Social water environment governance innovation in China driven by big data: Frontier trends, dilemma challenges and optimization paths

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Abstract. The iterative development of big data technology has been deeply applied in the field of social water environment governance, and has shown a number of cutting-edge and characteristic trends. Big data technology and thinking promote the transformation of governance concepts to integration, the governance subject to diversification and coordination, the governance field to new-type expansion, and the governance structure to an integrated transformation in the society's water environment. At the same time, there are challenges in data quality and decision-making quality, data validation and national security, data standards and structural reforms, data innovation and application in social water environment governance driven by big data. In the future, the government needs to further strengthen the top-level design, move towards the overall governance of the water environment, fill in the legislative gaps, clarify the ownership of water environment data, increase innovative applications, tap the potential of water environment data, and provide Chinese wisdom for international water environment governance.

1. Introduction
The arrival of the era of big data means that the social governance environment is increasingly complex and changeable, and traditional national governance capabilities are being challenged. However, the continuous technical innovation and iterative change of thinking have provided a strong driving force for the improvement of governance capabilities and the optimization of governance models. Social water environment governance has also entered the era of big data. The unprecedented development of data and related technologies has urged the country and society, the central and local, the government and the market to face the issues of big data production, management, application, and protection in water environment governance. In this big data-driven transformation of water environment governance, China and developed countries such as Europe and the United States have initiated and promoted social water environment governance innovation at a nearly synchronous pace. Summarizing China's case experience is helpful for understanding the trends and characteristics of water environment governance innovation in Chinese society, and providing China's wisdom for water environment governance in the world.

2. Frontier trends
Data science is changing water science and engineering [1]. Big data, as an emerging technology, cutting-edge thinking, and governance perspective, has gradually been applied to water environment governance in China. It has completed the rapid transformation from concept to application, and gradually presents some innovative and characteristic development trends (see Figure 1).

**Figure 1.** Frontier trends of social water environment governance innovation in the context of big data.

### 2.1. Governance idea: transition to integration

The International Conference on Water and the Environment held in Dublin, Ireland in 1992, put forward the "Dublin Principles for Water Management", with emphasis on integrated water resource management. Integrated governance is divided into three levels: (1) managers should include different sectors and different stakeholders in the process of public decision-making on water resources; (2) integrate natural systems and human social systems involved in water resources; (3) integrate water governance and environmental governance [2]. This concept has become the logical starting point for innovative exploration of social water environment governance.

Since the 21st century, technologies such as big data and cloud computing have developed rapidly, making the connections, opportunities, and layout of the information society more complex. Society has become a more closely related whole, and the change in the concept of integration of water environment governance has become more apparent. The water environment involves many factors and the situation is complex and changeable, which determines that water management must take river basins as a unit, adopt systematic and comprehensive measures, coordinate multi-sectoral interests, coordinate conflicts and conflicts between different governments, and achieve social, economic, and ecological benefits. The development of river basin integration and international water environment cooperation has further enriched the meaning and scope of integration. The construction and use of China's national water environment monitoring platform, river basin water environment big data platform, national water regime early-warning monitoring platform, and national water conservancy map are all integrated manifestations. In 2018, the Ministry of Water Resources and various river basin management agencies have fully realized the online processing of the entire process of administrative approval matters.

### 2.2. Governance subject: shift to diversification

Big data technology has run through every dimension from individuals to organizations to countries. In terms of public individuals, water environmental information no longer flows from the government to the public individuals in one direction, but instead becomes a two-way flow. Individuals of the public can learn about various monitoring indicators and early warning information of the water environment in time through the environmental information website. At the same time, people can also ask or supervise related behaviors through water conservancy petitions or water environment supervision and reporting platforms. For example, in 2016, the Ministry of Environmental Protection established the "National Urban Black and Smelly Water Body Regulation and Supervision Platform"
and launched the "Urban Water Environment Public Participation" WeChat public account to facilitate public participation in supervision.

