

The American Experience of Integrated Water Resources Management and Its Implications for China

Hang Xue

Xi'an Jiao Tong University Suzhou Academy, Suzhou 215000, China

ABSTRACT

Water, a crucial resource that effectively drives human socio-economic development and ecological conservation, boasts its effectiveness, controllability, and renewability. It is an indispensable strategic resource for social progress. The United States has achieved remarkable results and accumulated valuable experience in integrated water resources management. These encompass integrated watershed planning and governance, efficient water conservancy infrastructure construction, measures to improve ecological environment, wastewater recycling and reuse, water rights management and trading systems, laws, regulations and policy support, water resources monitoring and assessment, and international cooperation and exchanges. These experiences serve as invaluable references for developing countries such as China in enhancing global water management and attaining sustainable development goals. Integrated water resources management gains prominence globally, and the United States has accumulated a wealth of experience and lessons in this area. This article delves into the strategies and accomplishments of integrated water resources management in the U.S., providing China with pertinent inspirations and recommendations.

KEYWORDS

Integrated Water Resources Management; Implications; Ecological Environment.

1. INTRODUCTION

Water resources are a crucial component of the Earth's ecosystem and a fundamental resource for economic and social development. Over the years, the United States, as one of the countries with relatively abundant water resources in the world, has accumulated vast experience in integrated water resource management. However, China encounters numerous challenges in its efforts to effectively manage its water resources. These include inadequacies in legal frameworks, disorganized administrative systems, a lack of a well-defined water rights system, incomplete water abstraction permit regulations, widespread water wastage and pollution, insufficient research funding and technological advancements, declining water resources, and imbalanced governance measures. These issues have significantly hindered the protection and rational utilization of water resources in China, thereby affecting sustainable economic and social development.

The distribution of water resources in the United States is similar to that in China. The 48 states in the United States can be divided into east and west along the Mississippi River. The eastern region, which is rich in water resources, accounts for more than 64% of the national population, but has 69% of the national water resources. In contrast, the population in the arid west accounts for 35.8% of the national population, but the water resources it owns only account for 30.8% of the national population. In China, Qinling Mountains and Huaihe River are the climatic and geographical dividing lines, which can be divided into two parts: north and south. The water-deficient north accounts for 46.4%

of the national population, but the water resources only account for about 20% of the national population. South China, which is rich in water resources, accounts for 53.6% of the national population, but owns more than 80% of the national water resources (As shown in table 1).[1]

Table 1. Distribution of population and water resources in China and the United States

Country Region		Population (%)	Water Resources(%)	Water Resources (m3/person)
China	North	46.4%	19.6	747
	South	53.6%	80.4	3481
	Nation-wide	100	100.0	2220
U.S.	East	64.2	69.2	6147
	West	35.8	30.8	5049
	Nation-wide	100.0	100.0	11,500

This article will delve into the integrated water resource management experience of the United States, covering areas such as integrated watershed planning and governance, efficient water conservancy infrastructure construction, measures to improve ecological environment, wastewater recycling and reuse, water rights management and trading systems, laws, regulations and policy support, water resource monitoring and assessment, and international cooperation and exchanges.

2. BASIC DEFINITION OF INTEGRATED WATER RESOURCES MANAGEMENT(IWRM)

As one of the important resources to effectively promote human social and economic development and ecological environmental protection, water has effectiveness, controllability and renewability, and is an indispensable strategic resource for human economic and social development. Water is constantly circulating in nature and human society, reflecting the attributes of resources, environment, ecology, economy and society(As shown in figure 1).

