

## ORIGINAL RESEARCH ARTICLE

# Bottleneck and development path of water resources protection and utilization in Henan Province in the new era

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## ABSTRACT

**Objective:** to promote the sustainable and efficient utilization of water resources in Henan Province, accelerate the optimization of the water resources management system, innovate the government administrative management mode, and provide new strategic countermeasures and path choices for the industrial upgrading and transformation in water resources related fields and the high-quality development of regional economy in Henan Province. **Methods:** by combining the current situation and existing problems of water resources utilization in Henan Province, this study focuses on analyzing the strategic opportunities faced by the field of water resources in Henan Province and expounds on the innovation and application of cutting-edge key technologies for water resources protection and utilization in Henan Province. **Results:** while the protection and utilization of water resources in Henan Province have achieved great results, it still faces great challenges: low water-saving results, imperfect advanced technology system, unstable water pollution control results, and imperfect water resource management mechanism. **Conclusion:** in the future, we must coordinate the relationship between water resources development and protection, establish the idea of harmonious development, give full play to the regional advantages of Henan Province, strengthen the research and development of cutting-edge key technologies, innovate the government management mechanism, and realize the efficient and sustainable utilization of water resources.

**Keywords:** Water Resources Protection; Utilization of Water Resources; Food Security; Technological Innovation High-quality Development

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## 1. Introduction

Water is one of the indispensable resources for human survival and development. The protection and utilization of water resources have the dual characteristics of natural resources and economic resources<sup>[1]</sup>. Henan, as an emerging industrial province, has witnessed active economic development in recent years, making a significant contribution to the national economic development and energy consumption growth. At the same time, it is also an important major grain-producing area in the main functional zoning of China along the nine provinces and regions of the Yellow River (Qinghai, Sichuan, Gansu, Ningxia, Mongolia, Shanxi, Shaanxi, Henan, Shandong)<sup>[2-4]</sup>. According to the announcement of the National Bureau of statistics on the grain production data in 2019, the national grain planting area in 2019 was  $1.2 \times 10^8$  hm<sup>2</sup>; the total grain output is 663.84 million tons, of which the sown area in Hen-

an is the second in China, reaching  $1.1 \times 10^7 \text{ hm}^2$ ; the total grain output is 66.95 million tons, exceeding 1/10 of the national total. However, the economy of Henan Province has been an “extensive” development for a long time, and the problems of water resources waste and environmental pollution are serious. Economic development is increasingly restricted by the environment and resources. In order to support the national food security, provide the basic guarantee of agricultural water resources, strengthen engineering water conservation and agronomic water conservation, enhance the efficiency of water resources utilization and management, and build a water-saving and efficient modern irrigated agriculture and modern dry farming agriculture with rainwater harvesting efficiency, it has important strategic significance for the regional economic and social development of Henan<sup>[1,5-7]</sup>. Although some scholars have conducted in-depth research on the carrying capacity, sustainable utilization, evaluation and prediction, development strategy, and other aspects of water resources in Henan Province, the in-depth exploration and Research on water resources protection, utilization efficiency, and key technologies are still relatively weak<sup>[8-11]</sup>.

As the development of the Yellow River Basin has been identified as a major national strategy, Zhengzhou, Henan Province, as the strategic hub of the National Central City, is expected to continue to deepen the industrialization of the province, and the rise of the Central Plains will inevitably lead to the consumption of more water resources. On the other hand, the development concept of Xi Jinping’s thought on ecological civilization in the new era has its inherent requirements of keeping “lucid waters and lush mountains” and building a bridge from “lucid waters and lush mountains” to “golden mountains and silver mountains”, so that the lucid waters and lush mountains contain huge The ecological benefits, economic benefits and social benefits will continue to help the transformation of the Yellow River Basin to high-quality development<sup>[12-15]</sup>. On the whole, the above new development situation provides a new strategic opportunity for the protection and utilization of water resources and the transformation and upgrading of related

industries<sup>[1,16-18]</sup>. In practice, further controlling and reducing the waste of water resources and the emission of environmental pollutants has a very important impact on the high-quality economic development and transformation of Henan Province. By combing the current situation and existing problems of water resources utilization in Henan Province, this study probes into the bottleneck of water resources protection and utilization, and based on the relevant cutting-edge key technologies and their application prospects, attempts to provide scientific reference and theoretical basis for the ecological protection and high-quality development of water resources in Henan section of the Yellow River Basin.

