

PROMOTE THE SUSTAINABLE DEVELOPMENT OF WATER RESOURCE IN CHINA USING THE CONCEPT OF SCIENTIFIC DEVELOPMENT

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ABSTRACT: Water resource crisis is one of the important global environmental problems. There are serious contradictions both in quantity and quality of the water in the world. China is one of the water-lacking countries and its water resource per capita is a quarter of the world's average value. Moreover, water quality which is caused by serious water pollution further aggravate the crisis of the water shortage and it becomes the major factor which is directly related to economic safety of a country and effects people's daily life and stabilization of the political system. Many countries in the world have put the issue of water resource safety into country-level secure strategy and have paid much attention to it. In recent decades, Chinese government has conducted a great of work and obtained significant achievements in dealing with the serious problems of water resources and its sustainable usage as well as promoting national water resources safety. In this paper, the crisis of water resource will be assessed by employing the statistics database of hydrology and socio-economic development in China. In addition, the present performance and safety strategy of water development and planning in China will be discussed from the view point of solving the water scarce problem.

KEYWORDS: Water resource management, scientific development, water crisis, safety strategy

1. INTRODUCTION

Water resource is the basic natural resource and strategic economic resource as a key of the economic and social sustainable development which keeps ecologic and environmental balance. Water resources safety directly links to people's normal life and national stability as well as national economic safety. Water resources safety issue has become a task of primary importance which has been placed in the agenda of various countries' economic development. Establishing water resources safety guaranteeing system has become the most important and imminent realistic problem to be resolved. Water resources safety means that water can satisfy the requirement of humankind existence and development and ecologic environment. The adverse effects of water resources can be controlled within humankind's endurance and it could not inflict a threat to human

social stability and development. If water circulation system is broken and function of water deteriorates and brings forth a series of safety issues of economy, society and environment, the water resources is in an unsafe state.

Water resource safety includes water quality safety and quantity safety. Water quality safety is the first connotation of water safety, which means that the quality of water can satisfy the requirement of human's existence and production and keeping the ecologic balance. In the last century, the inkling of water resources scarce appeared and attracted high international attention. The first environment and development congress of the United Nations warned that "water would cause serious social crisis". In 1992, it has been pointed out that in the 21st century water is the most important among water, grain, and energy. In order to enhance public consciousness of

Table1 Themes of world water day and china water week from 1994 to 2007

Year	Theme of world water day	Themes of China water week
1994	Caring for Our Water Resources Everyone's Business	
1995	Women and water	
1996	Water for thirsty cities	Harness water by law, manage water scientifically, intensify water saving
1997	Water scarce	Water for development
1998	Ground water - invisible resources	Harness water by law - promote sustainable usage of water resources
1999	We lives in water resources scarce forever	To harness river is the fundamental to prevent draught
2000	Water and health	Strengthen saving and protection, realize sustainable usage and protection of water resources
2001	Water for the 21st century	Build up a water saving-style society, realize sustainable development
2002	Water for development	Take sustainable usage of water resources as the pillar of economic and social sustainable development
2003	Water for the future	Realize sustainable usage of water resources through harnessing water by law
2004	Water and disasters	Harmony between water and human
2005	Water for life	Guarantee drinking water safety, safeguard life health
2006	Water and culture	Change the concept of water usage, innovate development model
2007	Answer to water scarce	Water resources development for harmonious society

protecting water resources, the United Nations established March 22 is the “world water day”(Table1).

The situation of Chinese water resources still deteriorates further. In June 1998, the first remark of the report “Ways and means for Chinese water issue” was sent to the State Council by Chinese Academy of Sciences describes that water issue would be the most serious problem in the economic development in the 21st century. Some international organizations even connected Chinese food self-supplied ability with its water resources supply ability and argued that Chinese water resources scarce would become the biggest and the most formidable problem to be solved (Brown, 2002). It would even cause the change of the global food market and other

international problems.

