embedding according to regional cooperation characteristics, emphasizing the selection and combination of policy tools to act on the regional cooperation process. Based on the complexity of regional governance problems (conventional to interventionist) and the rigidity of vertical government embedding (coordinative to mandatory), vertical embedded governance policy tools are divided into four types: political embedding, administrative embedding, institutional embedding, and rule embedding (Figure 2). In regional cooperation practice, these four types of policy tools are often used in combination to form a bundle of vertical embedded governance policies.

Political embedding is highly interventionist, facing relatively complex regional cooperation problems that require local governments to strictly follow the instructions of the central government, otherwise they must bear political responsibility. The central government intervenes in regional cooperation through strategic policy formulation, political propaganda and mobilization, organizational and personnel appointments, and supervision and inspection. In this type of policy tool, the degree of vertical government relationship embedding is the strongest, and the efficiency of problem-solving is relatively high.

Institutional embedding is when the central government, according to the needs of regional cooperative governance, leads local governments or government departments involved in regional cooperation to form coordinating institutions to solve regional cooperation problems. Institutional embedding is not highly interventionist but organizes regional cooperation parties and embeds them into the regional cooperation process by establishing communication, exchange, and consultation platforms, including establishing regional cooperation leading groups and setting up regional cooperation management institutions.

Administrative embedding is a policy tool through which the central government intervenes in regional cooperation by stipulating administrative measures, issuing administrative regulations, publishing decisions and orders, and formulating strategic plans, helping to solve the "cooperation paradox" among local governments. Administrative embedding is an interventionist policy tool type with a high degree of central government embedding.

Rule embedding is a policy tool through which the central government solves cost-sharing and benefit distribution problems in local government cooperation by formulating corresponding rules to provide platforms and incentives, generally using economic and institutional means to solve cost-benefit problems. Rule embedding requires the higher-level government to coordinate the interests of all stakeholders and is the policy tool type with the lowest degree of central government intervention.

This paper integrates vertical embedded governance theory with spatial production theory to explore the relationship between vertical embedded governance policy tools and different dimensions of oasis ecological space production, forming a theoretical analysis framework with subject governance characteristics (Figure 3). It deeply analyzes the oasis ecological space production process and its embedded problems, clarifies how central government vertical embedded governance produces and reconstructs oasis space, and provides scientific support for improving oasis ecological governance research and achieving effective oasis ecological governance.

2.2 Research Methods and Data Sources

This paper adopts a combination of field investigation, in-depth interviews, and data analysis. The data mainly include hydrological monitoring data, engineering construction data, and social interview data. Hydrological monitoring data refer to the water discharge at major hydrological sections of the Heihe River main stream, water inflow to East Juyanhai, lake area, and water surface maintenance status since the unified water allocation in 2000, obtained from the Heihe River Basin Management Bureau and Ejina Banner Water Affairs Bureau. Engineering construction data include recent Heihe River (Ejina Banner) management data (water conservancy project construction and ecological project construction) and ecological migration data, obtained from the Heihe River Basin Management Bureau, Ejina Banner Water Affairs Bureau, and

Ejina Banner Agriculture and Animal Husbandry Bureau.

Social interview data were obtained from field research on oasis ecological governance and tourism development in Ejina Banner conducted by the authors from August 10 to 20, 2019. During the research period, through field visits, participatory observation, and in-depth interviews, unstructured and semi-structured interviews were conducted with different social groups on multiple aspects. To ensure sample representativeness, the research conducted 30 in-depth interviews. General interviews used random sampling methods, with the authors randomly selecting 15 local residents of different ages, genders, and ethnicities at oasis ecological migration resettlement sites and Juyanhai scenic areas for 15–30 minute unstructured interviews. Key informant interviews used non-random sampling methods, with the authors selecting 15 government staff members of different positions and ranks from the Ejina Banner Water Affairs Bureau, Agriculture and Animal Husbandry Bureau, and Tourism Bureau for semi-structured interviews lasting more than 30 minutes.

