

Analysis on the Current Status of Ecological Protection and Water Use in the Yellow River Basin

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Abstract: With only 2% of the nation's water resources, the Yellow River plays a vital role in supporting the livelihoods of people and sustaining industrial and agricultural activities in the provinces and regions it flows through, making it the lifeline of north and northwest China. Addressing the ecological and environmental challenges in the Yellow River Basin and improving water resource management are key to the sustainable development of the surrounding provinces. This paper investigates the water resource issues and obstacles in the Yellow River Basin by examining the region's current ecological conditions. By assessing water resources in the upper, middle, and lower reaches of the river, along with water usage and ecological protection practices, it outlines successful strategies for sustainable water use, focusing on ecological preservation, tailoring approaches to local needs, and implementing targeted measures. Furthermore, it recommends strengthening social support for equitable water allocation and promoting the restructuring of industries within the Yellow River Basin. This can be achieved by improving water resource management systems, enhancing administrative regulations, advancing scientific and technological standards, strengthening the legal framework, raising public awareness, and establishing a compensation mechanism.

Keywords: Yellow River Basin, ecological protection, sustainable water use.

1. Introduction

The Yellow River, China's second longest river, stretches 5,464 kilometers from its source on the Tibetan Plateau, flowing across northern China before emptying into the Bohai Sea. Its basin covers nine provinces in eastern, central, and western China, spanning approximately 752,000 square kilometers and supporting a population of around 420 million. In addition to supplying essential water resources, the Yellow River plays a crucial role in ensuring national food security. Economically, it is vital, and it significantly contributes to the region's cultural and agricultural development.

However, with the intensification of economic development and human activities, the ecological environment of the Yellow River Basin (YRB) is facing serious challenges, with frequent natural disasters along the coast, forest degradation and soil erosion. Since the beginning of the literature, there have been 26 major diversions of the Yellow River and more than 1500 downstream overflows, making the ecological management of the Yellow River an urgent problem to be solved [1,2]. In order to alleviate the ecological problems of the YRB, relevant reports point out that the Yellow River should be built into a river of ecology, affluence, civilisation and happiness[3]. Ecological protection and restoration measures have been launched along the coast, and soil and water conservation projects,

vegetation restoration projects, and scientific management of water resources have been initiated. When the crucial water conservancy hub at Sanmenxia had been constructed, for instance, numerous large floods were overcome, the Yellow River underwent a historic transformation, while the massive autumnal floods did not breach its mouth, essentially ensuring how secure of their Yellow River's flood prevention. Another example is the arid region of Ningxia section, in order to strengthen the protection of water resources, the report clearly puts forward that 'four waters and four definitions' will be carried out in the whole region, and water trading will be implemented for urban development, industrial layout, land use and comprehensive use of water resources, so as to achieve fine regulation and strict management of water resources [4]. There are other practices, due to the different levels of productivity development and governance needs, it is necessary to achieve sustainable governance in the basin through scientific research and policy development.

Based on the above research background, this paper will analyse the green and low-carbon governance approaches adopted after the implementation of the Yellow River National Strategy. It highlights the good experiences the region has had with concentrating on ecological preservation, adjusting to local situations, and categorizing policies by enumerating some of the most effective governance methods in diverse locations along the Yellow River Valley. This paper hopes to provide a reference for the sustainable use of water resources and local development in the YRB.

2. Status of ecological protection in the YRB

2.1. Geographic location, climatic conditions, and distribution

The Yellow River, situated in the mid-latitudes, originates from the Ba Yan Ka La Mountains in Qinghai Province at an elevation exceeding 5,400 meters. It is bordered by snow-capped mountains year-round and traverses nine provinces: Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan, and Shandong. This forms a unique "several" topography, making the YRB a critical ecological area. Climate variations in this region have a profound impact on water resource management and the preservation of the nation's ecological environment. The region experiences a typical continental monsoon climate, with over 30 significant tributaries and numerous streams. It also benefits from abundant sunshine and fertile agricultural land, which constitutes more than 40% of the national total and is home to about one-quarter of China's population [5]. The Yellow River Valley has four distinct seasons, with huge temperature differences, low humidity and high evaporation. Precipitation in the YRB is mainly concentrated in summer and autumn, with an average precipitation of 476 mm. The climate of the region is characterised by the frequent occurrence of extreme natural disasters, including floods, droughts and heavy rainstorms. This has had a significant impact on the hydrological cycle of the YRB, leading to a series of problems such as reduced river flow, drying up of lakes, and lowering of the groundwater table, as well as serious soil erosion, which not only threatens the agricultural production along the coastline, but also poses a challenge to the life and safety of the people living around the basin [5].

