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Research on Binary Water Rights System Based on Elastic Volume Control rid

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Abstract

Water quality is one of the main factors that limits the quantity of water intake in areas with rich water resources and causes the shortage of water resources in the region. Aiming at the quality-induced water shortage problem in some cities of China, this paper proposes a dynamic water rights management model based on the elastic volume control, which redefines the tradable water rights into the binary water rights including the water intake right and the pollution discharge right. And through the establishment of the unit system "water intake –pollution discharge" model, the functional relationship between the total water intake and the total pollution discharge amount under certain water quality management objectives has been quantitatively studied, which provided the necessary technical support for the binary water rights system, thus the overall technical framework of the binary water rights system was constructed.

Keywords:*Water Resources Shortage, Quality-induced Water Shortage, Elastic Volume Control, Binary Water Rights, Water Intake – Pollution Discharg Model*

1. INTRODUCTION

Water resources are the necessary public resources to maintain economic development, social stability and human survival. The rational development and utilization of water resources is the most fundamental and basic means to ensure the construction of ecological civilization and achieve green and sustainable development. The Water Law of the People's Republic of China stipulates that water resources are owned by the state. The public nature of water resources makes its allocation more administrative. The rapid economic development requires the efficient allocation of water resources. The social solidarity and stability require the fair distribution of water resources. The stable supply of water resources is needed for people to live a happy and peaceful life. The ecological environment needs the guarantee of water resources. However, with the emergence of global warming, rapid population growth, escalating water demand standards and extensive management of water resources, water resources have become the main factor affecting social solidarity and stability, and restricting regional economic development, especially in arid areas. In addition, with the uneven distribution of water resources in time and space, water pollution, water disasters and other issues, the pressure on water resources in most regions of China is increasing. According to statistics, more than half of the 670 cities in the country have different degrees of water shortages, and more than 110 cities have serious water shortage problem. Nine of the 14 coastal open cities are seriously deficient in water, for cities such as Beijing, Tianjin, Qingdao, and Dalian have the most severe water shortage problem (Liu, 2016). It is impossible to resolve the current crisis by relying only on the means of government administration. It is necessary to explore a new way to bring regional water resources to the balance state between supply and demand.

Establishing a sound water rights transaction system is one of the important contents of China's water resources management system reform. At present, many countries and regions domestic and abroad have actively developed the water resources trading market (Carl, 2010) to promote the optimal allocation of water resources. In the past decade, domestic research on the water rights and water market has made certain progress, and the concept and characteristics of the water rights and water market have been discussed extensively. The construction and necessity of the water rights system have also been discussed, especially the contradictions arising from the distribution and practice of water rights transaction have been explored theoretically and practically. A number of studies have been carried out on the construction of water rights system and the internal mechanism, theoretical framework and operational mode of the water market for China's national conditions, which provided the foundation for further research in the water rights and water market. Wang Shucheng pointed out that the establishment of the water market is the product of the transfer of water rights, and the water market is a “quasi-market” (Wang, 2001); Hu Jilian believed that the water rights market shall be composed of the primary market (water rights wholesale and auction market) and the secondary market (water rights transfer market) (Hu, 2004); Wang Yahua elaborated on the mechanism, practical examples and policy ideas of the water market, and believed that the water market is the auxiliary tool for implementing the administrative distribution index in the current water rights allocation mechanism, and the water rights market will have large space for development (Wang, 2007).

However, considering the irreplaceability of water resources, the allocation of water resources should also rely on the power of the government to fully consider the balance of the needs of social equity and the ecological environment (Babel, 2005). The water rights transaction system is essentially a water resource allocation mechanism aimed at correcting government failure and market failure. It is a “quasi-market” approach combining administrative allocation with market allocation (Hu, 2000) (Luo, 2006) (Liu, 2016). The core and difficulty lies in coordination of the responsibility distribution between the government and the market to find the balance between efficiency and fairness.