3 Vertical Embedded Governance and Oasis Ecological Space Production

The spatial coupling of desert systems and the scale dependence of oasis ecosystems determine the complexity of oasis ecological governance, involving watershed water resource allocation and water use relationship adjustment. Watershed ecological co-governance has become the prerequisite for oasis ecological space production. In the oasis ecological governance process, the central government promotes watershed ecological co-governance through institutional embedding.

In 1999, the Yellow River Conservancy Commission of the Ministry of Water Resources established the Heihe River Basin Management Bureau (hereinafter referred to as "Heihe Bureau"), responsible for the unified management and allocation of Heihe River water resources, exercising the functions of the water administrative department of the Heihe River Basin. Considering the complexity of water issues in the Heihe River Basin, the Ministry of Water Resources established the Heihe River Basin Comprehensive Management Joint Meeting Committee in 2001. The committee consists of the Ministry of Water Resources, provinces (regions) within the basin, Dongfeng field area, and the Yellow River Conservancy Commission, responsible for negotiating and resolving major issues in the comprehensive management of the Heihe River Basin. The implementation of matters agreed upon in the joint meeting is supervised by the Yellow River Conservancy Commission.

Institutional embedding has played an important role in promoting watershed management system reform. First, it ended the fragmented water resource management approach in the basin, established a water resource management system combining watershed management and regional management, and achieved the transformation of water allocation from intra-provincial to inter-provincial.

Second, the establishment of watershed management institutions provided a platform for basin parties to express positions and bridge differences, and offered solutions to coordination problems caused by divergent interest demands among local governments, initially forming a working mechanism and order of consultation, united water management, and solidarity. Third, it promoted watershed ecological collaborative co-governance by determining the division of responsibilities among basin parties through communication and exchange, reducing transaction costs of collaborative governance.

However, institutional embedding has problems. On the one hand, as a coordinating institution, the Heihe Bureau does not have high enough authority, and there are still problems of weak implementation and ineffective supervision in actual implementation, with the stability and sustainability of the working mechanism needing to be strengthened, making it difficult to play a long-term role in watershed ecological co-governance. On the other hand, as a dispatched institution, the Heihe Bureau has limited rank and authority, and is powerless in dealing with major watershed issues such as adjusting the Heihe River water allocation scheme. In recent years, Gansu and Inner Mongolia have held different views and engaged in mutual gaming over the adaptability of the Heihe River water allocation scheme and its implementation, given the reality of "more water when inflow is abundant, more water shortage when inflow is scarce" at the Zhengyixia section. Although the Heihe Bureau has coordinated and communicated multiple times at various water allocation meetings held annually, the effects are not obvious.

3.1.2 Watershed Management Reform and Oasis Ecological Space Representation

Watershed management reform broke the traditional "grain as the key link" orientation in water resource allocation, achieving a transformation of the basin water system from a "food production preference" to an "ecological protection preference." The state produced oasis ecological space by changing spatial representation to highlight the oasis' s ecological location, forming an ecological institutional space.

The Heihe River Basin spans three different natural geographical units: the upper reaches belong to the alpine pastoral area, which is the basin' s runoff formation zone; the middle reaches belong to the irrigated agricultural area, which is the basin' s runoff consumption zone; and the lower reaches belong to the desert oasis area, which is the basin' s runoff utilization and disappearance zone. For a long time, Heihe River water resource development and utilization have been concentrated in the middle reaches' irrigated agricultural area. The historically formed "equal water distribution system"was mainly "economic equal water distribution" within the middle reaches and did not involve "economic-ecological equal water distribution" between upstream and downstream, thus forming the notion that Heihe River issues are Gansu Province' s internal issues.

"Since the central government intervened, the Heihe River has become a real river···Previously, when discussing Heihe River issues, it was about water distribution within Gansu Province and had nothing to do with Inner Mongolia and Qinghai." (FT02-XZC-A)

With the change in watershed water system preferences, the state constructed the oasis as an important ecological security barrier in northern China by reshaping ecological spatial representation discourse. In subsequent planning documents, the oasis was endowed with specific natural conservation significance and windbreak and sand fixation functions, bearing the heavy responsibility of maintaining regional and national ecological security and becoming an institutional ecological space.