2.2. Upstream ecological issues

Qinghai Province, Gansu Province, Ningxia Hui Autonomous Region, Inner Mongolia, and the western part of the Hohhot metropolis encompass the higher reaches of the Yellow River. This region lies at the convergence of three major mountain ranges, extending from the river's source to the Toktor Hekou settlement. The river meanders through vast grasslands and wetlands, with its waters being remarkably clear, its flow steady, and its volume significant. Within this section, Zaling Lake and Eling Lake stand out as two of China's largest freshwater lakes, located at elevations exceeding 4,260 meters. These lakes hold 4.7 billion and 10.8 billion cubic meters of water, respectively. The upstream

area experiences an average annual precipitation of 446 mm, an annual temperature of 2.68°C, and an evaporation rate of 1,428.9 mm. The basin's terrain is highly varied, featuring a complex geomorphology and a fragile geological environment. The region is primarily mountainous, with diverse climatic conditions and frequent geological hazards.

Even though the upper Huanghe River territory has a unique agricultural and animal husbandry system and a significant location for water conservation, there are possible ecological security concerns to the region's growth, which have been linked to China's and maybe all of Asia's sustainable development [6]. Upper Yellow River region's natural capital drive as a whole by the population, social consumption, ecological construction, science and technology and environmental pollution multiple factors combined, the development and implementation of sustainable development according to local conditions is imperative. A lot of work needs to go into fine-tuning the use of water resources, ensuring the stringent and careful management of water resources, and encouraging the construction of water conservation, particularly with regard to agricultural water usage and efficacy, industrial water conservation and emission reduction, and urban water conservation and loss reduction measures [7].

2.3. Ecological problems in the middle and lower reaches

Severe soil erosion is the primary ecological issue in the middle and lower YRBs. With a drop of 4,480 metres, the Yellow River is the river with the highest sand content in the world. Historically, the YRB has been seriously flooded and often flooded. According to records, for more than 2,000 years, the lower reaches of the Yellow River have breached the embankment more than 1,500 times, and there have been 26 large-scale diversions, and the flooding range is from Tianjin in the north to Jiangsu and Anhui in the south, which is as wide as 250,000 square kilometres. Especially in the middle section of the Loess Plateau area when the flow with a large number of sand into the river, resulting in siltation of the river, the water flow is slow, and once became higher than the ground of the 'ground river'. According to records, the total amount of sediment carried downstream by the river, on average, exceeds 1.6 billion metric tonnes per year. As the terrain of the downstream section is low and flat, the slope of the river falls gently and the flow rate is reduced, a large amount of sediment is then deposited on the riverbed, averaging more than 400 million metric tonnes per year, while the rest of the sediment flows into the estuary, creating an average of more than 20 square kilometres of land per year. As river sediment increases, overflow, overflow and migration become the norm[8].

After the Yellow River overflowed, the flooding reached and the accumulated water seeped down, resulting in the rise of the water table, and the salts rose to the surface, and after the evaporation of water, the salts were deposited in the surface layer of the soil, which triggered the secondary disaster - soil salinisation. Records show that administration and repair of this sandy soil began in as far back into the pre-Qin era, with authorities and individuals in the central and bottom reaches of the Yellow River. A number of strategies for management were developed throughout both the Ming and Qing eras as a result of the lower Yellow River's increasing severity and the floodplain's growing salty soil[9]. For example, planting alfalfa to improve the degree of salinisation. Clover is a perennial herb that is easy to survive and grow after sowing, and is edible for both humans and animals. When planted in sandy and alkaline land, the roots of the grass are disjointed and the soil is strong, which improves the soil's PH value over the years. Alternatively, protect farmland by planting willows to prevent wind and sand. Another method is to replace the alkaline soil. By digging deep into the alkaline soil, you can turn the good quality soil underneath to the surface and plant a squash crop, which often produces a good crop. Over a number of years, such practices can restore the soil to normal.