The existing precedents for water rights transaction mainly occur in water-deficient areas. However, with the rapid development of China's economy and society, the traditional “water-rich area” has gradually showed the scarcity of water resources, which constitutes the basic premise of the establishment of water rights system and the trading market. The so-called "water-rich" is only a relative concept. From the perspective of the total amount of water resources, the water resources in the water-rich area may have surplus, but the total amount cannot be equal to the available amount. Except for water resources shortage due to the uneven distribution of time and space, the rapid increase in the total amount of pollutant discharge and the relative lag in the ability to control pollutants have also caused increasingly severe quality-induced water shortage. “Water pollution has become the disaster even more serious than the flood and drought". The contradiction between the efficient allocation of water resources and water environmental protection is particularly obvious in the water-rich area. The joint dispatch of water quantity and water quality or the allocation of water rights considering water quality factors has become a hot research topic currently (Marian, 2001) (Azevedo. 2000) (Luo, 2006). However, domestic and abroad researchers have focused on the optimal allocation of initial water rights under water quality constraints, and the simulation of water rights transaction behaviors of micro-water users, while

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there're relatively few researches on how to improve water rights management modes from the macro level. Therefore, this paper proposes the dynamic water rights management mode of which the government and the market coordinate with each other considering the characteristics of water resources in the cities with abundant water resources.

2. DEFINITION OF BINARY WATER RIGHTS

In the late 1980s, China has gradually constructed and implemented a series of water resources management system, including water resources planning, water allocation, planned water use and quota management, water intake permit and pollution discharge permit management. Since 2005, the Ministry of Water Resources has issued several guidance documents of "Water Rights System Construction Framework", "Several Opinions on Water Rights Transfer", "Notice on Water Rights Pilot Work", and "Interim Measures for Water Rights Transaction Management" successively, and stipulated the water rights system from the aspects of water resources ownership system, water rights use system and the water rights transfer system, providing foundation for the clarity of water resources right and the realization of water rights transaction. The Water Law clearly stipulates that water resources in China are owned by the state, and the ownership is exercised by the State Council on behalf of the state. In the civil law, the ownership is one of the property rights, which includes the powers of possession, use, earnings, and punishment (Li, 2010). Therefore, under the legal system based on this, China's water rights transaction is actually to divest the ownership of water resources, with the possession retained by the state while the water use and transfer rights by the subordinates through administrative allocation, that is, the object of the transaction is the partial use right of the water resources.

In general, the right to use water resources can be divided into two types: within the rivers and outside the rivers. The right to use water outside the river is the water intake right. Once obtained, the holders of water right have full rights to use and obtain benefit, and also the rights to transfer freely except for categories like basic domestic water restricted by the state; the right to use water within the river mainly indicates ecological water, water for navigation, power generation and so on, of which it's managed by the country mainly, and there's no trading condition on the urban scale.

The definition of traditional water rights often only refers to the definition of water quantity, and ignores the water quality as the core traits of water resources. Therefore, in recent years, the water quality has been taken into the consideration of water rights. For example, Cai Shouqiu (Cai, 2002) and others believed that water right is the right system that includes water environment rights, water resources ownership, water usufruct and use rights, and other rights, emphasizing the complexity of water rights and environmental rights in environmental law; Cui Jianyuan (Cui, 2003) believed that water rights are the general term for bundle of rights, and the right of drainage is mentioned. These articles only stays on the theoretical level. In the actual management work, the definition of tradable water rights should be concise, accurate and operable. Reasonable water rights management should focus on the most core content of water resources management - water intake and pollution discharge to achieve the connection and coordination of water resources allocation and water pollution prevention and control. In fact, from the perspective of water resources value, the value diversification of water quality and water resources is closely related. The water bodies with excellent quality have many functions and can bring greater economic benefits while the water bodies with poor quality have few function and bring less benefit even negative values, and the pollution discharge, like the water intake, uses and weakens the values of the water bodies in the region. Therefore, pollution discharge is essentially the consumption of water environmental capacity and water quality value, and the pollution discharge right is essentially part of the water use rights within the river.

Based on the above analysis, this paper proposes to define tradable water rights as binary water rights including water intake right and pollution discharge right. The water intake right generally refers to water use right outside various rivers, including various living, production water and ecological environment water outside the river channel; the pollution discharge right, i.e. the traditional right to discharge pollutants into water bodies, is essentially partial use right for untaken water bodies. For the innerconnection between the two, this paper proposes the concept of flexible volume control. On the basis of redefining the tradable water rights, the government can realize the total amount determination and micro-control of the assignable binary water rights through the elastic volume control of the total amount of water intake and the pollutant discharge.