After the outbreak of the oasis ecological crisis in 2000, journalists conducted field visits and interviewed watershed management institution officials. When asked about the consequences if the trend was not stopped, Chang Bingyan, then executive deputy director of the Heihe Bureau, stated that the oasis is an important ecological defense line in China, related to the ecological security of Northwest and North China. "If we lose the natural ecological barrier of Ejina Oasis, the deserts, Gobi, and severe arid areas from the Xinjiang border in the west to the Yellow River bank in the east will become connected, and the ecological environment will be more deteriorated than now, even leading to catastrophic consequences."

Subsequently, in the preface of the state' s "Heihe River Basin Short-term Management Plan," it was clearly stated that "Ejina Oasis in the Juyan Delta is not only a natural barrier to block wind and sand invasion and protect the ecology but also an important foundation for local people' s livelihood, national defense research, and border construction." The plan elevated watershed ecological governance to the national strategic level: "The ecological construction and environmental protection of the Heihe River Basin are important contents of the Western Development Strategy, not only related to the living environment and economic development of residents within the basin but also to the ecological environment of Northwest and North China. It is a major issue related to national unity, social stability, and national defense security."

Since 2010, with the release and implementation of the "National Main Functional Zone Planning," the main functional zone strategy has become the basic system guiding China' s territorial space development, and the windbreak and sand fixation function of oases has received increasing attention. In 2016, Ejina Banner was included in the national key ecological functional zone, marking that Ejina' s ecological functions have entered the national strategic level and the ecological status of Ejina Oasis as an ecological security barrier in northern China has been formally established. In the new era, with the rise of ecological civilization construction to a national strategy, the status of the oasis as an important ecological security barrier in northern China has become more prominent.

However, the problem with administrative embedding is that the "Short-term Management Plan" and Heihe River water allocation were emergency measures formulated during special periods, only addressing prominent problems in watershed water resource utilization and management. To fundamentally solve the ecological problems of Ejina Oasis and maintain and consolidate existing governance achievements, it is necessary to accelerate the implementation of comprehensive watershed planning and build a long-term mechanism for Heihe River water allocation and water resource management. In addition, administrative embedding lacks necessary legal support during implementation. Without corresponding penalties for inadequate water allocation implementation, the binding force and deterrent effect are insufficient, resulting in limited supervision effectiveness. There is an urgent need to accelerate the legislative process of the "Heihe River Basin Management Regulations" to bring watershed water resource management onto a legal track.

3.2.2 Heihe River Water Allocation and Oasis Ecological Space Practice

Heihe River water allocation is the foundation of oasis ecological space production, representing the state' s adjustment and spatial reallocation of watershed water resources through institutions. In the process of Ejina Oasis ecological governance, the central government promoted Heihe River water allocation through administrative embedding.

(1) **Issuing Heihe River Water Allocation Administrative Regulations**

To build a sound water allocation operation mechanism, the Ministry of Water Resources formulated the "Interim Measures for Water Allocation Management of the Heihe River Main Stream" in 2000. In 2009, based on systematic summarization of Heihe River water allocation experience, the "Measures for Water Allocation Management of the Heihe River Main Stream" was announced. This measure is the first administrative regulation focusing on Heihe River water resource management, providing legal norms for managing watershed water resources according to law and being of great significance for building a long-term water allocation mechanism and improving the effectiveness of watershed cooperation.

(2) **Formulating the Heihe River Short-term Management Plan**

Watershed ecological co-governance is the guarantee and promotion of Heihe River water allocation. In 2001, the State Council approved the "Heihe River Basin Short-term Management Plan" (hereinafter referred to as the "Short-term Plan"), which clarified the basic objectives and phased tasks of short-term Heihe River management and provided an overall layout for management tasks in the upper, middle, and lower reaches of the Heihe River, providing a policy basis for watershed cooperation risk control.

(3) **Establishing and Improving Water Allocation Supervision and Inspection Systems**

To ensure the order and effectiveness of Heihe River water allocation, the Heihe Bureau strengthened supervision and inspection while clarifying water allocation task division and responsibility implementation in river sections. It implemented a supervision system combining hierarchical responsibility, hierarchical supervision, watershed agency supervision, and joint supervision. During key allocation periods, the bureau conducted on-site coordination and 巡回 supervision of major water intake gates in main river sections and water storage in upstream cascade hydropower stations in counties (districts) of the middle reaches to ensure smooth Heihe River water allocation.