3. Utilisation of water resources in the YRB

3.1. Rigidity constraints and industrial development issues

The lack of water resources in the Huanghe Basin is the largest inflexible barrier. Only 29% of the country's average reservoirs are found in the YRB per capita, at 578 cubic meters [10]. The eco-flow in certain tributaries is inadequate, the over-exploitation of groundwater supplies in some areas has negatively impacted the manufacturing and expansion of the entire YRB, and the use and abuse of the water resources in the basin have increased recently. All over the YRB in the planned economy period of heavy industry a large number of convergence and presentations, the primary industry is more backward, the distribution of the secondary industry is more, the development of the tertiary industry is slow, and the development gap within the basin is large. Though there are significant regional barriers, a lack of cooperative procedures for making use of water resources, and unequal industrial growth, the Huanghe River itself is environmentally vulnerable and the financial connections between the different areas and provinces through which it runs are autonomous. Such relatively independent management measures have led to increasingly serious ecological damage and limited industrial development. In recent years, with the rise of the digital economy, traditional industries around the world have to change the mode, but the YRB industrial base is weak, the use of digital and network economic means to assist the development of the more immature way, the emerging industries do not have the space for development, a large number of talent and capital loss, the distribution of factor resources is unreasonable and so on have hindered the high-quality development of the footsteps. For this reason, the study of the coordinated development of water resources use and industrial structure in the YRB is the key to the high-quality development of the YRB, and the integration of rigid constraints and water-saving industrial development is imperative.

3.2. Water allocation issues

According to the relevant report, at present, agricultural water use in the Yellow River accounts for a higher proportion, industrial water use is the second, residential water use is second only to industrial water use, and ecological water use is the least, which is 71.16%, 14.54%, 10.33%, and 4.23%, respectively [11]. Agricultural water consumption in each region is heavier, the demand for water resources is greater and the degree of waste and pollution is higher, which to a certain extent inhibits the progress of other industries, and the unreasonable distribution of water use results in the water resources not giving full play to their due effectiveness. In addition, the YRB is an area inhabited by ethnic minorities, with distinctive industrial characteristics, and most of the industries in the basin rely on cattle and sheep animal husbandry and heavy industry for resource development. This process is also the main way to produce waste, and the natural environment is the only carrier of waste emissions, the YRB provinces and municipalities in general, the economic development rate is too low, the industrial structure is not optimised, the production efficiency is too low, and there is no excess funds can be invested in water resources and environmental restoration, and this situation of economic development on the water resources system has a negative impact. Especially in the pre-industrial era, in order to ensure the operation of production and produce the effect of the moment, the pre-industrial era everywhere in the production process and disorderly development of groundwater, and the YRB itself had complex topography, water resources are scarce, the exploitation of groundwater leads to underground infiltration, and breaks the original geographic features, the ecological balance of the ecological balance caused by a greater impact. Through the use of advanced technology and scientific and technological means, the resources to maintain a relative balance, so that the ecological environment to maintain a good state. After being regulated in recent years, the allocation of water resources in the Yellow River has gradually become reasonable. As of right now,

the Huanghe the canyon has 810,000 registered designed and under-construction water intakes. Additionally, localities have organized the correction of 703,000 illegal and irregular water intake issues, and the YRB's water intake order continues to get better.