3. DEFINITION OF BINARY WATER RIGHTS

3.1.Meaning of elastic volume control

The control of total amount of water consumption and pollutant discharge is one of the core contents of China's current water resources management policy. Strict total volume control and water intake and discharge permit management are the basis for establishing an effective water rights system, which fully reflects the advantages of administrative control in resources management. However, the current volume management has significant drawbacks: Firstly, the separated management of water intake and pollution discharge has split the connection between water quality and water quality. There is no effective communication and coordination mechanism between the water management department and the environmental protection department, which is likely to cause a disconnection in management; Secondly, the understanding of the relationship between water quantity and water quality is insufficient, and it cannot reflect the dynamic and controllability of the total control index in the water-rich area in south China.

In the context of high-speed industrialization, the quantity of water intake and quantity of pollution discharge is just as closely related to each other as the two sides of the coin. Wang Zongzhi and others (Wang, 2010) proposed to unify the distribution of initial water quantity right and the initial pollution discharge right when studying the initial allocation of water rights in the basin, but did not conduct an in-depth analysis of the dynamic relationship between the two and improvement measures. The elastic volume control proposed in this paper refers to the fact that the total amount of water intake in the city and the total amount of pollutants discharged are not fixed. Under certain water quality management objectives in the region, the total amount of water intake and the total amount of pollutants discharged can be adjusted accordingly in certain range, if the total amount of pollutants discharged is controlled, and the quality of the water environment is improved and more water can be taken appropriately. If the total amount of pollution is large, it is necessary to strictly control or even reduce the amount of water intake. The elastic volume control is realized through the interactive adjustment between the government and the water users. Its meaning mainly includes: a) at the macro level and the large time scale, based on the market feedback after completing the determination and initial allocation of the total amount, the government dynamically adjusts the water intake right and pollution discharge right in the market through buyback and increasing sales under the premise of ensuring stability; b) at the micro level and small time scale, the water users, obtained certain water right through the initial allocation or market purchase, convert their water intake right and the pollution discharge right amount held based on their own needs within a certain control quota.

In order to study the quantitative relationship between water intake and pollution discharge, a simple and feasible water quantity and water quality joint control model-unit system “water intake - pollution discharge” model is established to provide necessary technical support for elastic volume control.

3.2 Unit system "water intake – pollution discharge" model

The existence of water resources in surface water bodies such as natural rivers and lakes, and the changes of water quantity and water quality with time and space are full of uncertainties and complexities. In order to focus on the study of impact of human activities, this paper generalizes the water resources system in the region into a unit system, establishes a lumped model of the unit system “water intake - pollution discharge”, and adds two influencing factors of water intake and pollution discharge in the natural water quantity and quality balance equation, and studies the quantitative relationship between the quantity of water intake and pollutant discharge based on the basic principles of material balance and migration and transformation of pollutants. In practical applications, the research units should be divided according to the water functional zoning, administrative division, and distribution of water system networks and the actual needs.

The water quantity and quality changes of a unit system under human influence are shown in Figure 1. In the figure, Ri and Ci are the amount of water entering the unit system and its average pollutant concentration during the period; Rp and Cp are the local self-produced water quantity of the unit system and its average pollutant concentration, ie the concentration of the non-point source pollution; qw and Cw are the quantity of water intake and the water quality concentration of the unit system in the period respectively. The quantity of water intake includes agriculture, industry, and domestic water (covering the tertiary industry according to the old statistical standards) and the ecological water outside the river; Re and Ce are the discharge amount of the unit system and its average concentration during the period,mainly including urban domestic sewage and industrial wastewater discharged through the pipe network. Since the water structure and pollution discharge structure do not fluctuate too much during a certain research period, the change is slow and gradual; meanwhile, considering present idea of dual control of total discharge and concentration of pollutants, there’s certain proportional relationship between Re and qw, which is Re=αqw, where α is the comprehensive discharge coefficient under certain discharge standards; Ro and Co are the water quantity flowing out of the downstream unit system and its average pollutant concentration within the time period.