In terms of organization, driven by big data, the government launches public-private partnership (PPP) cooperation projects, establishes a national water conservancy market supervision service platform and approval service hall, continuously improves corporate sewage information, and promotes the construction of green credit systems and green financial systems. On the national side, on the one hand, various levels and departments within the national government continue to collaborate. In 2020, under the background of the outbreak of Corona Virus Disease (COVID-19), Hunan Water Affairs established information and data liaison with the government, Chinese Center for Disease Control and Prevention (CDC) and other relevant departments to ensure water safety and fight the epidemic. On the other hand, international cooperation outside the country has increased. For example, in 2019, the Water Environment Governance PPP Project in Deyang City, Sichuan Province is China's first water environment PPP project under the World Bank loan. It operates on a PPP model with an operating period of 25 years and a population of approximately 380,000.

2.3. Governance field: expand to intelligentization

The traditional water environment governance public service areas include administrative approval, early warning information, real-time water regime, and water conservancy letters and visits. In recent years, the application scenarios of big data technology in social water environment governance have continued to expand, involving intelligent planning and decision-making of water environment strategy, intelligent monitoring and enforcement of water environment pollution, intelligent forecasting and early warning in water environment governance, approval and guidance of public opinion on water environment, data security and protection of water environment governance.

In addition, the water environment governance has begun to pay attention to the wisdom construction of water culture and water conservancy scenic spots, and some new approaches have emerged. In 2018, the Ministry of Water Resources officially launched the "National Water Conservancy Scenic Spot Dynamic Supervision Information System", which integrates all basic and real-time data of local water conservancy scenic spots through technology docking, improving the management and operation efficiency of national water conservancy scenic spots. Various watersheds, management agencies, and operating scenic spots can use the system to grasp the real-time basic conditions and dynamic trends of the scenic spots, and coordinate dynamic supervision. In April 2019, the Three Gorges Dam Water Conservancy Scenic Area implemented face recognition to enter the park in accordance with the "Regulations on the Security Protection of the Three Gorges Water Conservancy Hub of the Yangtze River" and the latest requirements of public security organs.

2.4. Governance structure: reform to integralization

First, water environment governance in a big data society has led to a change in the power structure of water environment governance in China. In addition to emphasizing top-down executive orders, law enforcement, formal processes, and accountability mechanisms, it also emphasizes that power and rights should be balanced with each other, and that power moves from centralized to decentralized. Second, intelligent water environment governance promotes the reform of China's water environment governance organization structure, emphasizing network governance, public-private cooperation, third-party coordination, information sharing, and participation mechanisms. This breaks down the information barriers between departments, realizes information communication between departments, and makes governance from decentralized to overall.

The river chief governance model effectively fits the innovation of big data technology, the tradition of Chinese politics, and the current state of water governance. It is the wisdom of China to solve the fragmentation of complex cross-region water environment governance. In 2016, China's river chief system incorporating big data was established. On the vertical link, there are four levels of river chiefs — provinces, cities, counties, and townships. The hierarchical management of the main responsible persons of the local party and government has become an important node on the water
pollution control network. In the vertical, each person in charge reports the data in real time through the river chief application (APP) and river cruise APP. In horizontal management, a comprehensive platform was established through the river chief system, and a unified coordination mechanism for water environment governance. This not only established the relatively prominent advantages of the environmental protection department and the water conservancy department, but also fully mobilized the environmental protection, development and reform, finance, public security, transportation, agriculture and forestry and other functional departments to assume the division of labor and responsibilities in water governance.

3. Dilemma challenges
Of course, due to the immaturity of big data technology, the innovation and development of social water environment governance are not smooth sailing, and the hardships and challenges are not rare. To sum up, the related difficulties are mainly related to the following aspects.

3.1. Data quality and decision quality of social water environment governance
It is self-evident that the quality of data affects the quality of decisions. There are three key standards for data quality: (1) objectivity: whether the data is accurate, objective, complete, and unbiased; (2) utility: whether the data can be used by prospective users, including government, business, and society; (3) integrity: whether the data has been tampered with or manipulated improperly. There are three main issues with the current water environment governance data: The first is data integrity. "Missing data" is the number one cause of incomplete data. There are many cases of missing data, for example, the data does not exist at all, the data exists but is extremely difficult to obtain, the data exists but is confidential, and so on. The second is that the data is true and reliable. "Fake news" seriously affects the authenticity of the data, and the motivation behind it is profit-seeking. Water data was concealed or tampered during the collection and reporting process. Due to the phenomenon of concealment and errors in data collection itself, this inevitably causes data distortion, data deviation, data error, and data lag, which affects the scientificity and timeliness of decision-making. For example, in 2018, the Meteorological Observatory predicted that the accumulated rainfall in Weifang City on August 19-20 was about 40-70 mm, but the actual precipitation was about 6 times the predicted data. Upstream flooding combined with water from the interval, the Mi River's flood discharge in Shouguang City exceeded 800 cubic meters per second, which caused damage to 106,000 local greenhouses, affected 506,000 people, and lost 9.2 billion yuan in property.