Administrative embedding achieved oasis water inflow increase. In spatial allocation, in normal and dry years, water use in the core area of the East River Oasis was prioritized. In wet years, on the basis of meeting core area water needs, the water allocation scale of the West River was increased to allocate water to oasis marginal areas, ecologically fragile areas, and areas that had not been irrigated for many years, achieving full flow in both East and West Rivers. In temporal allocation, emergency water allocation only conducted water allocation during key allocation periods (July 1 to October 31) each year, with "full-line closure and concentrated discharge" during allocation periods. After normal water allocation, not only was water allocation during key allocation periods strengthened, but general allocation periods (November 1 to June 30) were also emphasized, improving the effectiveness of ecological water allocation and reducing water allocation pressure during key allocation periods.

From 2000 to 2018, the cumulative inflow at the upstream Yingluoxia section was 215.29$\times10^{8}$ m^3, 11.33$\times10^{8}$ m^3 more than the multi-year average. The cumulative discharge at the middle reaches Zhengyixia section was 119.11$\times10^{8}$ m^3, an increase of 6.27$\times10^{8}$ m^3 compared with the 1990s. The cumulative discharge at the downstream Langxinshan section was 58.12$\times10^{8}$ m^3, an increase of 3.05$\times10^{8}$ m^3 compared with the 1990s. The average annual discharge was 3.59$\times10^{8}$ m^3, an increase of 0.89$\times10^{8}$ m^3 compared with the 1990s. Under basically stable inflow conditions, the downstream ecological water use increased significantly (Table 1).

(4) **Terminal Lake Scenic Area Transformation**

Juyanhai is the terminal lake of the Heihe River and also the symbol of the Heihe River' s healthy life. Since normal allocation began in 2004, East Juyanhai has maintained a certain water surface and has not dried up for the past 15 years. The water surface area is maintained at about 40 km^2. From 2004 to 2018, the cumulative inflow to the lake was 10.44$\times10^{8}$ m^3, with an average inflow of 0.61$\times10^{8}$ m^3 and a maximum inflow of 0.89$\times10^{8}$ m^3 (Table 1). With consecutive years of water inflow to East Juyanhai, groundwater has been effectively recharged, soil moisture content around the lake area has significantly increased, regional biodiversity has significantly improved, bird species have

increased from 14 to 73, and numbers have increased from several thousand to over 30,000. The Heihe River terminal ecosystem has significantly improved.

"Sandstorms are much less frequent now, maybe 3-4 times a year. More than a decade ago, we had more than a dozen each year···I remember most clearly 1993, the year Chairman Li Xiannian passed away. The whole spring was continuous sandstorms, almost non-stop. When a sandstorm hit, the sky would darken instantly, as if night had fallen." (FT03-LHA-A)

"The environmental changes are huge, like night and day. Before (Heihe River water allocation), there was no water, and sheep had no grass to eat; they were 'dry sheep.' Now there' s plenty of water and tall grass, and sheep can disappear into the grassland···Moreover, sheep have learned to enter water and become 'water sheep.' " (FT04-DBXLT-A)

With the increase of oasis water inflow, oasis ecological deterioration has been effectively curbed, and the oasis' s original natural landscape has been sought after by tourists. Local governments have timely transformed their economic development models and vigorously promoted oasis eco-tourism development. The tourism, ecological, and cultural values of East Juyanhai have been discovered and shaped into a new eco-tourism scenic area. East Juyanhai has transformed from a Gobi desert lake wetland into an ecological tourism destination, reconstructing the ecological space at the Heihe River' s terminus.