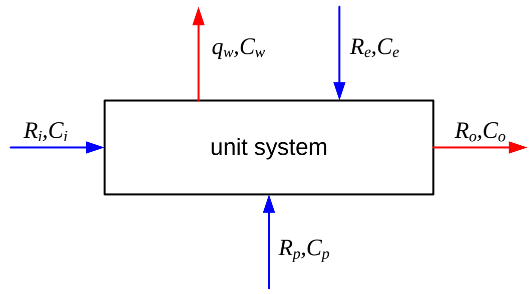

Fig.1. Schematic diagram of water quantity and quality changes in unit system.

There is natural water balance equation and artificial water balance equation respectively:

$$R_i + R_p = R_o + \Delta R \tag{1}$$

$$R_e = q_w - q_c \tag{2}$$

Where, ΔR is the change of channel storage capacity and various natural losses, and qc is the water consumption.

The time scale of the model is determined according to the details of the data. It can be studied by the year, month or the floodseason and the non-floodseason. During the study, the water quality change can be considered as stable, and the corresponding steady state model can be obtained after the boundary conditions are determined. Taking into account the basic principles of varioussources and exports and material balance during the migration and transformation of pollutants, the pollutant balance equation in the unit system is:

$$R_i C_i + R_p C_p + R_e C_e = q_w C_w + R_o C_o + K R_o C_o \tag{3}$$

Where, K is the comprehensive degradation coefficient of pollutants in the system.

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Then the maximum water intake increment and maximum water withdrawal can be calculated.When the quantity of water intake in the system increases, the pollutant balance equation should be:

$$R_i C_i + R_p C_p + \alpha(q_w + \Delta q)C_e = (q_w + \Delta q)C_w + (1+K)\left[R_o - (1-\alpha)\Delta q\right]C_o \quad (4)$$

Where, Δq is the system water intake increment. When the runoff volume is much larger than the water intake, the change amount (1-α) Δq of Ro can be ignored.

Obviously, when Cwis less than αCe an increase of water intake quantity causes the corresponding increase of Co. In the water-rich area, the water resource recycling rate is relatively low, and the α value is usually above 20%. Considering the current national pollution discharge standards and water quality standards in the water source region, this equation can be considered as accepted in water-rich area.

$$A = q_w C_w + (1+K)R_o C_o - R_i C_i - R_p C_p \quad (5)$$

When the water quality target of the output water from above equation is Co equal to or less than Ct,

$$A_t = q_w C_w + (1+K)R_o C_t - R_i C_i - R_p C_p \quad (6)$$

Then below equation can be got:

$$\Delta q_{\max} = \frac{A_t - \alpha q_w C_e}{\alpha C_e - C_w} \quad (7)$$

The corresponding maximum water intakeunder the current comprehensive pollution discharge coefficient is calculated with below equation:

$$q_{\max} = q_w + \Delta q_{\max} \quad (8)$$

In addition,the ecological water demand in the river(including the water maintaining the ecological balance and water for navigation function)is considered according to the certain proportion of the system's output water volume.The ecological water demand in the river can be taken as:

$$R_s = \eta R_o \quad (9)$$

Therefore,the maximum water intake considering ecological constraints and water quality constraints shall be:

$$q_{\max} = \min\left\{(1-\eta)R_o, q_w + \Delta q_{\max}\right\} \quad (10)$$

When the water intake has reached the threshold,ifneed to be continued,in order to ensure that the water quality target of the exit water meets Co ⩽ Ct,the pollution control process must be improved,and the comprehensive pollution discharge coefficientαunder the fixed pollution discharge standard must be reduced.When the reduction valueαis set asΔα,the pollutant balance equation should be:

$$(\alpha - \Delta\alpha)(q_{\max} + \Delta q) = \Delta q C_w + A \quad (11)$$

Similarly, if the water quality target of the output water volume is Co ⩽ Ct, the relationship between Δα and Δq can be obtained through below equation:

$$\Delta\alpha \geq \alpha - \frac{\Delta q C_w + A_t}{(q_{\max} + \Delta q)C_e} \quad (12)$$

Under certain pollutant concentration standard, the decrease of α means the reduction of the amount of pollution discharge. Therefore, after selecting the baseline, the function relationship between the water intake increment △q and the reduction amount ΔRe of pollution discharge can be furtherly obtained under certain water inflow condition and water quality control objectives:

$$\Delta R_e \geq R_e - \frac{A_t}{C_e} + \left(\alpha - \frac{C_w}{C_e}\right)\Delta q \quad (13)$$

The range of the total water intake quantity in the unit and the total amount of pollutants discharged, as well as the quantitative relationship between the amount of pollutant reduction and the increment of water intake after reaching the maximum water intake amount, can be obtained as one of the data supporting for the elastic volume control, based on the current status of the annual data.

