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Integrated Governance of Ecological Environment in Yellow River Basin Led by Major Projects

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Abstract: The Yellow River Basin is an important ecological barrier in China. Due to its sensitive and fragile ecological nature, severe problems have arisen in some regions. Therefore, there is a need to conduct systematic planning for the ecological management of this basin to address prominent problems. To further promote the ecological protection and high-quality development of the Yellow River Basin, this study analyzes the major challenges regarding ecological protection in the region and summarizes the major problems in terms of the investment in ecological management, construction of ecological monitoring networks, and modernization of ecological management capacities. To this end, we propose a strategic system framework for integrated ecological governance in the Yellow River Basin led by major projects. Integrated ecological governance should consider the spatial differentiation of the upper, middle, and lower reaches and adhere to the principles of systematic design. Moreover, measures need to be taken to adapt to local conditions, and land and water should be linked for joint prevention and control. Additionally, major projects are required to lead integrated governance, including mountain–river–forest–farmland–lake–grass–sand integrated protection, comprehensive environmental pollution control, and ecological management modernization projects. Considering the urgency and necessity of solving current ecological problems, we propose the following suggestions: (1) establishing an ecological management project library, (2) implementing major projects in stages and in batches, (3) conducting entire-process supervision and effectiveness evaluation of major projects, and (4) strengthening scientific and technological support for major projects.
Keywords: Yellow River Basin; ecological environment; major project; integrated governance

1 Introduction

As the second longest river in China and the fifth longest river in the world, the Yellow River flows through nine Chinese provinces, including Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan, and Shandong, with a characteristic "JI" shape and a total length of 5464 km. The Yellow River flows across the east, middle, and west of China, connecting Kunlun Mountain in the west, Yinshan Mountain in the north, Qinling Mountain in the south, and the Bohai Sea in the east. It is an ecological corridor connecting the Qinghai-Tibet Plateau, Loess Plateau, and North China Plain, and has become an important ecological barrier with a fundamental ecological status in China [1]. The Yellow River Basin is one of the most vulnerable ecological systems in China [2]. Since the 18th National Congress, new strategic policies have been launched by the Chinese government for the protection

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and governance of the Yellow River Basin, ushering in a new historical opportunity for ecological protection and governance more generally. In September 2019, a major national strategy was proposed to implement the ecological protection and high-quality development of the Yellow River Basin [3]. Then, in January 2020, the Chinese government proposed that we should attach greater importance to solving prominent and major issues in ecological protection and high-quality development in the Yellow River Basin, with projects targeting ecosystem restoration and pollution control specific to water, atmosphere, and soil.

In recent years, several major projects have been successively implemented, including the ecological protection and construction of Three-River-Source Nature Reserve [4–6], construction of Three-North Shelterbelts [7,8], protection of natural forests [9,10], and water and soil conservation [11,12], as well as ecological protection and restoration pilot projects within the mountains, rivers, forests, fields, lakes, grassland, and sands of Qilian Mountain and the Loess Plateau [13]. These have played a referential role in regional ecological protection and restoration. However, there is still a lack of systematic design and major projects that address eco-environmental governance in the Yellow River Basin. In certain areas of the basin, the main issues have not yet been effectively solved by means of eco-environmental governance projects, and a collaborative governance mechanism among the upstream, middle, and downstream areas has yet to be established. Therefore, there is an urgent need to conduct strategic research on integrated ecological governance in the Yellow River Basin to establish an integrated ecological governance system led by major projects and promote the ecological protection and high-quality development of the Yellow River Basin.

2 Challenges faced in the eco-environmental protection and governance in the Yellow River Basin

Despite its fragile ecology, the Yellow River Basin has been a pivotal part of the rapid development of its surrounding regions over many years. Although its overall ecological quality improved between 1990 to 2019 [14], some areas of the basin have continued to deteriorate ecologically due to the influence of human production activities [15], wherein local deterioration trends have yet to be fundamentally reversed [16,17]. Such ecological issues are manifested at large in the Yellow River, but are rooted in the basin in essence. Thus, there remains a long way to go for the ecological protection of the basin as a whole.