"After (Heihe River) water allocation, the (oasis) ecological environment has improved, and more and more tourists come here, from all over the country, even foreigners···The banner holds a Populus euphratica festival every year, lasting more than 20 days···(Tourism) was something we wouldn' t have dared to think about before water allocation." (FT05-JEAT-A)

3.3.1 Rule Embedding and Oasis Engineering Construction

Rule embedding is a commonly used policy tool type in vertical embedded governance, mainly manifested as financial support in oasis ecological space practice. The Heihe River Basin is located in a less-developed region of Northwest China, and funding shortage is an important factor restricting regional ecological governance. The state provided funding sources for short-term Heihe River management through public fiscal transfer payments, solving the funding shortage problem in oasis engineering construction.

According to project arrangements, the "Short-term Plan" budgeted an investment of 23.52$\times$10^{8}$ yuan, including 11.39$\times$10^{8}$ yuan for ecological construction, 11.03$\times$10^{8}$ yuan for water-saving construction, 0.25$\times$10^{8}$ yuan for the Heihe River main stream decision support system construction, and 0.85$\times$10^{8}$ yuan for basic research and preliminary work. Given the watershed' s economic foundation and ecological strategic position, funds for ecological construction and the Heihe River main stream decision support system construction were entirely invested by the central government,

while investment for irrigation area water-saving transformation was mainly from central investment with appropriate local matching.

In addition, the state also indirectly provided follow-up funding for oasis engineering construction through projects such as the grazing withdrawal and grassland restoration project, public welfare forest construction project, grassland ecological protection subsidy and reward policy, and nomadic settlement project, supporting oasis ecological construction.

Rule embedding has to some extent solved the problems of insufficient investment in ecological governance and low ecological compensation for farmers caused by funding shortage in the Heihe River Basin. However, it should be noted that because rule embedding involves finance and funding, the central government should conduct corresponding evaluations on the specificity of funds, the long-term effectiveness of results, and the continuity of funding. Additionally, rule embedding is phased, while ecological construction is long-term. If the livelihood issues of farmers and herdsmen cannot be resolved, the governance results produced by oasis ecological engineering construction will be difficult to maintain and face the risk of being destroyed again.

3.3.2 Water Conservancy Project Construction and Oasis Ecological Space Practice

Water conservancy project construction involves the repair (reconstruction) of water conservancy hubs and canal systems to control and allocate water from the middle reaches of the Heihe River and maximize the ecological benefits of water conveyance. Based on this, local governments have built a clear river water control system, reshaped the oasis river network form through artificial control of oasis irrigation, made the oasis river network canalized, and produced new oasis ecological space.

(1) **Artificialization of Oasis Irrigation**

According to the requirements of the "Short-term Plan," local governments focused on constructing the Inner Mongolia water conveyance canal, East Main Canal project, East-West River ecological water conservancy project, and Langxinshan water distribution hub project based on water availability and oasis distribution characteristics combined with natural conditions.

The Inner Mongolia water conveyance canal was constructed by building a 156 km water conveyance canal from Dadunmen downstream of Zhengyixia to the Langxinshan water distribution hub, with the entire canal lined to reduce water conveyance losses in natural river channels and increase water discharge at the Langxinshan section.

The East Main Canal was built to directly connect to East Juyanhai, constructing a nearly 110 km artificial canal from the Langxinshan water distribution hub to East Juyanhai to ensure water conveyance tasks to East Juyanhai in the lower reaches and guarantee water volume and area for East Juyanhai.

The East River river network and river channel renovation involved straightening 7 of 11 natural river channels below the Angci River water distribution gate in the oasis core area, constructing 7 branch canals, and setting up branch and lateral canals on both sides of the branch canals for two-way control.

The West River river network and river channel renovation adopted the approach of "blocking branches and strengthening main channels" to reorganize and renovate 5 West Rivers, making river water return to main channels, and newly built 1 West River water distribution hub to improve water conveyance efficiency.

The Langxinshan water distribution hub was reconstructed to improve flood control capacity, enabling it to have both water distribution and flood discharge functions to meet different water use needs in the lower reaches and achieve efficient utilization and rational allocation of water resources in the East and West Rivers.