4. CONSTRUCTION OF THE BINARY WATER RIGHTS SYSTEM

The construction of the binary water rights system can be divided into the following four steps: a) the definition of tradable water rights and the improvement of legislation; b) the determination of the total amount of water rights allocation; c) the initial allocation of water rights; d) the transfer of water rights. Its technical framework is shown in Figure 2.

The clear definition of tradable water rights is the premise of establishing an effective water resources management system. In the process of constructing the binary water rights system, the relevant legislation should be improved first, and the power range of various water resources use rights and the rights and obligations of water users should be clarified. Stable use rights and transfer rights shall be granted to the holders with the right to intake water and discharge pollutants within the allowable period. This has been initially analyzed in the above paragraphs, and further discussion will be made in the following paragraphs on the determination of the total amount of water rights, the initial allocation of water rights, and the transfer of water rights.

4.1 Determination of the total amount of water rights

The assessment of the total amount of water rights that can be allocated is the basis for the initial allocation and transactions of water rights. It is necessary to fully collect hydrological and water quality monitoring data and historical water and pollution discharge data in the region, and determine the appropriate range of water intake rights and total discharge rights according to the water quality management objectives of the water function zone,based on the principle of elastic volume control with unit system “water intake - pollution discharge” model. However, the determination of final allocation of water rights is linked with the initial allocation of water rights. In the verification of the status quo and forecasting, the regional economic and social development planning and ecological protection and restoration planning will be used to formulate the distribution plan, and the specific evaluation index system will be established according to the characteristics and main problems of local water resources for the evaluation and screening of the program (generally it can be based on efficiency, fairness and sustainability). And the final allocated water intake rights and pollution discharge rights is determined through continuous feedback and adjustment during this process.

For the influencing factors of the main natural and socio-economic development affecting the water intake right and the total amount of pollutant discharge rights, the provided distribution plans may include hydrological scenarios, water conservancy construction scenarios, water saving scenarios, sewage scenarios and industrial planning scenario factors (see figure 3).And the sub-programs is formed through reasonable combination of the actual needs with the guidance of relevant planning, to analyze the appropriate initial allocation of water rights and the total amount of water rights allocated from both perspectives of supply and demand.