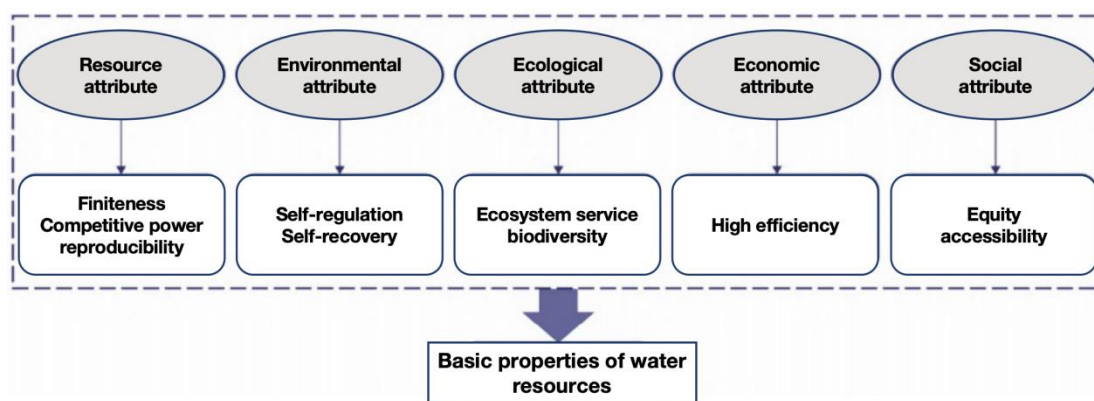


Figure 1. Basic properties of water resources

In 1968 and 1978, the United States completed two national water resources survey, monitoring and evaluation, which focused on the evaluation of the background status of water resources and the evaluation of water resources development and utilization, and formed a water resources evaluation method based on statistics. Since then, other countries in the world have imitated the United States in

carrying out water resource monitoring and evaluation work, World Meteorological Organization (WMO)[2] and United Nations Educational, Scientific and Cultural Organization (UNESCO)[3] based on the experience of many countries in carrying out water resources assessment, the Organization formulated the Manual on Water Resources Assessment Activities - National Assessment in 1988, which clarified that water resources monitoring and evaluation should be determined according to the source, scope, dependability and quality of water resources. In 1997, the Handbook was revised by WMO and UNESCO to form the Water Resources Assessment - National Capacity Assessment Handbook, which expanded the definition of water resources assessment.[4] The World Water Development Report released in 2000 emphasized the practical significance of protecting water resources and the necessity of water resources evaluation.[5]

The integrated water resources management(IWRM) is to achieve the effective use of water resources and the comprehensive management of environmental protection by comprehensively applying technical means such as water resources regulation, water environment protection, water resources development and utilization, water resources protection and water resources management within the river basin, with the main goal of water resources management. The American Water Works Association (AWMA) developed the concept of IWRM as “an attempt by the water supply industry to assure that water resources are managed for the greatest good of people and the environment and that all segments of society have a voice in this process”[6]

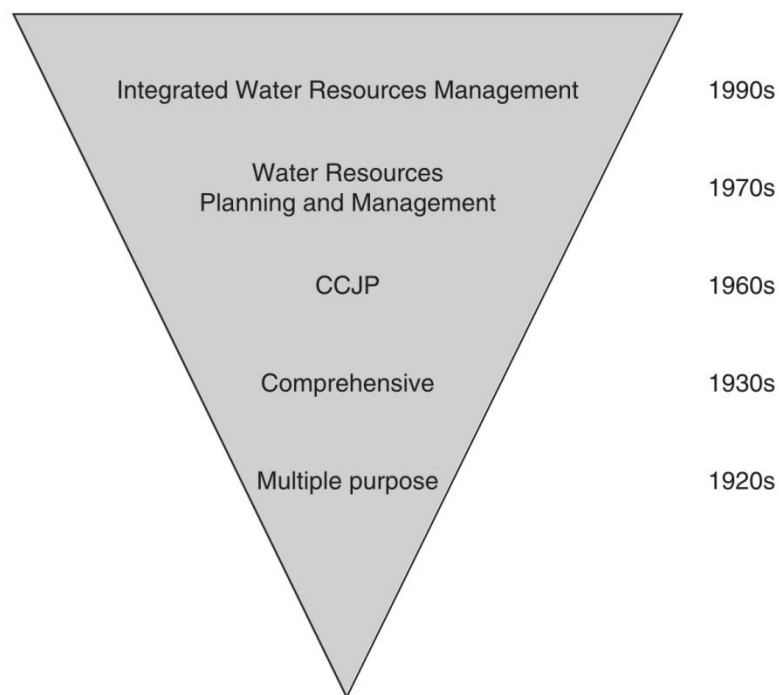


Figure 2. Evolution of IWRM concept[7]