## **2. Current situation of water resources protection and utilization in Henan Province**

### **2.1 Characteristics of water resources in Henan Province**

#### **2.1.1 Water resources are in short supply, and the per capita occupancy is small**

The annual average total water resources of Henan Province are 40.353 billion  $\text{m}^3$ , less than 1.45% of the national total, of which the total available is 19.524 billion  $\text{m}^3$ . At the same time, due to the large population base, the per capita water resources are only 376  $\text{m}^3$ , which is 1/5 of the national per capita water resources and 1/16 of the world per capita water resources. It is a province with insufficient self-produced water resources carrying capacity and a serious water shortage area. The total water resources of the Haihe River, the Yellow River, the Huaihe River, and the Yangtze river basins under the jurisdiction of the province in 2018 were 2.31 billion, 4.54 billion, 21.19 billion, and 5.94 billion  $\text{m}^3$  respectively, a decrease of 16.2%, 22.5%, 13.9%, and 16.7% respectively compared with the multi-year average.

#### **2.1.2 Uneven spatial and temporal distribution of water resources and mismatching of water and soil resources**

The water resources in Henan Province vary greatly from year to year. In 2018, the total amount of water resources in Henan Province was

33.98 billion m<sup>3</sup>, 16.7% less than the multi-year average and 19.7% less than that in 2017. In addition, the annual distribution of river runoff in Henan Province is uneven, and the runoff is mostly concentrated from June to September. The annual average maximum runoff for four consecutive months accounts for 45% to 90% of the annual runoff. The difference between the annual average monthly maximum and the monthly minimum is 9.5 times, which is very easy to cause drought and flood disasters. Spatially, the water and soil resources in Henan Province do not match, as shown in **Table 1**. In 2018, the total water resources in the northern and eastern plains of Henan province accounted for only 30.17% of the province, and the average water resources per mu and per capita were insufficient; the southern and western hilly areas account for 1/2. However, by the end of 2018, the population of the northern and eastern plains of Henan province accounted for 56.23% of the total population of the province, the GDP accounted for 59.76% of the province, and the grain output accounted for 57.52% of the province. Water and soil resources do not match, economic and social development does not adapt to the distribution of water resources, and water resource allocation is difficult, which restricts the high-quality development of Henan Province to a certain extent.

**Table 1.** Population, GDP, cultivated land area, grain yield, and total water resources proportion of Henan province in 2018 (%)

District	Population	GDP	Cultivated land area	Grain yield	Water resources proportion
Northern and Eastern Henan plains	56.23	59.76	50.73	57.52	30.17
Southern and Western Hills	43.77	40.24	49.27	42.48	69.83

Note: The data involved in this section are collected from the water resources bulletin, statistical yearbook, ecological environment status bulletin, and government documents of Henan Province.

### 2.1.3 The water environment is seriously polluted by human activities

In recent years, the rapid economic development of Henan Province has also caused great damage to the ecological environment. According to the statistical data of Henan Province, the

wastewater discharge in Henan Province increased from 2.507 billion tons to 4.113 billion tons from 2004 to 2017. Among the 141 monitoring sections in the province in 2018, 85 sections with water quality meeting the class I–III standards, accounting for only 60.4%, lower than the national average level; there are 5 sections whose water quality is inferior to class V, accounting for 3.5%. In 2019, of the 94 surface water national examination sections, 64 were class I–III water quality sections, accounting for 68.1%, and there were no sections with inferior class V water quality; the standard rate of centralized drinking water source is 97.7%.

### 2.1.4 Unreasonable water supply structure and serious groundwater overexploitation

In 2018, the total water supply of Henan Province was 23.46 billion m<sup>3</sup>, among them, groundwater supply accounts for 9.5% of the total water supply, and unconventional water sources such as rainwater collection account for only 2.6%. Due to unreasonable water supply structure and overexploitation of groundwater, the total area of shallow groundwater funnel in the province was 9,756 km<sup>2</sup> in 2018, an increase of 2,509 km<sup>2</sup> compared with 2004. In 2018, the agricultural water consumption, industrial water consumption, and comprehensive water consumption of urban and rural living environments in Henan province accounted for 51.1%, 21.5%, and 27.4% of the total water consumption respectively. However, due to the differences in economic structure and water resource conditions among cities, there are certain differences in water use structure among regions.