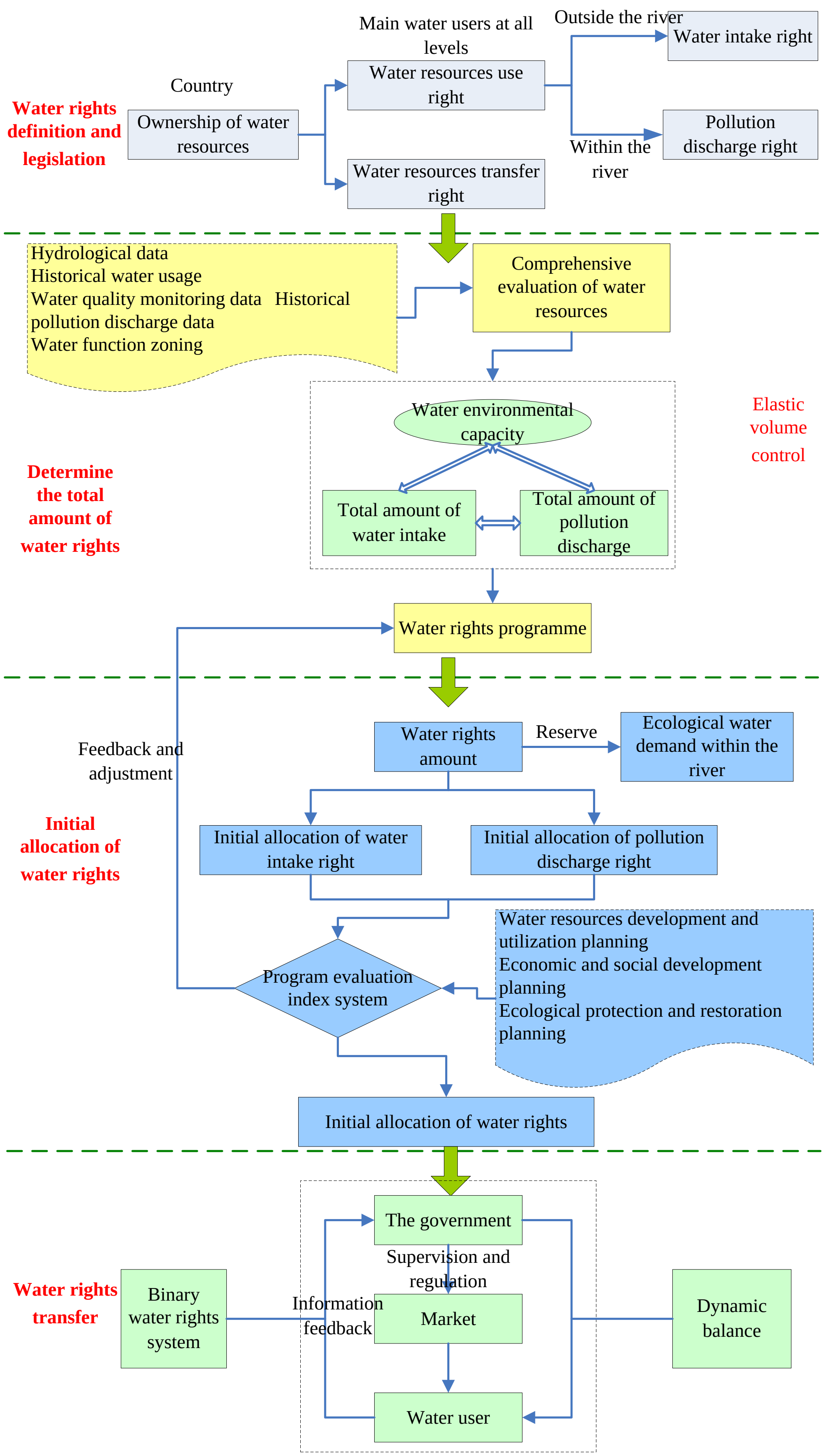

Fig.2. Technical framework of the binary water rights system

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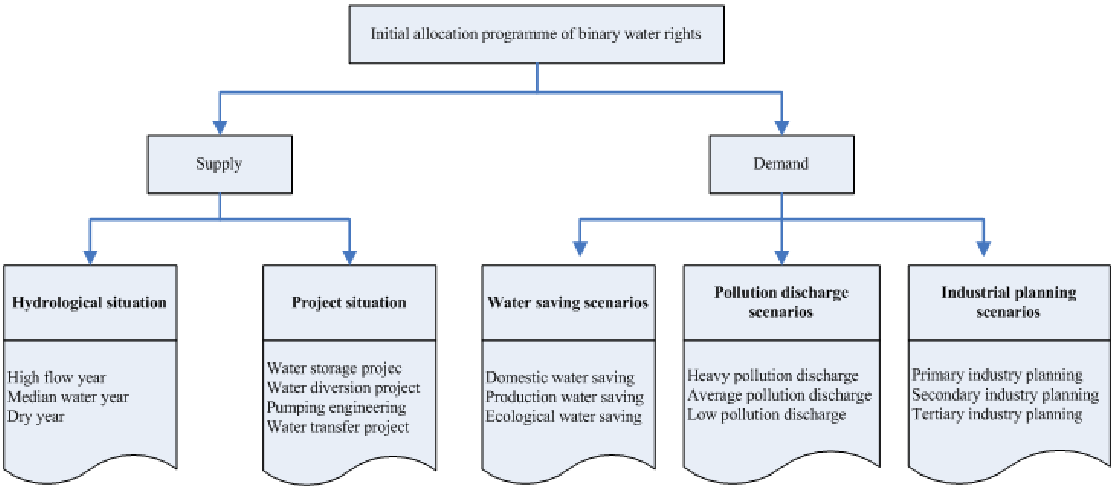