3. PROBLEMS IN THE INTEGRATED WATER RESOURCES MANAGEMENT IN CHINA

3.1. Legal system of water resources management is imperfect

At present, the legal system of water resources management in China is not perfect, and there are some situations that the connection between relevant laws and regulations is not close, the content is repeated or even contradictory. This makes in the actual water resources management, there are legal gaps and law enforcement difficulties, affecting the effect of water resources management. In addition,

although China has carried out a series of reforms and attempts in water resources management, the water right system has not been fully formed. The lack of clear regulations and effective supervision on the definition, distribution and trading of water rights leads to inefficient and unfair allocation and utilization of water resources. At the same time, the water drawing permit system is one of the important means of water resource management in China, but the system is not perfect at present. On the one hand, the application, approval and supervision process of water intake permits is not standardized and transparent; On the other hand, there is a lack of effective penalties and sanctions for illegal water withdrawals.

3.2. Imperfect water resources administration system

First of all, China's water resources management involves many departments and levels, and the administrative management system is relatively chaotic. Unclear responsibilities and responsibilities among various departments have led to duplication and omission in water resources management, which has affected the efficiency and effectiveness of management.

3.3. Waste and pollution of water resources

Water resource waste and pollution are still serious in China. In some areas, over-exploitation of groundwater has led to the decline of the groundwater table and the deterioration of water quality. At the same time, the discharge of industrial and domestic sewage has seriously polluted the surface water and groundwater. These problems not only aggravate the shortage of water resources, but also threaten people's lives and health. With the growth of population and the development of economy and society, the demand for water resources in China is increasing, while the supply of water resources is increasingly limited. As a result, water resources in some areas are increasingly depleted, which seriously restricts the local economic and social development.

3.4. Insufficient research funds and technology

Water resources management needs to rely on advanced scientific and technological means and research results. However, at present, China's research funds and technical investment in water resources management are relatively insufficient, resulting in the research and development and application of new technologies and new methods are limited, which affects the governance effect. The distribution of water resources in China is uneven, and different regions face different problems of water resources. However, in the actual water resources management, there is often a problem of unbalanced management measures. Some regions focus too much on economic development and neglect water conservation, while others may overemphasize water conservation and limit economic development. This kind of unbalanced management measures make the solution of water resources problem more complicated and difficult.

4. THE AMERICAN EXPERIENCE OF INTEGRATED WATER RESOURCES MANAGEMENT AND ITS IMPLICATIONS FOR CHINA

4.1. Establish a sound system of water resources laws and regulations

The United States has achieved remarkable results in the comprehensive management of water resources, and a key factor of its success lies in the establishment of a sound system of water resources laws and regulations. This system provides a solid legal basis for the rational use, protection and management of water resources, and effectively promotes the sustainable use of water resources. It is also of great significance for China to learn from the experience of the United States and establish a sound legal and regulatory system for water resources. For China, the establishment of a sound system of water resources laws and regulations can be learned from the following aspects: First,

strengthen the formulation and improvement of water resources laws and regulations. In light of China's national conditions and current situation of water resources, more comprehensive and systematic laws and regulations on water resources should be formulated to cover all aspects and links of water resources. At the same time, attention should be paid to the coordination and complementarity of various laws and regulations to avoid conflicts and duplication of laws. Second, we will strengthen public participation and democratic decision-making mechanisms. In the process of formulating and implementing water resources laws and regulations, the public has been extensively consulted and the voices of stakeholders have been fully listened to. Let the public participate in the process of water resources management through an open and transparent way, and enhance the justice and transparency of laws and regulations. Third, strengthen the publicity and popularization of water resources laws and regulations. Through various channels and forms, the knowledge of water resources laws and regulations should be popularized to the public, and the public's legal awareness and law-abiding awareness should be improved. At the same time, strengthen the supervision and punishment of illegal acts of water resources to form an effective deterrent. In short, learning from the experience of the United States in the comprehensive management of water resources and establishing a sound system of water resources laws and regulations is one of the important ways to realize the sustainable use of water resources in China. By strengthening the formulation and improvement of laws and regulations, strengthening the public participation and democratic decision-making mechanism, and strengthening the publicity and popularization of laws and regulations, we can provide a strong legal guarantee and support for China's water resources management.