## 2.2 Current situation of water resources protection and utilization in Henan Province

### 2.2.1 The utilization efficiency of water resources is improved, but the water-saving effect is low

Henan province takes the strictest water resources management system as an important measure to promote the construction of water ecological civilization, and constantly improves the efficiency of water resources utilization, as shown in **Figure 1**. The water consumption per 10,000 yuan of GDP in Henan Province decreased from 226 m<sup>3</sup>/10,000 yu-

an in 2004 to 37 m<sup>3</sup>/10,000 yuan in 2018; the water consumption of 10,000 yuan industrial added value decreased from 10<sup>3</sup> m<sup>3</sup>/10,000 yuan to 26 m<sup>3</sup>/10,000 yuan in 2018, but the GDP output per cubic meter of water in the province is only 1/3 of the world average level, and the water consumption of 10,000 yuan industrial added value is still 3–4 times that of developed countries. In 2018, the utilization coefficient of farmland irrigation water in Henan Province was 0.61, the reuse rate of industrial water

above the designated size was 90%, and the utilization rate of urban renewable water was 24.4%, which was a certain gap with the advanced regions in China. Water deficient cities above the prefecture level have not yet reached the national water-saving city standard, and the construction and development of a water-saving society is unbalanced, which is still far from the requirements of all-around and whole process water conservation.

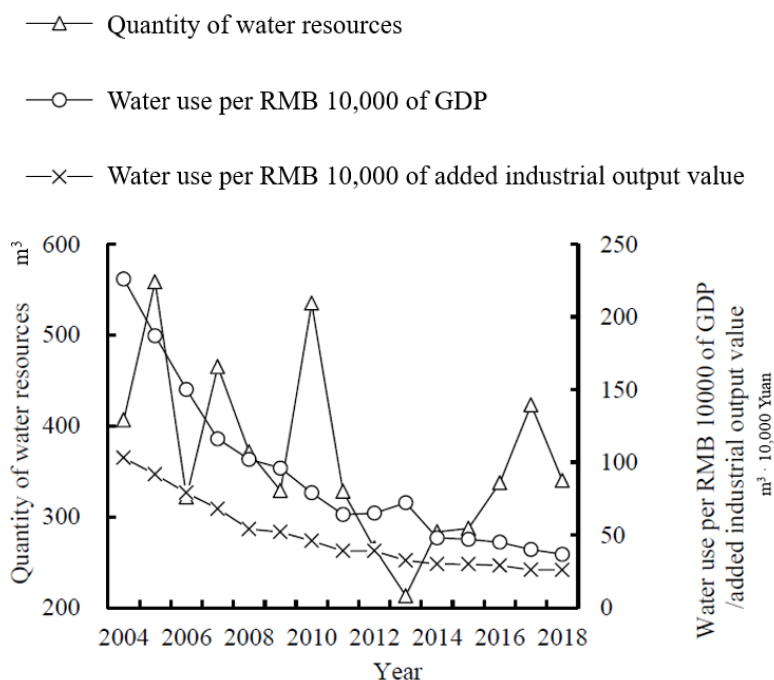


Figure 1. Annual variation of quantity of water resources and water use in Henan Province.

### 2.2.2 Vigorously develop advanced technology, but the technical system is not perfect

As a major agricultural province, Henan Province has continuously accelerated the pilot work of agricultural water-saving technologies such as border irrigation, furrow irrigation, sprinkler irrigation, and micro irrigation, so that the average water consumption per mu of farmland irrigation decreased from 176 m<sup>3</sup> in 2004 to 155 m<sup>3</sup> in 2018; strengthen the research and development of new technologies and equipment for domestic sewage and industrial wastewater treatment and resource utilization to realize the recycling of water resources; combining remote sensing and network monitoring technology, we will basically form an intelligent control supervision system for the construction of ecological civilization. However, in many areas of Henan Province, agricultural irrigation methods are still

relatively extensive, and there are still phenomena of blindly building high water consumption and heavy pollution projects in water resource shortage and ecologically fragile areas<sup>[7-9]</sup>. The development, promotion, and application of advanced and practical high-efficiency water-saving technologies are not enough, and the engineering technology system for high-efficiency utilization of water resources is not perfect.