3.3. Water scarcity

The YRB has only 2.2 per cent of the country's river flow, but it has to take over 15 per cent of the country's arable land cultivation water and 12 per cent of the population's domestic water use. As an important energy supplier in China, nearly 70% of coal resources and 50% of oil reserves come from the YRB[12]. Over the years, heavily polluted coal, ore and other raw materials processing, agriculture and animal husbandry and other heavy industries and labour-intensive traditional industries have always been prevalent, and coal, electricity, oil and other industries have geographical advantages, can quickly absorb a variety of factors gradually towards these industries, and the YRB's industries are perennial cycle of accumulation and reliance on the existing development path, resulting in a bias towards the heavy industrialization of the industrial structure, the layout of the disharmony, The industrial structure is biased towards heavy industrialisation, uncoordinated layout and excessive resource utilisation. At the same time, the large-scale traditional energy development is highly dependent on water resources, and the exploitation rate of water resources continues to rise rapidly, gradually exceeding the normal position of control. In the process of rational use of water resources in the YRB, it is necessary for the government to play its own functions, use the government's regulatory power to carry out a series of constraints and control of industrial structure under the system of financial decentralisation, and through the implementation of flexible fiscal policy and moderately loose monetary policy, reduce the pressure on water resources due to the problems of the energy market, and change the irrationality of the existing industries and resource use in the YRB, so as to assist the coordinated development of the basin's water resources use and industrial structure. It will modify the unreasonableness of current industries and resource consumption, lessen the strain on the use of water resources brought on by difficulties with the energy market, and support an integrated growth of water supplies and the industrial landscape in the basin. At the same time, the trading of water rights in the YRB will be vigorously promoted. The total length of the Yellow River is 5,464 kilometres, but only 174 kilometres flow through Sichuan. Among the nine provinces and regions along the Yellow River, Sichuan seems to be an 'inconspicuous' one, but it produces 4.4 billion cubic metres of Yellow River water, accounting for 21% of the total water resources of the YRB.20 Ningxia completed the first single inter-provincial water rights transaction in the history of the nation at the end of 2012, with the help of the Ministry of Water Resources and the Yellow River Commission. Ningxia paid 18 million yuan for its license to use 15 million cubic yards of water collected from the Yellow River for three years[13]. According to relevant reports, from 2019-2022, a total of 25,000 water right transactions will be carried out in the YRB, with about 2.94 billion cubic metres of water being traded, greatly supplementing the shortage of water resources[14].

3.4. Precipitation and flood management

The heavy precipitation weather in the YRB is mainly concentrated in the flood season, according to the statistics, the middle and lower reaches of the Yellow River, heavy precipitation processes and flood processes occur frequently, has been the focus of the Yellow River flood control zone, according to the report, the upper reaches of the Yellow River in recent years, the flood process is an increase in the trend and the upstream reservoirs group of scheduling has a direct impact on the. Especially in the flood season of 2020, the YRB has frequent heavy precipitation processes, with a total of six floods, which is the most numbered floods since the Yellow River started flood numbering,

so the meteorological and water services in the YRB are facing great pressure and challenges [15]. The affected area of the lower reaches of the Yellow River reaches Beijing and Tianjin in the north and Jianghuai in the south, which is 250,000km² in length and involves a large population. The management of the Yellow River has been regarded as a major event to settle the country in successive dynasties. However, due to the limitations of economic, social and technological conditions at that time, China has never been able to effectively solve the serious flood disaster of the Yellow River at the level of institutions and mechanisms. After the founding of New China, the development and management of the Yellow River has made great achievements that have attracted the world's attention, reversed the dangerous situation of frequent breakage and diversion of the Yellow River, and ensured that the Yellow River does not break during the big floods in autumn, and the benefits of flood prevention and disaster reduction are enormous.