2.1 Increasingly prominent contrast between the layout of economic structure and the carrying capacity of resources and environment

The phenomenon of “scrambling for water” has become a prominent point of contention resulting from the strained relationship between the economic development of China and the ecological protection in the Yellow River Basin [18]. Accounting for 2% of the total water resources in China, the Yellow River Basin supports 12% of the population and 15% of the cultivated land of the entire country. The development and utilization rate of water resources from the basin are as high as 80%, far exceeding the ecological threshold of 40%. Furthermore, the scale of agricultural activities does not reflect the conditions of water resources in the basin. The consumption of water for agricultural activity is currently too large, with a proportion as high as 67.5% in 2018 [19]. Moreover, the energy bases are highly concentrated: nine of the 14 top coal bases in China are distributed in the Yellow River Basin [20]. For example, the coal reserves in the energy “Golden Triangle” of Inner Mongolia, Shaanxi, Gansu, and Ningxia account for approximately 27% of the total reserves throughout the country; however, the amount of water resources accounts for only 0.37% [21]. Lastly, the industrial structure of the regions surrounding the basin is mainly composed of intensive industries, including coal mining and beneficiation, coal chemical industry, non-ferrous metallurgy, and rolling and processing, of which coal chemical enterprises account for approximately 80% of those in the whole country. In addition, there are nearly 1000 risk sources within the scope of 1 km along the main stream and tributaries of the Yellow River, with several sudden ecological and environmental accidents occurring in recent years.

2.2 Watershed ecological degradation is prominent

Over 3/4 of the Yellow River Basin belongs to moderately vulnerable areas. This is higher than the national average level, making this ecosystem highly sensitive and fragile. The main stream of the Yellow River is highly affected by human activity, and its tributaries are frequently cut off, resulting in an intensification of the fragmentation of this ecological environment [22]. Natural grasslands have been markedly degraded in the upstream area of the basin, with degradation rates of 60%–90% in some areas. In terms of sandy lands, although their area remains relatively large, the amount of land attributed to natural wetlands is shrinking, with reductions of nearly 70% observed in some areas, resulting in the decline of water conservation, regulation, and storage functions. Water and

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soil loss is serious in the middle reaches of the basin; at present, an area of over 2×10^5 km^2 urgently requires water and soil loss control measures. However, most are coarse sand areas, which are difficult to treat. In the Yellow River Delta, the natural wetland shrunk significantly from 1987 to 2017, decreasing by approximately 70% during this period [23]. As a result, aquatic biodiversity has also continuously declined in recent decades.

2.3 High rates of pollution in the water of tributaries

From 2006 to 2019, the proportion of parts of the Yellow River Basin with inferior Class V water quality among the state-controlled sections decreased from 25.0% to 8.8% [24]; however, this remained higher than the national average level (5.4%). Notably, pollution in some of the basin's tributaries, including the Fenhe, Weihe, and Sushui Rivers, markedly exceeded this standard. Accounting for only approximately 37% of the pollution carrying capacity, the main river sections of the basin carry approximately 91% of the pollution load. Seven of the nine sections with inferior Class V water quality in the Yellow River Basin are located in the Fenhe River Basin. From 2015 to 2019, the water of the Fenhe River Basin was heavily polluted [25]. Although the proportion of sections with inferior Class V water quality decreased by 3.2% (Fig. 1), it remained high at 53.8%. The safety of the water obtained for drinking from this tributary remains questionable, and 6.8% of urban centralized drinking water sources (including standby water sources) above the prefecture level do not currently meet water quality standards. In 2020, the proportion of sections with Class I–III water quality in the Fenhe River basin was 41.7%, and zero for sections with inferior Class V water quality, indicating that the water was slightly polluted [26]. During the 14th Five Year Plan period, the government will aim to continuously monitor the situation to address the fact that certain tributaries continue to face challenges in terms of water quality, including the Fenhe, Huihe, Ciyao, Malian, and Shichuan Rivers.

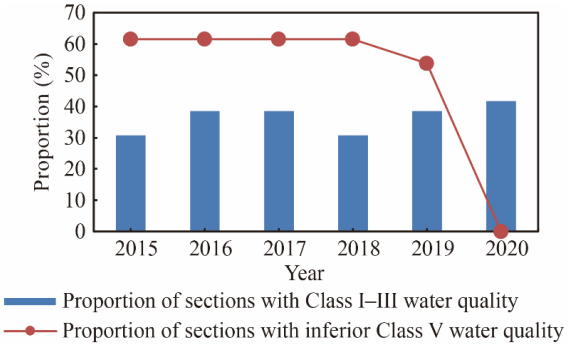

Fig. 1. Water quality of Fenhe River Basin (2015–2020).