### 2.2.3 The effect of water environment treatment is obvious, but the pollution source control is insufficient

Henan Province has carried out an in-depth battle for the protection of clean water, the water quality level of groundwater quality assessment points has remained stable, the black and odorous water bodies have been gradually eliminated in the built-up areas of cities under the pro-

vincial jurisdiction, and the water quality of Danjiangkou reservoir, the water source of the middle route of the South-to-North Water Transfer Project, has reached class II. In 2019, Henan Province newly revised its regulations of Henan Province on the prevention and control of water pollution, putting forward higher requirements for the prevention and control of water pollution. The Henan provincial government adheres to “governance” and “construction” at the same time. It plans to build Zhengzhou into a leading ecological construction area in the Yellow River Basin by 2020, with a wetland area of no less than 628,000 hm<sup>2</sup> and a wetland protection rate of more than 50%. However, due to the backward treatment idea and the neglect of the harmonious relationship between man and nature, the discharge of urban domestic sewage and industrial wastewater increases year by year, the water quality fluctuates greatly, and the problem of water pollution has not been fundamentally treated. At the same time, the excessive use of pesticides, fertilizers, and so on has led to the continuous increase of point source pollution and the increasingly prominent non-point source pollution<sup>[20]</sup>, which increases the difficulty of water resources system treatment and protection.

#### **2.2.4 The supervision ability of water resources is gradually improved, but the management mechanism is not perfect**

Although Henan Province has implemented a series of water resources management measures in recent years, issued the “implementation plan for deepening the reform of comprehensive administrative law enforcement of ecological environmental protection in Henan Province”, promoted the pilot construction of water rights, ecological water volume regulation, water ecological civilization, and improved the level of water resources management, there is a lack of coordination mechanism and management technology among departments, and the efficiency of water resources management system is low, including water intake licensing system, water rights trading system The water ecological compensation system and other systems are still not perfect, the market allocation mechanism is not perfect, citizens’ awareness of water resources pro-

tection is weak, and the integration of water resources protection supervision is not high, which is not conducive to the comprehensive management, scientific planning and unified scheduling of water resources.

### **3. Opportunities and challenges**

#### **3.1 Opportunities for water resources protection and utilization in Henan Province**

##### **3.1.1 Strong regional advantages**

Henan Province is located in the Central Plains, spanning the Huaihe River Basin, the Yangtze River Basin, the Yellow River Basin, and the Haihe River Basin (with drainage areas of 86,100, 27,700, 36,000, and 15,300 km<sup>2</sup> respectively). It is a national comprehensive transportation hub and logistics center, as well as an important area of national development strategies such as the “Belt and Road” and the Central Plains Economic Zone. Its geographical advantages can strengthen the formulation of water resources policies, infrastructure construction, and water disaster prevention and control Cooperation at different levels such as scientific, technological, and cultural exchanges<sup>[19]</sup> provides support for the protection and utilization of water resources in Henan Province and the research and development of advanced technologies.

##### **3.1.2 Major national strategic needs**

Henan Province involves the two national strategies of ecological protection and high-quality development of the Yangtze River economic belt and the Yellow River Basin. While building a well-off society in an all-around way and pursuing high-quality economic and social development, puts forward higher requirements for the protection and utilization of water resources in Henan Province. With the support of national strategies and national policies, it will help to give full play to the economic advantages of Henan Province, promote industrial transformation, increase investment in water conservancy projects and environmental governance, and promote the construction progress of the “top ten water conservancy projects”, build a livable environment in the process of “seeking development in protection and promoting protection



in development”, and realize the coordinated development of ecological civilization construction and economy.

### **3.1.3 Local governments attach great importance to it**

Henan Province has issued a number of measures from the policy level to practice the idea of ecological civilization and the concept of high-quality development. In 2013, the opinions on the implementation of the strictest water resources management system was issued, which established the red line for the development and utilization of water resources, the red line for the control of water use efficiency, and the red line for the limitation of water function areas; in 2019, the “implementation plan of water saving action in Henan Province” was issued, which made it clear that the reuse rate of industrial water above Designated Size in the province should reach more than 91%, the effective utilization coefficient of farmland irrigation water should be increased to 0.616, the leakage rate of public water supply pipe network should be controlled within 10%, and the total water consumption should be controlled within 28.215 billion m<sup>3</sup>; in February, 2020, a series of policies and regulations were issued, such as the notice on printing and distributing the implementation plan of the 2020 air, water and soil pollution prevention and control in Henan Province, which proposed that the surface water should eliminate the inferior class V water quality; the water quality compliance rate of centralized drinking water sources in cities under the jurisdiction of the province has reached 10%; the water quality of Danjiangkou reservoir, the water source of the middle route of the South-to-North Water Transfer Project, is stable and reaches class II; the water quality level of the groundwater quality assessment points remains stable, and the black and odorous water bodies are completely eliminated in the built-up areas of the cities under the jurisdiction of the province.