The management of Yellow River water resources is mainly in the following aspects: Firstly, an efficient management system and mechanism has been established. The Yellow River Flood Control and Drought Relief Command was set up, responsible for flood control and drought relief preparations, plan implementation and command and control. In terms of the organisation of the flood control team, the professional team, the army and the group defence team have been implemented in the form of 'three-in-one' organisation. Along the Yellow River to set up provincial, municipal and county river departments, the implementation of vertical management, responsible for flood control, drought relief organisation and coordination and technical support. Secondly, China had insisted on following the law when it came to flood control, and in 1955 the National People's Congress passed the Decision on Detailed Preparation for the Elimination of Yellow River Destruction and the Launch of Yellow River Water Conservancy. China then went on to enact various rules and regulations to bring flood management in line with the rule of law. Thirdly, the engineering system was improved. Large-scale hydraulic hubs such as Longyangxia, Liujiaxia, Sanmenxia and Xiaolangdi were built in the upper and middle reaches of the Yellow River, and the dykes of the lower reaches of the Yellow River of more than 2,000 kilometres were raised and thickened on four large-scale occasions. For the defence of the Yellow River against the great floods, the North Jindi, Dongping Lake, Dagong and other flood-control zones have been set up in the two downstream provinces. Initially formed by the main and tributary reservoirs, dykes, river improvement projects and flood control areas, such as the composition of the 'upper blocking and lower discharge, the two sides of the flood control engineering system of hysteresis. Fourth, to achieve scientific and technological progress. Initially built a set of meteorological, hydrological, water quality, sediment and other information in one of the modern hydrological monitoring and early warning system. In the new century, the concept of 'maintaining the healthy life of the Yellow River' and the theoretical system of 'three Yellow Rivers' have been proposed. So that the Yellow River floods from the sudden change into a certain range of measurable and controllable. The successful application of modern communication technology, large-scale computer and digital and information technology has extended and greatly improved the flood-resistant capacity of the Yellow River projects. Fifth, strengthening disaster response. Following the principle of 'unified leadership, classified management and hierarchical responsibility', a complete plan system has been formed, and a number of comprehensive plans, such as the Yellow River Flood Prevention Programme, have been formulated, and the governments at all levels have made corresponding plans according to the division of responsibilities. Along the Yellow River, cities, counties, and townships at all levels follow the division of responsibilities for flood control and flood control tasks to develop a corresponding plan. Sixth, the monitoring and early warning capacity to enhance the severity of the disaster according to set the level of warning, the establishment of a specialised agency responsible for meteorological water monitoring, to ensure the timely transmission of information, and to strengthen the capacity of communication security. Seventh, good emergency response. Such as in the flood season, the implementation of 24-hour duty system around the whole

tracking rain, water, work, disaster conditions, and according to different situations to start the relevant emergency procedures. Post-disaster recovery and reconstruction. After the Yellow River flood disaster, the local governments at all levels are responsible for timely carrying out the disaster recovery and reconstruction work, such as the supply of life in the disaster area, health and epidemic prevention, the supply of relief materials, the management of public security, the resumption of school classes, the repair of water damage, the resumption of production and the rebuilding of homes.

4. Recommendations and outlook

4.1. Strengthening policy implementation and coordination

To effectively manage water resources in the YRB, several measures need to be implemented [16]. Firstly, it is crucial to enhance the water resources constraint system. This involves setting clear control indicators for ecological water use, regulating surface water indicators, and defining groundwater control measures. Efforts should be focused on county-level administrative units to monitor and regulate total groundwater withdrawal and groundwater levels. Strict control measures should be applied, utilizing a combination of administrative, technical, legal, and economic strategies to ensure efficient management, conservation, and protection of water resources.

Secondly, administrative measures must be reinforced. Special actions should be undertaken to address issues related to groundwater over-extraction. Administrative tools should be employed to monitor and report groundwater level changes across districts, with a focus on addressing declines and conducting technical consultations in regions facing significant problems. These actions aim to strengthen local government accountability in managing groundwater over-extraction.

Thirdly, scientific and technological advancements should be promoted. This includes improving monitoring and measurement systems to enable real-time measurement of water usage in large and medium-sized irrigation districts within the YRB. Efforts in provinces like Inner Mongolia, Shandong, Henan, Shaanxi, and Ningxia should focus on implementing groundwater irrigation measurement systems, such as ‘electricity discount water’ schemes. Additionally, enhancing the direct reporting of water consumption statistics has led to more than 37,000 households in the basin participating in this system, representing 13.5% of the national total. The integration and application of information technology should be promoted to improve the digital, networked, and intelligent aspects of water resource management.

Lastly, legal measures need to be strengthened. Actions should be taken against unauthorized water resource development by improving the connection between water abstraction license approvals, supervision, and law enforcement. Specific legal actions will be implemented to protect water resources in the YRB, support financial mechanisms for water management, and safeguard national and public interests. The cooperative mechanism of regulatory enforcement and public interest litigation should be fully utilized to ensure comprehensive oversight.

4.2. Promoting scientific and technological innovation and application

Firstly, it serves as a hub for coordinating science and technology efforts. Focused on critical areas such as flood and drought management along the Yellow River, efficient and strategic water resource utilization, regulation of water and sediment movement, development of a national water infrastructure, and ecological restoration of rivers and lakes, there is a push for localities to pursue scientific and technological projects through various channels. Concurrently, cities and provinces in the Yellow River region have benefitted from collaborative initiatives aimed at protecting the river, advancing cutting-edge technology, and applying research outcomes. These efforts have led to significant advancements in technology and a unified objective to enhance contemporary innovations in river management.