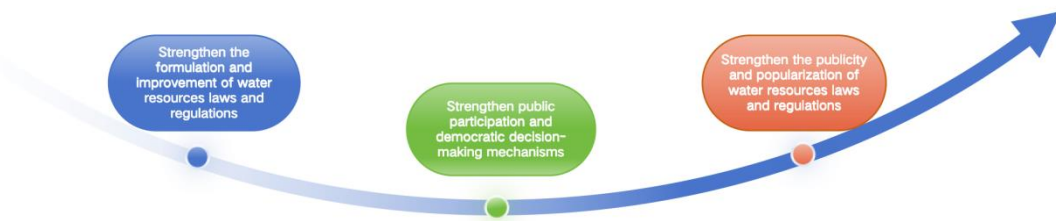


Figure 3. Establishing a sound system of water resources laws and regulations

4.2. Attach importance to integrated river basin planning and management

The United States has accumulated rich experience in integrated river basin planning and management. They focus on the whole river basin, consider the relationship between water resources, ecological environment and socio-economic development, and formulate comprehensive planning and management strategies. Through unified planning, unified management, unified scheduling and unified management, the optimal allocation and efficient utilization of water resources in the basin are realized.

For China, integrated watershed planning and management is also critical. China is home to many large rivers with vast drainage areas, uneven distribution of water resources, and faces increasing water pollution and shortages. Therefore, strengthening the integrated planning and management of river basins is of great significance to solve the current water resources problem and promote the sustainable use of water resources. Learning from the experience of the United States, China can strengthen the integrated planning and governance of river basins in the following aspects: First, strengthen the unified planning of river basins. The distribution of natural resources, the condition of ecological environment and the needs of economic and social development should be fully considered

in the formulation of river basin planning, so as to ensure the comprehensiveness and scientificity of the planning. At the same time, the cohesion and coordination between the plans should be strengthened to avoid conflicts and duplication between the plans. Secondly, strengthen river basin governance. In view of the problems of water pollution and shortage of water resources in the basin, effective measures should be taken. We will strengthen the prevention and control of water pollution, strictly control the discharge of pollutants, and improve the treatment and reuse of sewage. At the same time, strengthen the protection and conservation of water resources, promote water-saving technology and equipment, and improve the efficiency of water resources utilization. Thirdly, implement unified watershed scheduling and management. River basin management institutions shall be established to be responsible for the unified scheduling and management of water resources in the river basin. Through scientific scheduling and rational allocation of water resources, the water demand of all regions in the basin can be satisfied. At the same time, strengthen the protection and restoration of the ecological environment in the basin, and promote the healthy development of the basin ecosystem. Finally, we should strengthen public participation and social supervision. Comprehensive river basin planning and governance involves the interests of the general public, and public opinions should be widely solicited to enhance the public's sense of participation and gain. At the same time, a social supervision mechanism should be established to supervise and evaluate the watershed governance work to ensure the effectiveness and sustainability of the governance work.