### **3.1.4 The external environment tends to be perfect**

Although Henan Province is short of water resources, it is rich in transit water, with an average annual inflow of 41.364 billion m<sup>3</sup> and an outflow

of 63.022 billion m<sup>3</sup>. At the same time, as the main water receiving area of the South-to-North Water Transfer Project, the water allocation of the South-to-North Water Transfer Project in Henan Province is 2.994 billion m<sup>3</sup>, which effectively solves the problems of water resources shortage, uneven spatial and temporal distribution and serious groundwater exploitation in Henan Province. The aforementioned series of water-saving policies and regulations, market mechanisms, and standard systems are further improved, which plays a positive role in improving the utilization efficiency of water resources in Henan Province, increasing water-saving measures, and protecting water ecological security.

## **3.2 Challenges faced by water resources protection and utilization in Henan Province**

### **3.2.1 Contradiction between economic and social development and water ecological protection**

Since entering the 21<sup>st</sup> century, the economy of Henan Province has developed rapidly. From 2005 to 2018, the per capita GDP of the province increased from 11,346 yuan/person to 52,114 yuan/person. The industrial structure has been optimized and upgraded, but the traditional industries with high energy consumption and high pollution still account for a large proportion. Economic development is accompanied by changes in population structure. According to statistics, from 2005 to 2018, the urbanization rate of Henan Province increased from 30.65% to 51.72%. Population growth and industrial scale expansion make the resource and environmental carrying capacity of Henan province close to the limit. Although relevant governments have always emphasized the pursuit of green and sustainable development, how to balance the relationship between economic and social development and water ecological protection, change the existing development model and achieve high-quality economic development is still an urgent problem to be solved.

### **3.2.2 Contradiction between water security engineering and technical system**

Henan Province is endowed with insufficient water resources, the contradiction between humans

and water is prominent, and drought and flood disasters are frequent. According to statistics, the annual average value of direct economic losses caused by natural disasters in the province from 2014 to 2018 was 8.38 billion yuan, and the affected area of crops was  $1.4\% \times 10^5 \text{ hm}^2$ . In order to realize the scientific development, rational allocation, and efficient utilization of water resources in Henan Province, we must build water conservancy projects such as high-quality water supply, flood control, and waterlogging elimination, and strengthen non-engineering measures such as disaster prediction. At the same time, it also needs a series of advanced technologies to improve the efficiency of water resource utilization, improve the water environment, repair the water ecosystem, and reduce flood and drought disasters. How to combine water conservancy projects and technical systems to achieve drinking water safety, water supply safety, and flood control safety will be the focus of further research in the future.

### **3.2.3 Contradiction between water safety system and administrative management mode**

In recent years, under the guidance of the strictest water resources management system, Henan Province has strictly adhered to the “three red lines”, established and continuously improved the “four systems”, promoted the innovation of the system and mechanism of the same governance of the four rivers, formulated the river director system management system, and reorganized and reformed the relevant departments of water resources management. At present, the government functions of Henan Province are still inconsistent with the requirements of ensuring the sustainable and efficient utilization of water resources. In order to ensure the water safety of Henan Province, strengthen the management of water demand and water use process, formulate a complete set of scientific and effective administrative management systems, and ensure the implementation of various systems is urgent work to be carried out in the future.

### **3.2.4 Contradiction between traditional technology and advanced technology**

Since the founding of new China, the water

conservancy industry in Henan Province has experienced a development stage from primary to advanced, especially since the 21<sup>st</sup> century, with the rapid development of computer network technology, the continuous combination of modern technology and traditional water conservancy technology, so that the traditional water conservancy continues to transform to wisdom. However, “smart water conservancy” is not only the construction of water conservancy informatization but also the full use of the existing water conservancy construction experience. Based on traditional water conservancy, it organically combines big data, artificial intelligence, and other new generation technologies to intelligently handle all kinds of water affairs events and improve the efficiency of water resources management. At present, the “smart water conservancy” in Henan Province mainly focuses on discussion, research, technical preparation, etc., and only some areas rely on some basic network technologies such as 3S to realize real-time monitoring of water resources. Combining the existing experience and technology with advanced technology, it is still a great challenge to realize the intellectualization of water conservancy monitoring.