2.4 High rates of pollution in the air and soil in areas of the Yellow River Basin

At present, there is a marked difference between the air quality of the Yellow River Basin and the national average level. In 2019, the concentration of $PM_{2.5}$ in the basin was 8.3% higher than the national average, while the proportion of days with excellent air quality was 5.5% lower than the national average [27]. Among the affected regions, air pollution prevention and control is particularly worrying in the Fenwei Plain (Fig. 2); the average concentration of $PM_{2.5}$ in 2019 increased by 1 μg/m^3 compared to 2018, and the proportion of days with excellent air quality was 61.7% with a year-on-year decrease of 2.2%. Furthermore, the proportion of days with heavily polluted air quality reached 6.0% with a year-on-year increase of 1.8%, significantly higher than the average level of other regions and whole country, exceeding 5.4% in comparison with that of the "2 + 26" cities [28]. However, in 2020, the air quality in the Fenwei Plain improved in comparison with that in 2019; the proportion of days with excellent air quality increased by 8.9%, while the number of days with severe pollution decreased by 3.2% [26]. However, the industrial structure in the Fenwei Plain is mainly composed of heavy industries, whose energy sources mainly rely on coal, combined with a traffic structure that is in great part composed on highways. Therefore, improving the atmospheric quality of this region remains a challenge. Farmland pollution is more prominent in non-ferrous metal mining areas, with different degrees of heavy metal pollution, including Cd, Pb, As, and Hg, in the soils of Dongdagou, Baiyin in Gansu Province, Sanmenxia, and Jiyuan in Henan Province [29].

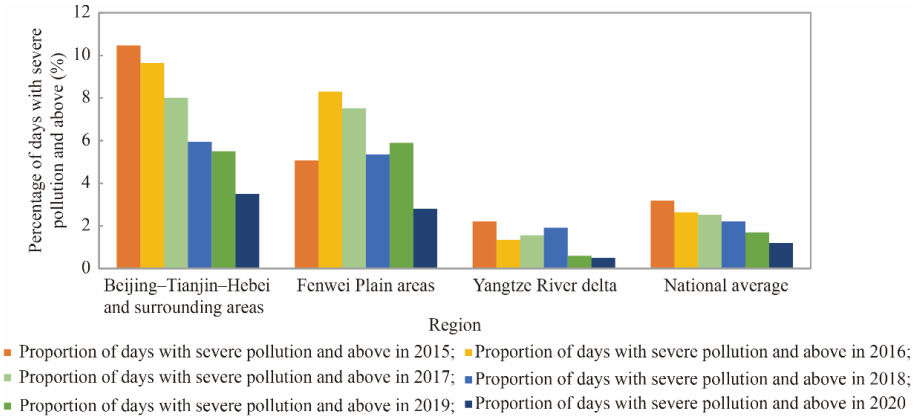

Fig. 2. Proportion of days with severe and above pollution in key areas, such as the Fenwei Plain (2015–2020).

3 Key challenges for ecological protection and governance in the Yellow River Basin

3.1 Investment structures need to be improved for ecological governance projects

To implement a national strategy for the ecological protection and high-quality development of the Yellow River Basin, nine provinces along the Yellow River are currently actively planning key projects aimed at ecological protection and governance. At present, among the key projects requiring investment, the capital input for the comprehensive water pollution treatment project is ranked first, followed by rural environmental improvements, atmospheric environment treatment, ecological protection, and restoration projects, whereas the input for modern governance system projects is ranked last. Comprehensive water pollution treatment projects comprise water environment treatment, comprehensive treatment of black-odorous polluted water bodies, upgrading and reconstruction of sewage treatment system and construction of sewage pipe network, water purification of constructed wetland, pilot groundwater restoration, protection of drinking water source, recycling of reclaimed water, and construction of standardized sewage outlets. Similarly, rural environmental improvement projects include rural domestic sewage treatment, rural domestic waste disposal and treatment, and the prevention and control of pollution from livestock and poultry breeding. Atmospheric environment treatment projects cover ultra-low emission transformation of non-electric industry, clean energy substitution, volatile organic compound (VOC) prevention and control, and the comprehensive treatment of industrial pollution sources, while ecological protection and restoration projects include water conservation projects, soil erosion control, biodiversity investigation and protection, degraded grassland control, flood control and ecological bank protection, wetland protection and restoration, saline alkali land improvement and treatment, and ecological corridor construction. Lastly, modern governance system projects include fundamental investigation and evaluation, construction of ecological environment monitoring network, ecological law enforcement capacity construction, ecological environment early-warning and emergency capacity construction, and basic ecological environment capacity construction.