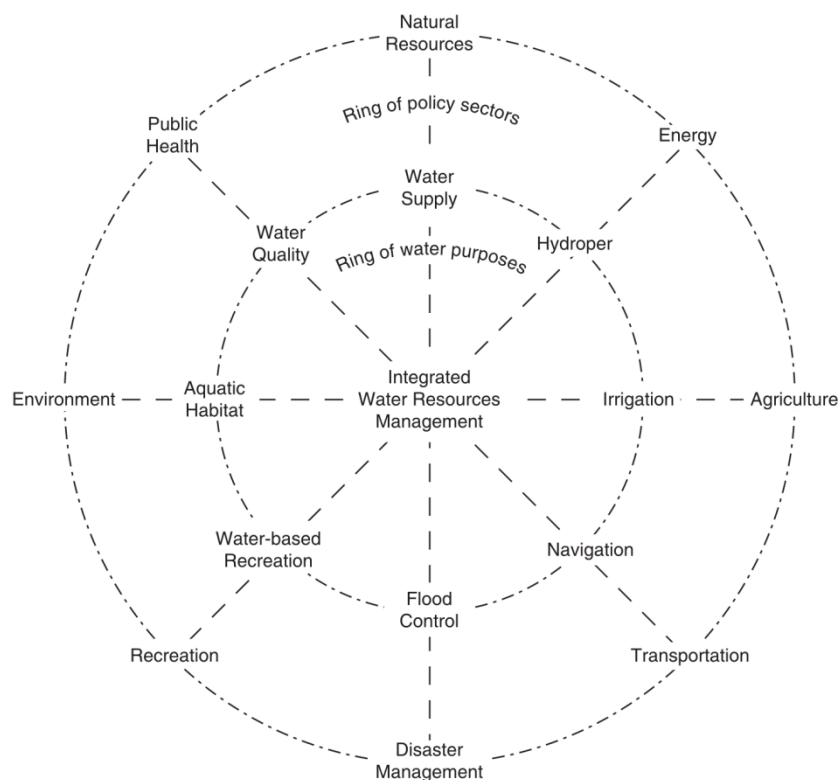


Figure 4. United States water resources integrated planning and management program

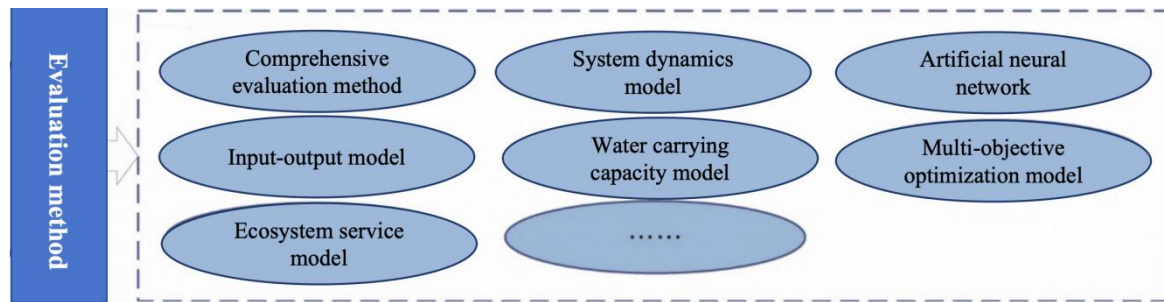


Figure 5. Multi-evaluation method of integrated water resources management

4.3. Strengthen the construction of high-efficiency water conservancy projects and improve the ecological environment

On the one hand, the construction of efficient water conservancy projects is the key to realize the optimal allocation and efficient utilization of water resources. The United States has effectively improved the efficiency of water resources by building advanced water conservancy facilities, such as large reservoirs, irrigation systems and water treatment facilities. China can learn from the United States and strengthen the construction of efficient water projects, including building more large reservoirs, optimizing irrigation systems, and improving water treatment technology to meet the growing demand for water and reduce water waste. On the other hand, measures to improve the ecological environment are crucial to maintaining the quality of water resources and ecological balance. The United States attaches great importance to the protection of water sources, wetlands and river ecosystems, and has effectively improved the water ecological environment by implementing ecological restoration, soil and water conservation and pollution control measures. China is also facing serious problems such as water pollution and ecological damage, so it should step up efforts to improve the ecological environment. This includes strengthening water pollution control, implementing ecological compensation mechanisms, promoting wetland protection and restoration, and strengthening soil and water conservation. In addition, the United States also pays attention to scientific and technological innovation and intelligent management in the construction of efficient water conservancy projects and ecological environment improvement measures. Through the application of advanced technology and intelligent system, the real-time monitoring, prediction and scheduling of water resources are realized, and the efficiency and accuracy of water resources management are improved. China can strengthen the investment in scientific and technological innovation and intelligent management, and promote the modernization and intelligent level of water resources management.[8]

4.4. Promote sewage recovery and reuse

The United States has achieved remarkable results in the comprehensive management of water resources, especially in the recovery and reuse of sewage accumulated rich experience. First of all, the United States pays attention to the establishment of a sound system of water resources laws and regulations, which provides a solid legal guarantee for water resources management and protection. China can learn from this practice, further improve the relevant laws and regulations on water resources, clarify the policy guidance and specific requirements for sewage recycling and reuse, and provide legal support for relevant work. Second, the United States has made great efforts in publicity and education to raise public awareness of water conservation and water recycling.[9] China can also strengthen publicity and education to increase the importance and participation of the whole society in sewage recycling and reuse. Through the popularization of relevant knowledge, guide the public to develop good water habits and reduce water waste. Finally, in promoting wastewater recycling and reuse, the United States also focuses on strengthening cooperation between the government,

enterprises and society. China can learn from this experience, strengthen cross-sectoral and cross-field cooperation, and form a joint force to promote the development of sewage recycling and reuse. At the same time, enterprises and social forces are encouraged to actively participate in sewage recycling and reuse projects, and promote the formation of diversified investment and operation models.