## **4. Solutions to water resources protection and utilization problems**

With the deepening of the construction of ecological civilization and the marginal decline of the effect of administrative measures, technological innovation will play an increasingly important role in breaking the constraints of resources and the environment and achieving sustainable development. It can be seen from **Figure 2** that in order to strengthen the institutional reform of ecological civilization construction and strengthen the utilization and protection of water resources in Henan Province, it is necessary to treat ecological environmental protection from the perspective of the fundamental plan related to the sustainable development of the Chinese nation, combine the characteristics of water resources utilization in Henan Province, start from the current challenges, firmly grasp the new opportunities of water resources protection and utilization in Henan Province, and con-

trol environmental pollution with stricter standards, greater efforts, and more practical measures Improve the ecological environment.

#### 4.1 Coordinate the dialectical relationship between development and protection

The key problems existing in the protection and utilization of water resources in Henan Province, such as insufficient water resources carrying capacity, aggravated water ecosystem and groundwater pollution, the prominent contradiction between supply and demand, frequent floods, and other disasters, are in the final analysis the contradiction between water resources protection and economic and social development. Therefore, the Henan government needs to clarify the dialectical relationship between development and protection, determine the important strategic position of water resources protection, and analyze the balance point between water resource utilization and economic development. It should not only meet people's needs for water resources development, but also ensure that it is within the bearing capacity of

nature, so as to achieve the optimal state between economy, resources, and natural environment, and ensure the benign evolution of economic society and natural environment. Based on this, the relevant governments must be based on the current and long-term, systematically consider the requirements of open source, throttling, protection, and other aspects, and establish an economic structure and industrial layout suitable for regional water resources on the basis of ensuring the harmonious relationship between resource utilization and long-term stable economic and social growth, so as to realize the determination of production and city by water. In addition, accelerate the construction of ecological civilization, improve the utilization efficiency of water resources, and lay the foundation for the high-quality economic and social development of Henan Province. At the same time, the rapid economic and social development also provides greater fund support for environmental protection and promotes the further deepening of environmental governance, so as to create a harmonious and virtuous cycle between development and protection<sup>[21]</sup>.