The second is to fortify leadership in scientific and technology innovation. We will continue to be at the forefront of technological research, enhance technological training, fully improve the capacity of soil and water conservation, flood management, and other work, and encourage the popularization and application of water resources technology by leveraging provincial key laboratories, technological innovation centers, scientific observatories, universities, and colleges, among others.

Thirdly, to increase the capability of services related to popular science. To increase people's participation and cognitive ability, plan excellent technical research, science popularization, and other related activities in different locations. You should also make full use of National STEM Week and Science Popularization Day to aggressively carry out memorable scientific initiatives in the YRB.

Fourth, it will improve communication and collaboration with other countries. actively support the construction of water conservancies along the "One Belt and One Road," enhance public awareness of the Yellow River narrative, fortify external exchanges through water-related events like the World Water Forum and the World Bank's YRB Project, present cutting-edge international concepts and technologies, and contribute to the high-quality development of the YRB.

4.3. Establish and improve ecological compensation mechanisms

According to the actual development of each region, we should do a good job of combining the work of ecological construction, conforming to nature, respecting the law, and not engaging in a one-size-fits-all approach. Around sustainable top-level planning and design, carry out soil and water conservation, water resources protection, continue to promote the river and lake long system, good water environment management and restoration, ecological water supply network construction, etc., highlighting the green as the bottom, the development of new productivity, release the economic vitality of each place. Firstly, strengthening the top-level design of ecological compensation in the YRB[17]. Taking the concept of overall protection and systematic management of basin ecology as the lead, co-ordinate and promote horizontal ecological compensation to achieve full coverage in the whole YRB. Encourage and localise the legislation on ecological protection compensation in the YRB in the light of local realities. Secondly, establish mechanisms to achieve full coverage. Achieve upstream and downstream communication in the river basin, implement the supervision and management of cross-provincial ecological compensation, incorporate the compensation mechanism into the provincial assessment system, and link it with environmental protection funds. Third, improving the ecological compensation standard of the YRB needs to consider the environmental status of the basin, governance input, economic development and residents' income and other factors, and formulate scientific and reasonable compensation standards. Fourth, expand the ecological compensation in the YRB. Explore national projects, industrial compensation methods, the use of 'industry chain co-construction', 'park co-construction' and other modes, to help localities actively develop green emerging industries, and accelerate the modernisation, intensification, greening and digital transformation of traditional industries. Fifthly, it encourages social capital to participate in ecological projects, creates green venture capital funds, explores market trading mechanisms such as sewage rights and carbon emission rights, and improves ecological protection compensation methods. For example, covering Gan, Ningxia, Mongolia, Shaanxi, Jin 5 provinces and 14 cities of the Yellow River several word bay strategy implementation[18], is through several places of synergistic development, aggregation of resources Bing Fu advantage, in the economic acceleration at the same time jointly carry out the long-term environmental pollution control, so that people and the Yellow River and the harmonious coexistence of the governance and development of the effective approach to achieve a win-win situation in all aspects!

5. Conclusions

This paper enumerates the development path of the YRB by listing a series of measures to promote the ecological obvious improvement of the YRB in the face of all kinds of contradictions and problems arising from water resources in different parts of the YRB. It studies the process of improving the utilisation of water resources to change the ecological environment by adopting control indicators, strengthening control measures, implementing the measure of water, making efficient use of water, and carrying out overloading management, etc. in varying parts of the YRB due to the need for development. In-depth analysis of the contradictions and links between water resources and social development in the YRB will facilitate the formulation and implementation of future measures related to governance and water resources in the YRB. The data analysis in this paper is basically from existing literature, and there are still some limitations for the analysis and exploration of water resources utilisation. It is suggested that all parts of the YRB should establish an alliance through administrative channels to jointly formulate relevant water consumption regulations and take measures such as mutual compensation for water use to strengthen water transfer. Meanwhile, the protection and restoration of the Yellow River should be increased to recover the ecological environment of rivers and lakes. And for the relevant areas in the YRB where surface water is overloaded and the ecology is severe and poor, formulate policies and measures to restrict water withdrawals, and guide and supervise the development of comprehensive management.

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