Fig.3. Schematic diagram of the initial allocation of binary water rights

4.2 Initial allocation of water rights

The purpose of the initial allocation of water rights is to clarify the subject and object of water rights, and to achieve the privatization of water use rights to certain extent, which is the springboard from pure administrative allocation to market allocation under government regulation. Considering the difference in the nature of the water intake right and the pollution discharge rights, the allocation principle of the two is different and should be treated differently.

➢ Initial allocation of water intake right

The initial allocation of water intake right should follow the following basic principles:

Fairness and efficiency while fairness is priority. Water resources are the basic resources for maintaining human survival. Considering the basic requirements of politics and ethics, the allocation of initial water rights should follow the principle of fairness and efficiency.

Respect for customs while compliance with planning. On the one hand, it should fully consider the informal constraints such as water consumption habits in the target area, step by step to reduce the implementation cost; on the other hand, it should be based on the forecast of water supply and demand of the target area, and coordinated with related urban planning.

Layered and orderly. It means: a) horizontal classification, there're three categories in the city: domestic water, production water and ecological water. The basic domestic and ecological water must be guaranteed first, and for production water, the consideration for industry with high water consumption efficiency shall be prioritized; b) vertical classification. According to the importance and time sequence of water demand, the water consumption can be divided into three categories: basic water, water for development and water for high level of development, of which its priority is reduced orderly.

➢ Initial allocation of pollution discharge rights

For the allocation of initial pollution discharge rights, most scholars tend to the compensated allocation methods such as auctions. For example, Cramton and Kerr concluded that the auction method is more advantageous than the free method when studying charcoal transactions. Considering the current market conditions and institutional basis of China, the appropriate approach should be further deepen and improve the emission system, and conduct the initial allocation of pollution discharge rights through the government pricing and enterprise purchase.

The selection of pollutant control should be flexible according to the actual situation of each region. Theoretically, the pollutant types should be comprehensive but usually is appropriate to choose one or two major pollutants that affect the water quality, such as ammonia, nitrogen or COD, due to the limit of the operating cost.

4.3 Transfer of water rights

- Ways of water rights transfer

In the process of constructing the binary water rights system, it should be fully integrated with the existing system. In the transitional stage, two small markets can be established firstly, and the transaction market of water rights and pollution discharge right should be developed on the basis of water intake permit management and sewage permit management. And in order to promote the transfer of water rights and the realization of elastic control, this paper proposes to establish the water rights conversion system based on traditional water rights transaction. The government can set the value relationship, the allowable amount and the relevant execution rules for the conversion between the water intake right and the pollution discharge right in the region according to the current water resources utilization level and total index, allowing the water rights holder to convert the water rights held according to its own needs. That is the binary water rights, which includes: the water intake right trading market, the pollution discharge rights trading market, and conversion of the water intake right and the pollution discharge right.

This combined transfer method is not a simple combination of traditional water right transaction and emission trading, but an organic combination based on the internal connection. Its advantages mainly include:

It is conducive to the government's macro-monitoring and dynamic regulation of the overall water use, and promotes the joint optimal allocation of water resources and water environment capacity. The two markets are paralleled. The government as the facilitator establishes corresponding trading platform and water rights registration, supervision and guarantee mechanism, and links the operation of the two markets through the conversion of water rights, which is conducive to the realization of integrated management regulation of water users at the beginning and the end, and the coordination of administrative means and market mechanisms to jointly promote the optimal allocation of water resources and water environment capacity.

Reduce the cost of water rights transfer and encourage polluters to improve production process. Water rights conversion can provide flexible trading mode for market players. Under the current immature market conditions, there’s no need to sign agreements with other water users, thus the conversion can effectively improve the efficiency of water rights transfer and encourage the polluters to improve their process.

- Analysis of the market behavior of principal part

The binary water rights system is a dynamic system involving the government, the market and the water users. It includes two types of parties: the government and the water users. The process of water rights transfer and management is essentially the multi-party game process in which the two parties adapt to each other, communicate and coordinate around the market until dynamic balance is reached.