(2) **Canalization of Oasis River Networks**

Water conservancy project construction has reshaped the river network form of Ejina Oasis, making the oasis river network canalized and forming a multi-level irrigation canal system of main canals, branch canals, and lateral canals, with some canal systems lined to reduce river seepage and improve water conveyance efficiency. Currently, the oasis (excluding the Inner Mongolia water conveyance canal) has built 1 river canal, 7 main canals, and 7 branch canals, with a total canal length of 1408.5 km (river canal length 1147.2 km, branch canal length 261.3 km, and lined length 231.1 km). The canal project includes three major areas: the East Main Canal irrigation area, East River irrigation area, and West River irrigation area, mainly concentrated in the East River irrigation area of the oasis core area, with the East Main Canal fully lined.

"Behind (oasis) ecological governance is strong support from state (fiscal) funds, such as grazing withdrawal and grassland restoration projects, public welfare forest construction projects, grassland ecological subsidy and reward policies, etc. Local finances alone are far from sufficient···I hope state projects can be continuous and stable, which is more conducive to (oasis) ecological restoration." (FT06-CYS-A)

3.3.3 Ecological Engineering Construction and Oasis Ecological Space Practice

Ecological engineering construction is an ecological construction method to reduce oasis ecological pressure, optimize oasis human-land relationships, and protect and restore the oasis ecosystem. Based on this, local governments have zoned the oasis ecological protection area, transforming Ejina Oasis into a regional and national ecological defense line, achieving functionalization of oasis space, and producing the oasis ecological space as a whole.

(1) **Zoning of Oasis Ecological Protection Areas**

The Populus euphratica forest enclosure project: The Populus euphratica forests and Tamarix forests along the Ejina River channel are important ecological defense lines of the oasis and the main body of local usable grassland. Large and small livestock in the oasis are mostly scattered in the irrigated forest grassland along the river, with prominent overgrazing phenomena. Unenclosed Populus euphratica seedlings cannot rejuvenate due to browsing by goats and camels, and the forest land is increasingly aging and declining. To prevent livestock browsing and human destruction and improve oasis forest and grass coverage, local governments implemented enclosure management in Populus euphratica forest areas (including some Tamarix and Elaeagnus forests) according to the requirements of the "Short-term Plan," with an enclosure area of 2.67$×10^{4}$ hm^2 to maximize the protection of the riparian Populus euphratica ecosystem.

The ecological migration project: According to the "Short-term Plan," local governments also transferred and relocated farmers and herdsmen living in Populus euphratica forest areas, areas with serious grassland degradation, and areas with difficulties in drinking water for humans and livestock, arranging them centrally in government-built resettlement areas and providing vocational training for them to engage in secondary and tertiary industries such as processing, tourism, commerce, catering, and transportation. By 2018, a total of 1,116 people had been transferred and relocated, accounting for 28.5% of the total farmer and herdsman population in the banner. Among them, 560 people were resettled in Dalaihobu Town and 556 people were resettled locally in sumu towns. The resettlement objects in Dalaihobu Town were from Populus euphratica forest areas and grazing withdrawal households, while the local resettlement objects in sumu towns were mainly herders from their own gacha.

(2) **Functionalization of Oasis Space**

Through ecological engineering construction such as Populus euphratica forest enclosure and ecological migration, local governments purposefully changed the relationship between local farmers and herdsmen and the oasis ecology, guided farmers and herdsmen to transform production methods, promoted reform of livestock production and management methods, and promoted transformation of regional development modes and economic structures. While building an important ecological security barrier on the northern border, they achieved functionalization of oasis space—regional and national ecological functions. Ecological engineering construction has built a good land ecological environment foundation, protecting basic ecological land such as oasis forests, grasslands, water areas, and wetlands, and ensuring a reasonable scale of ecological land. Since 2000, the proportion of forest land, orchard land, pasture land, and water areas that protect and improve the ecological environment has remained at 95% of the banner' s total area, and a land use pattern with ecological priority orientation is forming.

Ecological engineering construction has produced new spatial forms, with new spaces such as Populus euphratica forest enclosure areas, forage bases, ecological migration resettlement areas, and livestock product production and processing

bases emerging successively, reshaping the traditional living space form and economic structure of Ejina Oasis. At the same time, with extensive ecological engineering construction, the forest ecosystem dominated by Populus euphratica and Tamarix has been strictly protected, originally degraded grasslands have been restored on a large scale, the stability and security of the oasis ecosystem have been greatly improved, the main functions of the oasis have changed, and the trend of oasis spatial ecological functionalization has become increasingly obvious, gradually transforming from a border traditional pastoral production and living space to a national important ecological functional space.