From a spatial perspective, natural grasslands and wetlands in the upper reaches of the Yellow River Basin have degraded over time. Some tributaries, such as the Fenhe River, are heavily polluted, and the urban atmospheric environment of the Fenwei Plain and the lower reaches, which are prominent ecological and environmental areas in the Yellow River Basin, is faced with a severe situation. Thus, these are key issues in the eco-environmental protection of the Yellow River Basin. However, the ecological management and recovery of the Yellow River Basin still lacks the support of major leading projects, with projects aimed at improving water conservation in upstream areas, such as Qinghai and Ningxia, remaining scarce, particularly in terms of water pollution control in the Fenhe River and air pollution control in the Fenwei Plain.

3.2 Network of ecological monitoring has yet to achieve full coverage

Ecological monitoring is the basis of ecological protection and a component of the modern ecological governance system. To protect the ecological environment, there is a need to investigate the fundamental issues and understand the underlying dynamics; namely, it is necessary to build and make good use of an ecological monitoring network [30]. At present, various monitoring stations and points have been set up by each level of government, including 282 state-controlled surface water monitoring sections in the main stream and main tributaries of the Yellow River, important water functional areas and cross-provincial and municipal boundaries, 138 state-controlled automatic

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water quality monitoring stations (including 16 across-provincial water quality automatic monitoring stations transferred by the departments of water conservancy), 552 state-controlled urban ambient air monitoring stations, and 1168 local automatic air monitoring stations. Particulate matter composition and manual automatic monitoring has been conducted in 11 cities in the Fenwei Plain, and 6880 national soil monitoring points in the Yellow River basin composed of background points, foundation points, and risk points have been established. The national monitoring points are distributed reasonably for surface water, ambient air, and soil in the Yellow River Basin.

However, there remains a lack of coverage for integrated ecological monitoring networks between sky, space, and Earth, which would be useful for water ecological monitoring, emergency monitoring, and data collection. Currently, 17 ground ecological monitoring stations have been built in the Yellow River Basin to regularly monitor and evaluate the structure and functions of relevant ecosystems. However, these stations fail to cover all key ecological functional areas and wetlands in the Yellow River Delta. Furthermore, there is a notable absence of the monitoring of the aquatic biological environment. At present, basic instruments and equipment, such as microscopes and chlorophyll meters, are only available in a few select provinces. Professional aquatic biological laboratories have not been built in most areas, and the technical specifications and evaluation standards systems needed for aquatic biological monitoring are lacking [31]. Furthermore, the cross-regional emergency monitoring capacity remains poor, the on-site sampling and detection equipment are lacking, as are the technical means for monitoring, and the mobility and flexibility of technologies are poor, which makes it difficult to meet the needs in the case of cross-regional major environmental accidents. The eco-environmental monitoring of the Yellow River Basin is also in charge of multiple sectors and is implemented by the watershed. Because a monitoring data sharing mechanism with natural resources, water conservancy, emergency, and other departments has not yet been established, various types of monitoring data at all levels are not shared effectively. Additional problems in the ecological monitoring of the Yellow River Basin include the low timeliness of monitoring, a lack of active early warning against the occupation of ecological space, and reduction of ecological function. The establishment of a sky–space–Earth integrated ecological monitoring network could help to address these issues.