3.2. Data confirmation and national security in social water environment governance
Due to the overall backwardness of big data security, in the integration process, the field of water environment governance has become even more backward. In 2019, the Ministry of Water Resources website's security monitoring was conducted 13 times, and the number of security problems was found to reach 13. 41.5% of the offensive and defensive drills found by the Ministry of Water Resources belonged to the problems left by the failure to implement the network security level protection requirements during the planning and construction phase of the informatization project, and 58.5% were caused by insufficient management during the operation phase. Big data for water environment governance also includes personal information and corporate information, such as public platform participation data, corporate approval data, water usage data, personal water conservancy scenic face identification data. The systematic data also makes the leakage of personal privacy more systematic and easier. At a large level, big data on social water environment governance also includes sensitive, complex, intertwined, dynamic, and comprehensive information about land, resources, government affairs, public opinion, and population. If it is attacked, defrauded, or lost by criminals, it will affect the security of state secrets and even affect politics. In addition, the current trend of internationalized big data cooperation on water environment governance has made water environment governance data rise to the national security level.
3.3. Data standards and structural reform in water environment governance
The structure of fragmentation has always been a major factor affecting the level and ability of Chinese government governance. Driven by big data, the overall planning of the data integration of various departments has gradually eased the division and shifted to overall governance. But it is still an obstacle. First, in terms of water environment data, sectoral interests have led to management fragmentation and information barriers between sectors, which are the primary obstacles to data system and structural changes. Secondly, in terms of information sharing, the emphasis is still on top-down access to information. Grass-roots departments only have the obligation to upload data, but they do not enjoy the right to obtain data. Thirdly, there is still a lack of strong overall planning and implementation in the overall planning of data-based water environment governance. The public sharing of data in the water environment governance process is already the norm, but there are still problems such as different information standards, different formats, diverse forms, different standards, and different reference systems.

3.4. Data innovation and promotion in water environment governance
The strong driving force of big data in social water environment governance need not be repeated, but the application of big data in water environment governance is still at a low level of integration. The driving force and innovation of big data are not fully explored. First, the potential of innovation entities has not been fully explored, and the investment entities for environmental governance innovation are relatively single. Most are directly invested and constructed by the government, which is not conducive to absorbing social and market funds to serve public utilities, is not conducive to the bold participation and innovation of other entities, and is not conducive to the market-oriented innovation, operation and management of the project. Secondly, the content of innovation is simple. The integration of "big data" + "water environment governance" is currently mostly at the stage of intelligent supervision and intelligent prediction. The deepening role of big data in innovation has not been fully formed. Water resources have certain similarities, and the innovation models in the initial stage of big data also have similarities. Due to the lack of main body capabilities or poor counterparts of innovation projects, the innovation did not consider regional and cultural characteristics in depth, and did not fully utilize the innovation of big data, resulting in the same innovation and development models for water environment governance. Finally, there is less innovation exchange and cooperation at home and abroad.

4. Optimization paths

4.1. Strengthen the top-level design and move towards the overall management
Adhere to the concept of integration and carry out top-level design of water environment governance at the national level.

4.1.1. Establish a big data-driven smart water conservancy overall framework. The government should determine the important tasks of the sky-ground integrated water perception network, the high-speed interconnected water information network, the intelligent water conservancy brain, the intelligent application of innovation and collaboration, and the security system. All departments, interest groups, and river basins should carry out corresponding intelligence and information construction according to the design of the national level, to avoid factors such as transfer and interests affecting the efficiency and accuracy of big data social governance. Develop smart water management standards [3]. Establish a big data-driven long-term mechanism for water environment governance to ensure the accuracy and timeliness of source data, and unify and security of platform data.