4 Discussion

(1) Oasis ecological governance is a production and practice of both physical space and social space, reflecting both the physical shaping of oasis ecological space by actors (Heihe River water allocation, water conservancy project construction, ecological engineering construction, etc.) and the conflict negotiation among actors in watershed ecological co-governance, producing new oasis ecological space through relationship reshaping and meaning reconstruction. Examining oasis ecological governance from the perspective of spatial production is beneficial for breaking the traditional technical and economic tendencies of ecological governance, improving the depth and breadth of ecological governance research, and promoting the transformation of oasis ecological governance from technological governance to actor governance in the new era. On the other hand, it helps highlight the complexity of oasis ecological problems, revealing that oasis ecological governance is a spatial production practice jointly conducted by multiple actors, promoting the integration of ecological governance research and spatial production theory, and achieving coordination among space, people, and governance.

(2) The oasis ecological space production process is the result of coordinated development of human-water relations in the Heihe River Basin after vertical embedded governance. Among them, the influence of government, especially the central government, occupies an absolutely dominant position. The administrative authority and policy systems of the central government play a decisive role in oasis ecological space production. This not only demonstrates the prominent role of government in the supply of ecological public goods but also shows the powerful strength of the central government in organizational mobilization, interest coordination, policy promotion, and social integration at the macro (watershed) scale.

(3) After the central government' s vertical embedding, there are differences in local government responses to ecological governance based on their own interests. Among them, as the main beneficiary, the downstream local government has responded more actively to water allocation and oasis ecological construction according to comprehensive watershed governance requirements and has actively adjusted regional development strategies to

optimize oasis human-land relations. As the interest-losing party, the middle reaches local government is in a passive response position, lacking in implementation of the water allocation scheme and engaging in continuous debate over how to implement it and its adaptability.

(4) This paper focuses on the process of oasis ecological space representation and practice under central government vertical embedded governance through policy tool combination analysis, reflecting a "state perspective." However, for residents within the oasis, the other side of the state-dominated ecological space production process is the reconstruction of their living space. Future research needs to pay special attention to examining local residents' representational ecological space from a "life actor perspective," fully reflecting local residents' living demands and spatial identity.

5 Conclusions

Based on hydrological monitoring data, engineering construction data, and social interview data, this paper studied the production process of Ejina Oasis ecological space under vertical embedded governance through policy tool combination analysis. The main conclusions are:

(1) The central government' s institutional embedding promoted watershed management system reform, achieving a transformation of the watershed water system from "food production preference" to "ecological protection preference."The state produced new oasis ecological space by changing spatial representation to highlight the oasis' s ecological location. Through planning texts, the oasis was endowed with specific natural conservation significance and windbreak and sand fixation functions while being represented as an important ecological security barrier in northern China, completing the production of institutional rule space.

(2) By issuing Heihe River water allocation administrative regulations, formulating short-term Heihe River management objectives, and establishing and improving water allocation supervision and inspection systems, the central government completed administrative embedding, facilitating Heihe River water allocation. Based on refined spatial and temporal allocation of water resources, it achieved increased water inflow to the oasis. East Juyanhai, which had been dry for many years, now maintains a stable water surface and has been developed as an eco-tourism scenic area, transforming from a Gobi desert lake wetland into an ecological tourism destination and reconstructing the ecological space at the Heihe River' s terminus.

(3) Through the public fiscal transfer payment system, the central government completed rule embedding, solving the funding shortage problem in oasis engineering construction. Water conservancy project construction, through artificial control of oasis irrigation, reshaped the oasis river net-

work form, making the oasis river network canalized. Ecological engineering construction, through zoning of oasis ecological protection areas, built a land use pattern with ecological priority orientation, achieving functionalization of oasis space. The oasis has transformed from a border pastoral production and living space into a national key ecological functional space.

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Note: Figure translations are in progress. See original paper for figures.