3.3 Delays in the modernization level of ecological governance capacity

The proportion of coal chemical industry remains relatively high in the Yellow River Basin, and the emergence and incidence rates of eco-environmental events are also high. However, the existing eco-environmental governance system has a weak capacity for early warning, prediction, and emergency response concerning sudden eco-environmental events, with a lack of an early warning system that integrates monitoring, evaluation, early warning, and disposal. Thus, its current capacity for rapid prediction simulation and early warning response decision-making is insufficient. For key river sections, grassroots staff, material, and equipment reserves are insufficient in terms of quantity, pertinence, and professionalism. Some conditions, including pollution control facilities and technologies, enterprise supervision, early warning, and response levels against pollution along the river do not currently meet the minimum requirements for a high quality system. In addition, many problems are localized in provinces found in the middle and lower reaches of the Yellow River, including insufficient urban sewage treatment capacity, imperfect pipe network, non-diversion of rain and sewage, excessive discharge of sewage treatment plants, difficulty in stable and effective operation of rural domestic sewage treatment facilities, and inadequate allocation of ecological treatment infrastructure. A market-oriented, diversified, and multi-factor eco-compensation mechanism could help to ease these challenges; however, it is making slow progress due to a lack of synergy between ecological and environmental protection, wherein a diversified environmental governance investment and financing mechanism has yet to be established [32].

4 Integrated ecological governance strategy in the Yellow River Basin

With regard to the overall and long-term interests of the Yellow River Basin, governance strategy should focus on maintaining the ecological security and solving key ecological and environmental issues in the upper, middle, and lower reaches of the basin. To this end, an integrated strategy that targets the ecological protection and restoration of the “mountains, rivers, forests, fields, lakes, grassland, and sands” system is needed, under which environmental pollution will be managed in terms of key problems, key regions, and key industries. An integrated ecological and environmental governance approach should be implemented via major projects to ensure the stable improvement of ecological functions, a comprehensive improvement of environmental quality, the effective prevention and control of environmental risks, and gradual advances in ecological governance in the Yellow River Basin. Based on the principle of zoning and classification, it is necessary to carry out comprehensive treatment of ecological environment

for key problems, regions, and industries: integrated treatment projects will need to be organized according to local conditions, and projects will need to be implemented from three aspects (e.g. ecology, environment, and governance system). Potential projects include the integrated protection and restoration of the "mountains, rivers, forests, lakes, grassland, and sands" system, the comprehensive treatment of environmental pollution, ecological environment treatment, and the modernization in the Yellow River Basin (Fig. 3).