4.1.2. Restructure the power structure of water environment governance driven by big data. The government needs to further reform the organizational structure and power structure, and gradually move towards a problem-oriented overall governance. Through information and technical means to
break organizational boundaries, enhance mutual understanding and trust, and promote cross-departmental collaboration. Accelerate the realization of full sharing of relevant information about river conditions, river patrols, corporate sewage, governance progress, monitoring data, law enforcement penalties and other related information. Through frequent cross-border cooperation between the main bodies, the business processes of government departments are re-engineered, the work between public and private institutions is enhanced, and the "one-stop service" is provided to the public to achieve seamless governance.

4.2. Fill legislative gaps and clarify ownership of water environmental data
The legal framework builds a "frontier" for the development of social water environment governance driven by big data, delimits the boundaries between various subjects, and promotes water environment governance security.

4.2.1. Improve the data rights pedigree of water environment governance driven by big data. The data rights pedigree is the basic standard for data confirmation and rights regulation. A clear pedigree of rights, including the subject, object, and content of rights. The subjects of water environment data rights involve national governments, enterprise platforms, non-governmental organizations, and individual users. Different subjects have different rights, and different rights have different regulations.

4.2.2. Formulate big data tenure laws and security legal systems. The state should further formulate laws and regulations such as the Big Data Security Law, the Big Data Transaction Law, and the Data Transnational Circulation Law. The water resources department should refine and improve water environment data rights issues in this field based on national-level policies, and improve docking with other fields. Study the "Administrative Measures for the Sharing of Water Resources Information Resources" and "Supervision and Inspection Measures for the Construction and Application of Water Resources Network Information". Develop an information security emergency response plan, set up an emergency leadership group, strengthen platform function authority management, and entrust professional and technical units to regularly conduct security inspections of the platform to ensure platform security.

4.3. Increase innovative applications and tap the potential of water environment data
Based on demand analysis, new technologies such as remote sensing, cloud computing, internet, big data, artificial intelligence are deeply integrated to establish innovative fusion mechanisms to promote social governance and social innovation [4,5].

4.3.1. Strengthen the multi-agent interaction of water environment governance driven by big data. In accordance with the principle of "government and market" joint efforts, open bidding under the one-stop service plan of "construction + management + operation + maintenance". Set up a certain proportion of mobile posts in the talent flow mechanism between the government, universities, research institutes, and enterprises, and exchange personnel to improve the water environment governance innovation ability.

4.3.2. Construct a multidisciplinary framework for water environment governance innovation driven by big data. On the one hand, it promotes cross-border integration of water conservancy, management, information technology, economics and other disciplines to participate in the innovation of big data water environment governance, and provides intelligent support for innovation in different disciplines. On the other hand, qualitative, quantitative, theoretical, practical, simulation and other methods are used to promote the scientific, precise, and practical application of big data water environment governance innovation.
4.3.3. Promote multi-country exchanges on big data-driven innovations in environmental governance. The government should establish a network of interaction and cooperation at home and abroad to prevent backward innovation in water environment governance. Under the "Belt and Road" initiative, strengthen foreign exchanges and cooperation, and strive to deepen international cooperation in water conservancy. Give full play to the important role of water-related platforms such as the International Water Cooperation Mechanism and the World Water Forum to provide Chinese wisdom to global water environment governance.

5. Conclusions
The iterative development of big data technology has been deeply applied in the field of water environment governance in China, and has presented several new trends: (1) The idea of social water environment governance is changing to integration, including water and environment integration, integration of nature, society, and economic systems, integration of various departments, integration of various stakeholders, integration of river basins, and international integration. (2) The subjects of social water environment governance are more diversified and collaborative, running through all dimensions from individuals to organizations to the country. (3) The fields of social water environment governance are expanding to new types, from the informatization of public services for basic water environment governance to the intelligentization of cross-border integration. (4) The structure of social water environment governance driven by big data is reform to integralization, including the decentralization of vertical power structures and the integration of horizontal organizational structures.

Of course, the governance of social water environment driven by big data still faces challenges in terms of data quality and decision quality, data confirmation and national security, data standards and structural reform, data innovation and application. In the future, it is necessary to further strengthen the top-level design, fill in the legislative gaps, increase innovative applications, and tap the potential of water environment data.

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