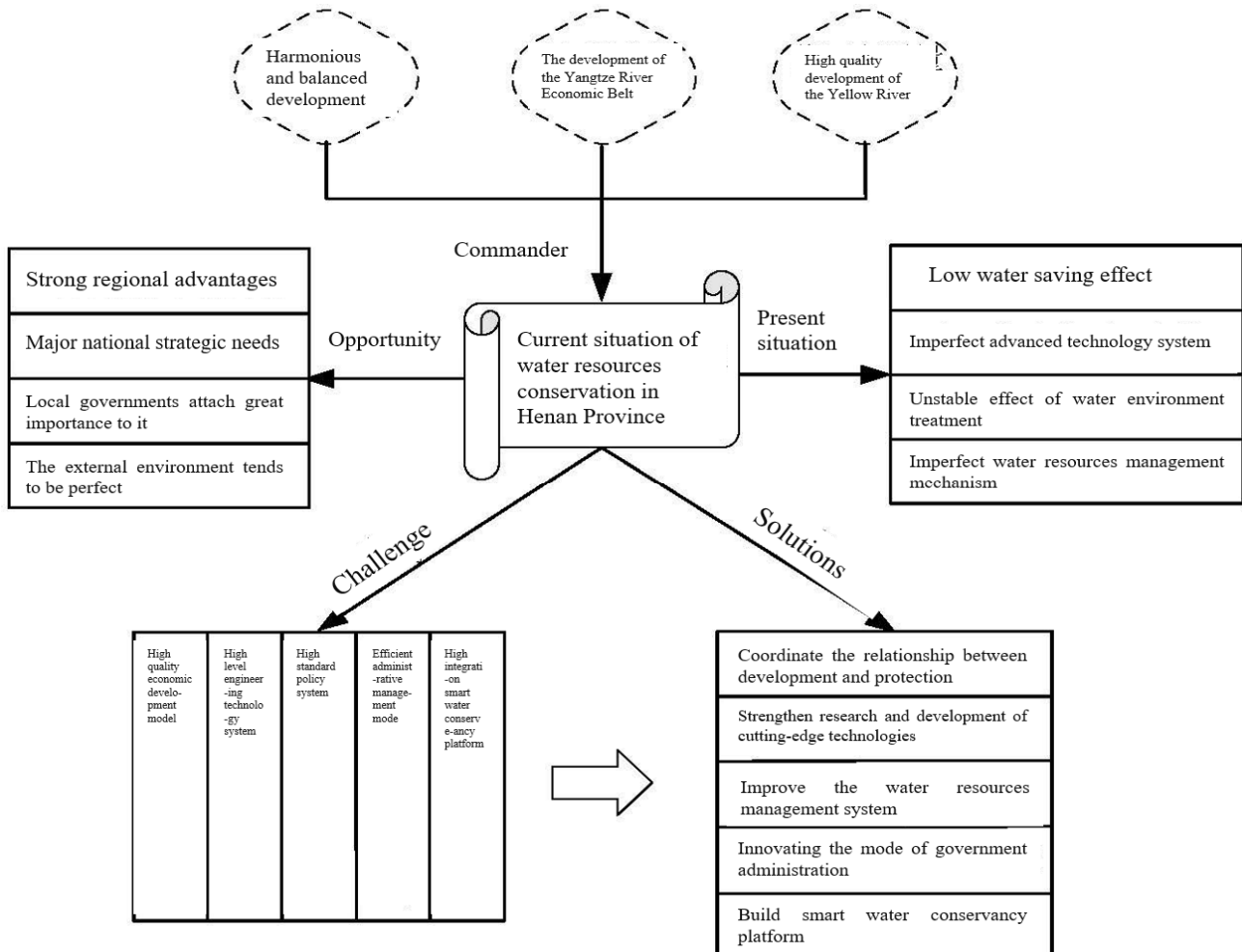


Figure 2. Current situation and path solutions in Henan Province water resources protection and utilization.



## 4.2 Strengthen the research, development, application, and promotion of cutting-edge key technologies

Scientific and technological innovation driving high-quality development has gradually become the consensus of most scholars to solve the problems of water resources protection and utilization, and the promotion and application of these cutting-edge key technologies in social development is the focus and new opportunity to win the battle for clear water and realize the efficient utilization of water resources under the new situation. Aiming at the key problems existing in the protection and utilization of water resources in Henan Province, the newly released and updated technical guidance catalog for energy conservation, low carbon, and environmental pollution prevention and control in Henan Province, as well as other more forward-looking technology integration, can be used as a reference and priority for users such as various industrial enterprises, industrial technology funds, funds in various green and low-carbon fields, and venture capital institutions in the upgrading and transformation of water resources protection technology. Combined with the actual situation of water resources in our province, some mature and promising cutting-edge key technologies are briefly introduced as follows:

1) Water resources protection. The integrated intercepting well and its control system reduce the pollution of black and odorous water, simulate the optimal operation scheme of the sewage treatment plant, and digital intelligent management system for the urban water environment. Five effectively stereo technology for the integrated treatment of hydrology, the construction and application of digital intelligent management system for urban water environment, the integration of lid (low impact development) and regulation and storage technology for rainwater purification and reuse, and the reduction of black and odorous water pollution by intercepting wells and their control systems.

2) Water saving. Intelligent motors and control systems for the electrical equipment of water-related enterprises such as tap water, domestic sewage, and industrial wastewater, cascade utilization technology for industrial and agricultural production and domestic water for urban residents, new

technology for water-saving transformation of the production process, manufacturing technology of high-efficiency water-saving sanitary ware, water-saving technology for urban rainwater collection, purification and recycling, etc.

3) Resource utilization of industrial wastewater. High salt wastewater and miscellaneous salt resource utilization technology, high concentration ammonia nitrogen wastewater resource treatment technology, starch sugar electro dialysis desalination technology, acid salt separation and reuse technology of acid containing high salt wastewater, aniline high color wastewater treatment, and resource application, new activated carbon adsorption regeneration wastewater advanced treatment technology, coal mine drainage water preparation desalination technology, etc.

4) Technologies related to water resources in agriculture and aquaculture. High-efficiency micro drip irrigation new technology, livestock and poultry sewage treatment and biogas residue biogas liquid comprehensive utilization technology, research on compound probiotics in reducing river pollution, farm waste gas, kitchen waste treatment, soil improvement, sewage resource utilization technology, water-saving cloud and soil free plant intelligent cultivation technology, etc.