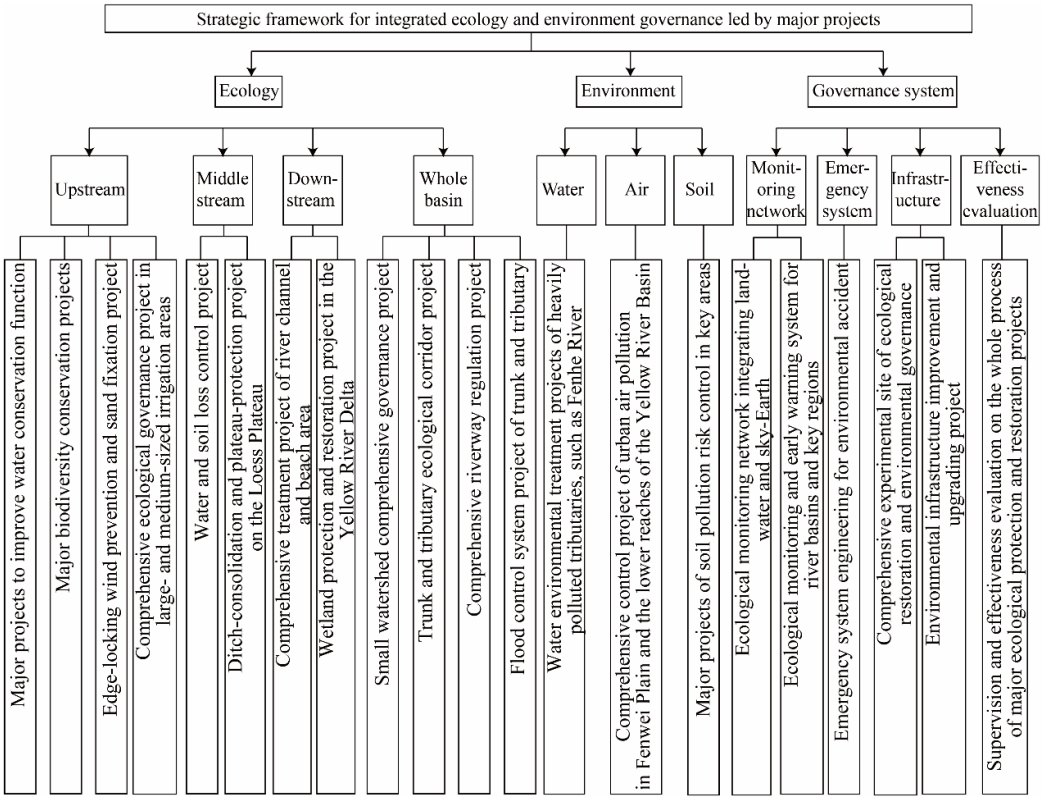

Fig. 3. Strategic framework for integrated governance of ecological environment in Yellow River Basin led by major projects.

4.1 Implementation of major project for the integrated protection and restoration of the "mountains, rivers, forests, lakes, grassland, and sands" system

The overall idea is to steadily improve water conservation function and restore ecologically degraded areas in the upper reaches, conduct water and soil conservation in the middle reaches, implement ecological treatment of river channels and beach areas in the lower reaches, and strengthen the protection of natural wetlands in the estuaries of the Yellow River. To this end, projects should be implemented for the integrated protection and restoration of the "mountains, rivers, forests, lakes, grassland, and sands" system as a whole. In order to address issues in areas with fragile ecological environments along the Yellow River Basin and its key tributaries, it is necessary to implement comprehensive governance of small watersheds, the construction of trunk and tributary ecological corridors, and the comprehensive governance of river courses covering the whole basin to maintain the integrity and connectivity of the watershed ecosystem. It is also necessary to further coordinate the construction of flood control systems for the tributaries, strengthen the flood control safety of key tributaries, such as the Huangshui, Taohe, Weihe, and Fenhe Rivers, and jointly prevent and control sudden floods caused by rainstorms.

The ecological status of the area upstream of the Yellow River Basin is the most significant. Thus, it is necessary to implement major projects to improve water conservation function in this important ecological area, which comprised the Three-River-Source area, Qilian Mountains, Ruoergai Plateau Wetland, and Gannan area. Additional projects include the conservation of water in forests in the basin, treatment of degraded grasslands, and protection and restoration of rivers, lakes, and wetlands, as well as projects that protect important water source areas upstream and improve the water conservation capacity of the source area. Moreover, there is also a need to carry out major biodiversity conservation projects that focus on biodiversity conservation functional areas, such as the Huangshui River Basin, Three-River-Source area in Qinghai, Baiyin along the Yellow River, Gannan Mountain Area, and

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Qingtongxia Reservoir Area, as well as protecting and restoring natural wetlands and indigenous fish habitats and improving the level of biodiversity protection in the basin.

Alongside these projects, desertification control projects will also need to be established, such as projects focusing on the southern edge of the Inner Mongolia Plateau and the central part of Ningxia, popularizing the experience of Kubuqi and Ulanbuhe in desertification control and implementing the edge-locking wind prevention and sand fixation projects. In addition, a comprehensive water ecological governance project should be implemented in large- and medium-sized irrigation areas, such as the Ulansuhai irrigation area in Inner Mongolia, the Ningxia irrigation area, the Huangshui River in Qinghai, and regions along the Yellow River in Gansu. It is further necessary to carry out a comprehensive treatment of farmland backwater pollution, build ecological ditches, sewage purification ponds, and artificial wetlands, and strengthen the circular utilization of agricultural backwater.

In the middle reaches of the Yellow River, there is a need to emphasize soil and water conservation in the Loess Plateau, continuously return farmland to forests and grasslands, strengthen the protection of vegetation, and promote soil and water loss control projects in the Loess Plateau areas of eastern Gansu, northern Shaanxi, and northwest Shanxi. Moreover, other key projects to be implemented include the protection of the tableland surface on the Loess Plateau, the reinforcement of dangerous silt dams, and the comprehensive treatment of sloping farmland. In the hilly and gully areas of Shanxi, Shaanxi, and Inner Mongolia, coarse sediment interception and reduction projects should be established. Focusing on the Dongzhi tableland in eastern Gansu, Taide tableland in western Shanxi, and Luochuan tableland in northern Shaanxi, gully consolidation and tableland protection projects should be implemented on the Loess Plateau.