2. ACHIEVMENTS OBTAINED BY CHINA IN PROMOTING WATER RESOURCES SAFETY

China is the biggest developing country in the world and water resources in China is no so huge (Table2). It is the strategic choice in Chinese modernization drive that takes sustainable usage of water resources as the pillar of economic and social sustainable development. In recent decades, Chinese government has done a great deal of work and obtained great achievements for the sustainable usage of water resources and promotion of national water resources safety.

2.1 Highlight the issue of water resources safety

Table2 Water resources in some counties.

Country	Average annual flow (100 m ³)	Average annual flow (mm)	Average water amount (m ³)
World	468000	314	2350
Brazil	51912	609	10700
Russia	47140	211	1390
Canada	31220	313	4770
America	29702	317	1050
Indonesia	28113	1476	13200
China	26380	276	1750
India	17800	514	720
Japan	5470	1470	8460

China always pays high attention to water resources safety. China has obtained great achievements which attract worldwide attention. The ability of the comprehensive adjusting and controlling water resources in China has been improved and the ability of actual water supply rises up to 659.1 billion m³. It plays an important role in economic construction and reducing floods. In 1994, China made out “the Agenda of China in 21st century” and became one of the earliest countries which made out and practiced the 21st agenda. Meanwhile, China also made out “Water Resources Agenda of China in the 21st century” concerning with water issue (Zhou, 2007).

2.2 Establish the new thought of water resource safety sustainable development

Chinese government made a great work in harnessing water and gradually changed from traditional water resources development to sustainable development water resources. The thought of water resource sustainable development is the embodiment of the concept of scientific development. It is a successful way to deal with the water resources issue of China. The new thought of sustainable development of water resources safety

has much connotation. It covers various aspects of water resources safe development and reform, and possesses distinctive epochal characteristics. With realizing a harmonious development between human and nature as the core idea, the new thinking of sustainable development of water resource safety takes people as the center. It holds harmony between human and nature. It emphasizes curbing human damage to water resources development and usage through the reasonable development, high efficient usage, comprehensive management, optimization allocation, all-round saving, effective protection and scientific management. It aims to realize a harmonious development between human and nature by taking water resources sustainable development as the guarantee of economic and social sustainable development and opens a new journey of practicing sustainable development of water resources.

2.3 Establish laws and water resources management system

New “Water law”, “Flood protection law”, “Water pollution control law”, “Water and soil conservation law”, etc., were promulgated and taken into practice by China. New administrative regulations, technology policy standard, and water law, i.e., “Hydrology regulations of China”, “Management regulations of water intaking permission and water resources levy”, etc., were constantly perfected. Water resources programs were gradually improved and further perfected. Large quantities of water resources comprehensive and special planning were worked out. These preliminary achievements of water resources allocation with drainage area established a planning basis for establishing water right system.

Water resources management was gradually strengthened. Water resources demonstration system, water intaking permission system and water resources payment service system were further

implemented. Moreover, water resources engineering construction and management were improved. Water price reform and water resources engineering emigrant settlement were further strengthened. Water resources science and technology reform and innovation as well as quality and technology supervision were steadily performed.

2.4 Investment and infrastructure construction

Regulating rivers and watercourses is the everlasting theme for human society. The water resources infrastructure in China possesses a fair scale through many years of hard work. In recent years, dynamics of water resources investment increased and a great stride in water resources construction was realized. Large quantities of significant water resources infrastructure concerning national economy, livelihood, and development were established. Guaranteeing people's life and health as well as guaranteeing ability of economic and social development were obviously improved. Seven river flood control systems were preliminarily formed and the ability of flood controlling and calamity reduction was conspicuously improved through consolidating the trunk embankment of the large rivers. A series of water resources engineering such as 'South Water Transfer to North' are being constructed to improve the ability of the water resources existence in spatial-temporal and overcome the serious imbalance situation of the water resources' spatial distribution.