5) Groundwater. Real-time monitoring and evaluation technology of groundwater in major grain-producing areas, simulation technology of groundwater dynamics in watershed irrigation areas and administrative areas, dual control management technology of groundwater quality and quantity, calculation and post evaluation technology of pressure extraction capacity in groundwater overexploited areas, groundwater ecological restoration technology, and application, etc.

6) Hydrological environment effect and key technology of water security in Zhongyuan urban agglomeration. Research on the impact of Zhongyuan Urban Agglomeration on the associated process of the water cycle, the impact of the social water cycle on regional water quality and quantity, and the application-oriented development of the comprehensive regulation platform for hydrological environmental effects of Zhongyuan urban agglomeration.

7) Water ecosystem protection and restoration technology. Water ecological restoration and sustainable guarantee technology, construction and application of water ecological civilization system, comprehensive treatment technology and demonstration of mountains, rivers, and lakes, research, and application of river and lake dredging technology, river and lake wetland ecological restoration technology and application, water ecological assessment and monitoring research, etc.

### **4.3 Improve the water resources management system**

Henan spans four river basins. According to the actual situation of Henan Province, we should establish a water resources management system according to the idea of unified management of the four river basins and coordinated management of administrative regions, strengthen the management of water safety by the water administrative departments of governments at all levels, strengthen the management of groundwater overexploitation and the operation of the South-to-North Water Diversion Project, so as to ensure the basic needs of economic and social development for water resources. At the same time, we should take planning as the starting point and strengthen the “four water simultaneous governance”, Strictly implement the national water-saving action plan, constantly promote the optimal allocation and scientific management of water resources, and achieve water-saving efficiency in agriculture, water-saving and emission reduction in industry, water-saving and loss reduction in cities and towns, water-saving and open source in key areas, etc. In order to promote the construction of water ecological civilization, Henan Province also needs to continue to improve the laws and regulations related to ecological protection, promote the construction of a law enforcement team, comprehensively deepen the reform of water prices on the existing basis, promote the reform of water resources tax, strengthen the national awareness of water conservation, and give play to the supervisory role of the people in water resources management.

### **4.4 Innovate the government administration mode**

In order to solve the problem of “multiple departments and multiple dragons governing water” and poor coordination ability among departments, a cooperation mechanism should be established, a unified supervision and management organization should be established, and the functions of the management organization should be strengthened. At the same time, due to China’s unique political system, we cannot copy the western administrative management model. We should give full play to the unique advantages of the government, take government planning as the command, and establish a water market system that combines administrative allocation and market regulation. In addition, it is also necessary to innovate the government assessment mechanism, link the implementation of various water management policies and water resource utilization efficiency with the government work assessment, strengthen the assessment support, and “force” the government to improve the construction of water resource monitoring capacity and water resource utilization efficiency, promote the development of water conservation work in the whole society, and speed up the construction process of ecological civilization.

### **4.5 Construction of “smart water conservancy” platform**

The primary task of building a smart water conservancy platform needs to cultivate high-level scientific and technological talents, and strengthen interdisciplinary exchanges in hydrology, water resources, water economics, ecology, computer networks, and so on. In the future, it is necessary to build a complete water conservancy information monitoring system in combination with big data and system network, so as to realize the automation of real-time monitoring of water conservancy information and the digitization of water system data; combining modern technical means such as Internet of things and 5 g, comprehensively considering multiple factors such as economic and social development, coupling multiple modules such as water supply, water demand and flood control, realizing real-time scheduling of water resources, flood control and disaster reduction based on cloud computing technology, and building an intelligent water

conservancy “module integrated system”; combine smart water conservancy with smart city, build a “decision-making and service system” for smart water conservancy, realize information-based management and intelligent decision-making, achieve refinement of water resources management, and provide platform support for water resources protection, utilization and optimal allocation<sup>[22]</sup>.

## 5. Conclusion

A series of documents of governments at all levels and relevant competent departments in Henan Province provide policy basis and cutting-edge key technical support for the protection and utilization of water resources; together, the two have created a foreseeable strategic opportunity for the protection and utilization of water resources in Henan Province, and these opportunities and challenges require more open thinking, innovative passion, and practical efforts. Looking forward to the future, the continuous innovative application of multidisciplinary cutting-edge technologies, management systems, and models in the field of water resources will permeate every corner of social and economic development, help the industrial upgrading and transformation of water resources protection and utilization industry, and open up a new situation of high-quality development of regional economy in Henan Province.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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