In the downstream areas of the Yellow River Basin, potential projects include the comprehensive improvement of river courses and beach areas, protection and restoration of wetlands in the Yellow River Delta, and promotion of the ecological protection of coastal zones, as well as the restoration of the offshore water environment and water ecology, greening and upgrading of Yellow River embankments, returning farmland (aquatic farm) to wetlands, ecological protection and restoration of wetlands, comprehensive treatment of pests, protection of key species, and ecological replenishment of rivers to protect the biological resources of salt marshes, tidal flats, and estuarine shallow-sea wetlands. These projects could be used to promote the natural restoration of estuarine wetlands.

4.2 Implementation of major projects to comprehensively control environmental pollution in the Yellow River Basin

Environmental pollution needs to be addressed from the perspective of its key problems, regions, and industries. To this end, several projects should be implemented for the comprehensive treatment specific to heavily polluted tributaries, key regions with poor atmospheric environmental quality, and local polluted soil in the Yellow River Basin.

First, water environmental treatment projects should be carried out specifically for heavily polluted tributaries, such as the Fenhe River. black-odorous water bodies and inferior Class V river sections should be treated with an emphasis on the removal of industrial wastewater, urban sewage, rural drainage, and farmland backwater. A more in-depth approach should be used when tackling the consequences of key industries, such as the coal chemical industry. Furthermore, agricultural non-point sources should be prevented and controlled within key irrigation areas. A pilot project could be carried out for the conservation of water resource and sewage/wastewater reuse. This project could be conducted in areas with a shortage of water resources, a high development and utilization value of water resources, and a low reuse rate of water resources to build a regional water-saving and sewage reuse and recycling system.

Second, there is a need for comprehensive treatment project that specifically targets urban air pollution in the Fenwei Plain and lower reaches of the Yellow River Basin. Structural adjustments should be promoted in terms of energy, industry, transportation, and land use, which would allow for clean heating in winter. Projects targeting these issues include the establishment of comprehensive treatments specific to the “scattered and polluted” enterprises, transformation of the iron and steel industry with the ultra-low emissions, treatment of air pollution from industrial furnaces and kilns, and VOC of key industries and diesel truck pollution, as well as transport of bulk goods (e.g., coal and ore) over long distances in trains rather than cars.

Third, major projects should be implemented to control soil pollution risk in key areas. Safe utilization projects should be organized and implemented in regions with concentrated arable land, such as Baiyin City and Gannan Prefecture in Gansu Province; Xining City in Qinghai Province; Baoji City, Weinan City, and Shangluo City in Shaanxi Province; as well as Sanmenxia City, Luoyang City, and Jiyuan City in Henan Province. Focusing on areas

with intensive mineral development, a general study should be conducted on historical mining areas, tailings ponds, and the stacking of waste residues to promote the comprehensive treatment of tailings ponds. Moreover, projects should target the reduction of the emission of heavy metal pollution, especially in Luanchuan in Luoyang City, Mengzhou in Jiaozuo City, and Jiyuan City.

4.3 Implementation of major projects for environmental governance modernization in the Yellow River Basin

In accordance with the requirements for the ecological protection and high-quality development of the Yellow River Basin, the following describes several major projects aimed at modernizing the overall ecological governance system and the capacity of the Yellow River Basin:

(1) Establishing an ecological monitoring system in the Yellow River Basin to strengthen the aquatic organism-monitoring capacity and highlight regional ecological monitoring, such as ecological red line, nature reserves, and key ecological functional areas, and forming an ecological monitoring network integrating water–land and space–sky–Earth.

(2) Improving the monitoring network of water, atmosphere, and soil environmental quality in the Yellow River Basin, and establishing an early-warning system in the basin and key areas for ecological environment monitoring.

(3) Establishing an emergency system for environmental accidents covering the whole basin and featuring joint prevention and control.

(4) Building comprehensive experimental sites by region dedicated to ecological restoration and environmental governance in the upstream, middle, and downstream areas of the Yellow River Basin.