2.5 Prevent and harness water resources

It has become a significant task for national development to enlarge the dynamics of prevention, harness water pollution, and curb the tendency of water environment deteriorating. Prevention and harnessing water pollution started in late 1970's. Some achievements were obtained since then. Especially in recent years, Chinese government paid high attention to

prevent water pollution. As results, investment gradually increased in China. The emission amount of chemical oxygen from industrial declined almost 50%. Preventing and harnessing water pollution of the key drainage area was promoted, harnessing the polluted water was focused. The deteriorating tendency of water pollution of Huai River and Tai Lake's drainage area was basically under control. The ability of prevention and harnessing water pollution was increased. The system and mechanism of prevention and harnessing water pollution are gradually perfected. The organizational leadership and comprehensive coordination in preventing and harnessing water pollution has been strengthened.

2.6 Actively build a water saving style society

Building a water saving style society is the most fundamental and effective strategy to deal with water resources scarce of China. It is an important to build an all-round harmonious society. "Water law" was revised and enforced in 2002, which clearly prescribes that Chinese government rigorously enforces saving water, vigorously implements measures of saving water, spreads new technology and industrial arts in saving water, develops water saving style industry, agriculture and service industry, builds a water saving style society.

From the view of the whole country, the efficiency of water usage in China increased by 5% each year from 1995 to 2000. 26% increased within 5 years. Comparing with 2000, the water usage was 327 m³ per 10000 Yuan GDP in 2006, which declined 41.8%. The water usage of 10000 Yuan industrial production was 177 m³, which declined 39.2% compared with that of 2000. The rising rate of water usage was under effective control and the average rising rate per year of national total water usage was not up to 1% (**Table3**).

Water consumption for agriculture purpose constitutes 70%-80% of the total water consumption of China. The potentiality in increasing agricultural water

Table 3 Comparison of the water usage by producing 10000 Yuan GDP in drainage areas and in agricultural irrigation areas.

Drainage area	Water usage per 10000 Yuan GDP (m ³)			Average water usage per Mu (m ³)		
	2000	2004	change	2000	2004	change
The whole country	610	399	-211	479	450	-29
Songhua River	600	447	-153	533	517	-16
Hai River	350	180	-170	261	238	-23
Huang River	680	343	-337	412	387	-25
Huai River	390	236	-154	271	272	1
Yangtze River	550	335	-215	489	467	-22
Pearl River	640	396	-244	916	852	-64
Southeast rivers	370	222	-148	665	558	-107
Southwest rivers	1280	972	-308	616	613	-3

usage efficiency is very large. The most effective way to increase the efficiency of agricultural water use is to make water saving reconstruction in the irrigation region. Since 1996, China continued the construction and reconstruction of the saving water system in 363 large irrigation regions and 164 medium irrigation regions, which effectively improved the agricultural comprehensive productivity. Compared with that of 2000, average water usage in agricultural irrigation region decreased 29 m³ in 2004, which shows that the efficiency of water use was greatly enhanced.

3. CHALLENGES FOR CHINESE WATER RESOURCES SAFETY

Compared with other countries in the world, Chinese water resources is still prominent and water perplexing issues such as “too much water, inadequate water, dirty water and muddy water” are still faced by Chinese water resources due to its rapid economic development and fast growth of industrial and agricultural water resources usage as well as its general population growth despite China made a fair achievement. Four big water issues of water environment, water ecology

and water calamity react each other, superimpose each other and forms a multi-level water crisis which affects China’s future development and safety. Among them the threat of water pollution is particularly prominent. Water resources issue has become the grave restrict factor to Chinese economic and social development and ecologic environment construction.

3.1 Frequent flood and drought

China is one of the countries in the world with frequent floods and droughts. Floods and droughts in China have brought forth grave threats to the national economy and safety of people’s life and property. The characteristics of China’s flood are: frequent occurrence, long duration, wide region, high intensity, economic loss and casualties caused by flood occupy the first position in all kinds of natural calamities. According to the statistics, since 1990 the national average loss caused by floods is about 110 billion Yuan per year. In 1998, the longest river of China was in floods and caused a loss of almost 39 billion dollars. In 2006, the direct economic loss caused by national floods with diverse degrees was 133.26 billion Yuan.