4.5. Improve the water rights management and trading system

The comprehensive management of water resources in the United States has provided important enlightenment for China in improving the management and trading system of water rights. On the one hand, the United States has established a diversified water rights system, including riparian rights, preemptive rights, mixed water rights and public water rights. Except for public water rights, the other three types of water rights can be transferred. This diversified water rights system helps to flexibly allocate and use water resources according to differences in different regions and water status.[10] China can learn from this classification of water rights, establish a water rights system suitable for its own country according to its own national conditions and regional characteristics, and provide institutional guarantee for the rational allocation and efficient use of water resources. At the same time, the water rights trading system in the United States is also worth learning. In the United States, water rights trading is one of the main reasons for the change of water rights, especially in the western region where water resources are relatively short, water rights trading is more active. Through water rights trading, the optimal allocation and efficient utilization of water resources can be promoted, and the formation and development of water rights market can also be promoted. China can gradually establish and improve a water rights trading system, clarify trading rules, procedures and regulatory mechanisms, and provide legal protection and a market environment for water rights trading. The legal and regulatory system of the United States in water resources management and protection is also worth learning from China. Through the establishment of a sound legal and regulatory system, the rights and obligations of all parties can be clarified, the development and utilization of water resources can be regulated, and legal support can be provided for the management and trading of water rights. China should continue to improve relevant laws and regulations on water resources management, increase penalties for violations, and ensure the sustainable use of water resources and the protection of the ecological environment.[11]

4.6. Strengthen international cooperation and exchanges

The remarkable results achieved by the United States in the comprehensive management of water resources not only provide valuable experience for China, but also emphasize the importance of strengthening international cooperation and exchanges. The United States is actively engaged in international cooperation in the field of water conservation, conducting research and sharing experience and technology with many countries. Such cooperation has not only promoted the improvement of global water resources governance, but also strengthened friendly relations between countries. China should actively participate in international water resources protection organizations and forums, work with other countries to address water resources challenges, and jointly promote the process of global water resources governance. At the same time, the knowledge exchange and scientific research cooperation between China and the United States in the field of water resources and environmental protection are worthy of China's in-depth learning and reference. Through regular academic seminars and symposia, experts from China and the United States can share the latest scientific research results and experience, and jointly solve problems in water resources and environmental protection. This mode of cooperation will help China to introduce and absorb international advanced water resources management concepts and technologies, and improve its own water resources management level. In addition, China and the United States can strengthen cooperation in technical cooperation and project cooperation. For example, in the fields of water treatment plant construction and water pollution control, China and the United States can jointly carry

out cooperation projects, share technology and resources, and achieve mutual benefit and win-win results. This mode of cooperation will not only help improve China's technical level in water resources management, but also promote the common economic development of the two countries. Finally, strengthening international cooperation and exchanges will also help enhance China's influence and voice in the field of international water resources governance. By actively participating in the formulation of international water resources governance mechanisms and rules, China can promote the formation of a more just and reasonable international water resources governance system and make positive contributions to safeguarding global water resources security and sustainable development.[12]