(5) Improving environmental treatment infrastructure, promoting the construction of sewage pipe network and the upgrading of sewage treatment plants, and promoting the continuous improvement of urban sewage collection and treatment efficiency and discharge up to standards along the trunk and tributaries.

(6) Supervising and evaluating the effectiveness of all ecological protection and restoration projects scientifically and formulating countermeasures after comprehensively analyzing the results of previous projects.

5 Countermeasures and suggestions

To promote integrated ecological governance in the Yellow River Basin, governance projects should be systematically designed to take into consideration the spatial differences between the upper, middle, and lower reaches of the basin. To this end, it will be necessary to adjust the corresponding measures to local conditions, implement policies by classification, and implement plans step by step.

5.1 Establishment of a national database of major projects for ecological environment governance in the Yellow River Basin

According to the national requirements for the ecological protection and high-quality development of the Yellow River Basin, the Ministry of Finance, together with the Ministry of Ecology and Environment, Ministry of Water Resources, Ministry of Natural Resources, and Ministry of Agriculture and Rural Areas, as well as 9 provinces along the Yellow River, will need to establish a national database of major ecological and environmental improvement projects on the basis of overall and long-term interests of the Yellow River Basin. The aim of this database is to solve the most prominent ecological and environmental issues and maintain the ecological and environmental security of the Yellow River Basin. This national project database will need to be established in collaboration between the central and local powers and incorporated into the financial budgets at all levels, with priority support for the corresponding areas, categories, and batches.

5.2 Implementation of major projects in stages and batches according to the local conditions

According to the principle of overall planning and step-by-step implementation, we recommend focusing on the elimination of inferior Class V water bodies in the near future, and construct the monitoring network and pilot of modern ecological and environmental governance systems. This will allow for the gradual establishment of a national project database for ecological and environmental governance in the Yellow River Basin, and would include the following:

(1) Comprehensively eliminating inferior Class V water bodies in the whole basin of the Yellow River by preferentially eliminating deteriorated bodies of water found in the areas surrounding the main river stream and the primary tributaries of the Yellow River, followed by deteriorated bodies of water surrounding the secondary and

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tertiary tributaries.

(2) Establishing an integrated monitoring network covering all aspects of the water environment, ecology, and resources in the Yellow River Basin by constructing ground ecological monitoring stations in the upstream areas of the basin, water environment supervision and emergency monitoring sites in the middle areas of the basin, and a monitoring system for wetland water ecology in the downstream areas of the basin.

(3) Selecting representative cities in the upstream, middle, and downstream areas of the river basin in which to conduct a pilot project of a modern eco-environmental governance system with which to promote relevant experience.

5.3 Supervision and evaluation of the effectiveness of major projects

Evaluation methods and standards systems specific to the implementation effect of major projects should be formulated to ensure the specific conditions and benefits of various projects, summarize the data and results, and identify existing problems and constraints. For those who fail to achieve the governance objectives, corresponding countermeasures and suggestions should be put forward for rectification in time. It will also be necessary to establish an information platform through which the effectiveness of major projects (i.e., management, supervision, monitoring, and information sharing) can be evaluated for the entire lifecycle of the project, that is, from project approval, design and budget, implementation, completion acceptance, and post management. This will allow for the monitoring, early warning, and dynamic optimization of entire projects' processes.

5.4 Strengthening of technological innovation and increasing support for major projects

It is suggested to conduct research on key ecological issues in the Yellow River Basin, breakthroughs of major equipment and projects, achievement transformation, and entrepreneurship; and establish scientific experiments and technological research and development specific to key challenges (e.g., water safety, ecological protection, vegetation restoration, and water-sediment regulation). Collaborative innovation can be harnessed to promote research on key common technologies within the fields of the green transformation and upgrading of traditional industries as well as the development of strategic emerging industries. To this end, large scientific and technological infrastructures will need to be built in the Yellow River Basin, including national key laboratories, industrial innovation centers, and engineering research centers. However, this will require further investment and financial support, such as support for social capital for the formation of scientific funds, to promote the transformation and modernization of the Yellow River Basin. To achieve this, systematic technological integration and innovation within environmental governance will need to be accelerated in key regions, giving rise to the formation of new models of regional environmental governance to be replicated and popularized over time.

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