By August 8, 2007, flood with diverse degree broke out in 29 provinces, autonomous banners and municipalities. The population hit by floods was up to 120 million, direct economic loss was 91.9 billion Yuan. Especially the medium and small rivers and the medium and small reservoirs faced grave threat. In recent years, the loss caused by floods which broke out in the medium and small rivers constituted from 60% to 80% of the whole loss caused by flood. Moreover, along with the rapid economic and social development, the economic stock, population density and people's property threatened by floods increased in a large scale. The loss caused by floods is becoming higher and higher.

The droughts in China are also rather serious. In 2006, droughts occurred in most regions in China. Especially the east region of Chongqing and Sichuan were the most serious with direct economic loss was 98.6 billion Yuan. Meanwhile, the global warming will further affect the whole water cycle and change the distributive pattern of the regional amount of precipitation and rainfall, which brings forth climatic calamities frequently.

3.2 Inadequate usable water resources

Water resources in China are extremely inadequate and freshwater is very deficient. A large population with relatively little water, imbalance of water resource distribution in space and time, and the situation of water and land resources mismatched with economic and social development are the basic water resources problems in China.

According to the statistics, the total freshwater resource in China is 2805.31 billion m^3 , constituting 6% of the global water resources. But, the average amount is 2200 m^3 per person which is only 28% of world average amount. In recent decades, the decreasing tendency of water resources appeared in northern China. Annual flow of Huang, Huai, Hai and Liao river drainage area decreased more than 10%,

among which the annual flow of Hai drainage area decreased the most. Droughts and water deficiency become the prominent problem in northern China. It is predicted that the contradiction between water resources demand and supply will be further intensified when the population reach the peak of 1.5 billion by 2030.

Meanwhile, because Chinese water resources distribution is spatial-temporal unbalance. With regard to time, the precipitation within a year and between years changes greatly. There exists an obvious high flow period and drought period alternation of the change of annual flow with each year. With regard to space, spatial distribution is extremely out of balance. The disparity of average usable water resources per person in the whole country is much larger. The population of Southern China consists of 54.4%. The water resources of Southern China consist of 81%. Farmland and irrigation area of Northern China consist of 65% and 59% of the whole country, respectively, but water resources possessed by them only consists of 19% in China. The average water resources per person of Beijing, Tianjin, Hebei, Shanxi, Shandong, Henan, Ningxia is even below 500 m^3 . Global warming and large-scale human activity further affect the change of the amount and quality and distribution of Chinese water resources.

3.3 Low benefits of water resources utilization

Water resource in China is extremely scarce and China consumes the largest amount of water resources in the world. "The statistic bulletin of water resources development in China" demonstrated in 2006 that national water resources was 2556.7 billion m^3 , which reduced 8.9% compared with that of the last year, 7.7% compared with that of the average year, respectively. Annual consumption of water resources was 571.6 m^3 , which increased 8.3 billion m^3 . Presently there exists a big gap in the utilization ratio and benefits of water resources between China and the advanced level of the

world. In 2006, the water use per GDP decreased to 273 m³, which was still 3 times of the world average level.

The major reasons are three. First, water use efficiency of agricultural irrigation is very low. Average shortage of 30 billion m³ water exists in agricultural irrigation and the traditional broad irrigation is applied in most agriculture area of china. In 2006, the water use efficiency was 0.45 in China and 0.7-0.8 in developed countries. The productive ratio of agricultural irrigation water in China was 0.87-1.1 kg/m³, which were 2.3-3.5 kg/m³ in Israel. Secondly, water consumption in industrial production is high but industrial water cycle usage is very low. The water consumption per ten thousand Yuan in industrial production is much higher than that of the developed countries. The present water consumption of ten thousand Yuan in industrial production is 103 m³, which is 8 m³ in America, 6 m³ in Japan. The ratio of industrial repetitive usage of water is about 55%, which is more than 80%-85% in the developed countries. Thirdly, the waste of domestic water is very widespread. According to the statistics, the water loss ratio in cities is 20%-30%. Each year the wasted water is about 10×10⁸ m³. The reuse of the polluted water and the use of sea water and rain are very low.