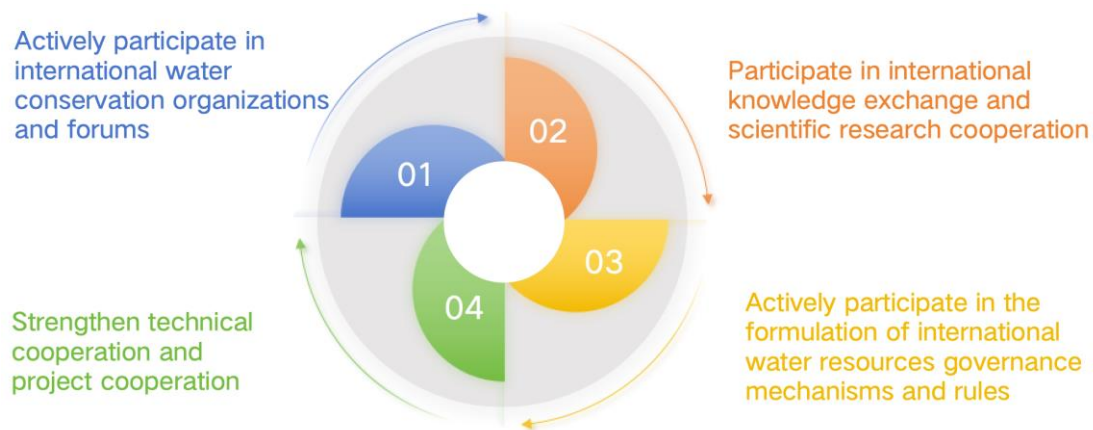


Figure 6. Strengthening international cooperation and exchanges

5. CONCLUSION

The United States has achieved remarkable results in the comprehensive management of water resources, providing China with valuable experience and inspiration. In light of its own national conditions and characteristics of water resources, China should actively learn from the experience of the United States, strengthen the comprehensive planning and management of the whole basin, improve the legal and regulatory system, and promote scientific and technological innovation and application, so as to realize the sustainable use and development of water resources. In the context of globalization, countries should strengthen cooperation and exchanges in the field of water resources, jointly cope with water resources crisis, and achieve sustainable use of water resources and common prosperity. In addition, we also need to note that although the experience of comprehensive water resources management in the United States is worth learning from, due to the differences in national conditions, natural conditions and economic development levels between China and the United States, we can not simply copy the American model, but should be combined with the actual situation to formulate water resources management strategies in line with China's national conditions. At the same time, we also need to pay attention to the impact of climate change on water resources and actively respond to the challenges of water resources brought by climate change. Through scientific planning, rational utilization and protection of water resources, to ensure the sustainable utilization of water resources in China', to provide a strong guarantee for the sustainable development of economic society. Finally, through in-depth analysis of the experience and lessons of the comprehensive management of water resources in the United States, we can better understand the complexity and challenge of water resources, and provide useful references for China's water resources management, so as to achieve sustainable utilization and development of water resources and promote sustainable economic and social development.

REFERENCES

- [1] He C, Harden P C, Liu Y. Comparison of water resources management between China and the United States[J]. *Geography and Sustainability*, 2020, 1(2): 98-108.
- [2] Canton H. World Meteorological Organization—WMO[M]//*The Europa Directory of International Organizations* 2021. Routledge, 2021: 388-393.
- [3] Information on: <https://www.unesco.org/en>
- [4] Jain S K, Singh V P. Water resources systems planning and management[M]. Elsevier, 2023.
- [5] Information on: <https://www.unesco.org/reports/wwdr/en/reports>
- [6] Grigg N S. Integrated water resources management: balancing views and improving practice[J]. *Water international*, 2008, 33(3): 279-292.
- [7] Grigg N S. Integrated water resources management: balancing views and improving practice[J]. *Water international*, 2008, 33(3): 279-292.
- [8] Liang Bin, Zhu Mingqiu, Pei Jianguo, et al. Experience in exploitation, utilization and comprehensive management of karst water resources: A case study of Karst area in western Hunan [J]. *Water Resources Protection*, 2007, 23(2): 64-69.
- [9] [J] Mukherjee M, Jensen O. Making water reuse safe: A comparative analysis of the development of regulation and technology uptake in the US and Australia[J]. *Safety Science*, 2020, 121: 5-14.
- [10] Pan Y, Dong F. Design of energy use rights trading policy from the perspective of energy vulnerability[J]. *Energy Policy*, 2022, 160: 112668.
- [11] Meng H, Bai G, Wang L. Research trends and areas of focus on water rights: a bibliometric analysis 1971–2020[J]. *Environmental Science and Pollution Research*, 2022, 29(50): 75119-75133.
- [12] Bernauer T, Böhmelt T. International conflict and cooperation over freshwater resources[J]. *Nature Sustainability*, 2020, 3(5): 350-356.