- Analysis of water user behavior

Under the premise of individual rationality, the behavior characteristics are shown in Table 1.

Table 1. Stimulus-reaction behavior characteristics of water user

Stimulus	Reaction
Production expansion	Buy the water rights
Production reduction	Sell the water rights
Improve process	Sell the pollution discharge right

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Improve process & expand production	IF P(transfer)＜P(trade): THEN the pollution discharge right is transferred to the water intake right
	IF P(transfer)＞P(trade):THENsell the pollution discharge right& buy the water intake right

Assuming the production process is the same, the water intake and pollution dischargeof the enterprise increase and decrease in the same proportion, when the water users need to expand (reduce) the production scale, the water rights will be purchased (sold) through the market; if the production process is improved , the extra pollution discharge rights will be sold; if production expansion is done while improving the process, there’re two choices, one is to sell the right to discharge and purchase the water intake right, and the other is to directly convert the right to discharge into the water intake right, which depends on the cost of water users' access to the same amount of water rights, including price factors and time spent in the transaction or conversion process, labor and other costs:

$$P = P_{mon} + P_{tim} + P_{hum} \tag{14}$$

Where, Pmon, Ptim, and Phum are price cost, time, and labor costs, respectively.

- Analysis of government behavior

As the macro-controller of the overall utilization rate of water resources and water environment quality, the government aims to ensure the efficient and orderly water resources market and maximize the economic benefits and environmental benefits of water resources. Its main market behaviors include:

Adjust the total amount of water rights in time. As shown in Table 2, N is the number of units divided in the area, and q(n) and qmax(n) are the water intake amount and the maximum water intake amount in the unit respectively. After the government completes the determination of the total amount and the initial allocation work, the amount of water intake right or pollution discharge right in the market can be dynamically adjusted according to the market feedback information and the evaluation of the water use status, and the total amount of water rights can be reduced (increased) by means of buyback (auction).

Table 2. Characteristics of government stimulus – reaction behavior

Stimulus	Reaction
$\sum_{n=1}^{N} q(n) > \sum_{n=1}^{N} q_{\max}(n)$	Buy back the water rights
$\sum_{n=1}^{N} q(n) < \sum_{n=1}^{N} q_{\max}(n)$	Increase the sale of water rights
$\overline{P}(transfer) < \lambda \overline{P}(trade)$	Reduce ξ
$\overline{P}(transfer) \geq \lambda \overline{P}(trade)$	Increase ξ

Establish and timely adjust the value relationship of water rights conversion. The supervision of water rights transaction price is one of the most important contents of water rights management. The water rights conversion system is actually a price guiding mechanism. On the one hand, it will affect the market price of water rights. On the other hand, the government should also make appropriate adjustments based on the feedback of the market to prevent market imbalances caused by improper

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value relationships, and even the extreme scenarios such as collective runs and speculative attacks.

Considering the impact of market price factors, the water rights conversion formula is adjusted by formula (13) to:

$$\Delta R_e = R_e - \frac{A_t}{C_e} + \xi\left(\alpha - \frac{C_w}{C_e}\right)\Delta q \qquad (15)$$

Where, ξ is the market price factor, and in Table 2, $\overline{P}(transfer)$ and $\overline{P}(trade)$ are the average cost required for the conversion of water rights in the region and market transactions respectively. The market price can be guided by moderate adjustment of factor ξ , $\overline{P}(transfer)$ will be controlled slightly less than $\overline{P}(trade)$ (the threshold can be set as λ times of $\overline{P}(trade)$) to achieve incentive for the pollution enterprise to improve the process without occurrence of vicious run.

5. CONCLUSIONS

This paper puts forward a clear and new idea of timely adjusting the total amount of water and the total amount of pollution discharge in the region, and discusses the problem of coordination of the roles and responsibilities between the government and the market and reduction of the transaction cost of the market. The binary dynamic water rights system constructed by the elastic volume control mechanism has positive reference in realization of water quantity and water quality, the beginning and end of water resources utilization, the use and management of water resources within rivers and outside the rivers, and it is one of the development directions of water rights system reform in China, especially in water-rich area.

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