3.4 Water resources environment deterioration

Water resources environment deterioration is becoming the critical factor impacting the water resources safety in China. Along with the rapid economic and social development, the construction of the basic facilities for sewage treatment, the price system of the city and industry sewage treatment has not been perfected, which makes water pollution issue quite prominent. A large amount of sewage was discharged directly into rivers, lakes, and seas, which caused the pollution of the water body. In 2006, “the statistic bulletin of national environment” demonstrated that the general amount of national waste water discharge was 53.68

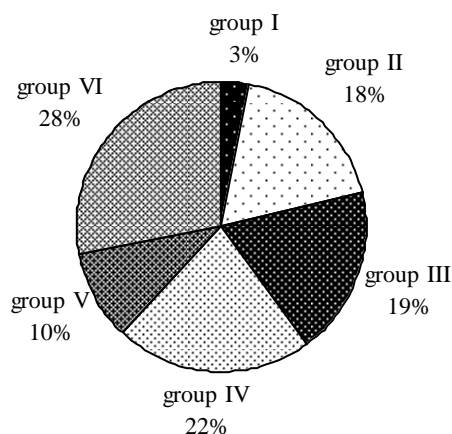


Figure 1 Quality groups of rivers.

billion tons, which increased 2.3% compared with that of the last year. Among the 408 monitoring sections of the 197 rivers of the seven river systems, i.e., the Yangtze, Huang, Pearl, Songhua, Huai and Liao Rivers, the ratios of the sections of I-III groups, IV group, V group, V inferior group water quality were 46%、28% and 26% respectively. Among the 27 key lakes (reservoirs), there were 2 lakes (reservoirs) (constitute 7% of the whole) which meet the standard of II group of water quality, 6 lakes (reservoirs) (constitute 22%) which meet the standard of III group of water quality, 1 lake (reservoir) (constitutes 4%) which meets the standard of IV group of water quality, 5 lakes (reservoirs) (constitute 19%) which meet the standard of IV group of water quality, 13 lakes (reservoirs) (constitute 48%) which meet the standard of inferior VI group of water quality. Among them, the water quality of Cao Lake was V group, the water quality of Tai Lake and Dian Lake was inferior group (Fig. 1 and Table 4).

3.5 Unreasonable development of water and soil resources

There is a strong relation between the occurrence of flood and the serious damage caused by unreasonable productive activity of humankind. The occurrence of blind land reclamation, enclosing lakes, disorder engineering construction in rivers, caused a series of ecologic and environmental problems such as rivers'

Table 4 River quality in rivers of China.

Seven river system	Group I (%)	Group II (%)	Group IV(%)	Group V(%)	Group VI (%)
Yangtze River	58	18	12	5	7
Huang River	18	32	25	0	25
Pearl River	58	24	15	0	3
Songhua River	3	21	48	7	21
Huai River	5	21	37	7	30
Hai River	14	8	11	10	57
Liao River	27	8	17	5	43
General	27	19	23	5	26

drying up, withering up of wetland, degenerating of grassland, etc. Forests lost its normal function of conserving water. The sedimentation of the middle and lower river reaches and enclosing lakes caused the disappearance and contraction of lakes, which greatly reduced the regulating ability of lakes to floods. It not only reduced the conserving ability of vegetation and aggravated the soil erosion, but also increased the incidence of flood and greatly reduced human ability in preventing flood.

The area of the soil erosion in China is 3.56 km². The area of the soil erosion needs to be treated is more than 2 million km². The area of whole national lakes reduced 15% compared with that of 1950's. 90% of the available grasslands of the whole nation were in differential degree of degeneration and desertification. The exceeding extraction area of ground water has been expanded to 190 thousand km². Ecologic and environmental problems seriously threaten the economic and social sustainable development of China.

4. GUARANTEE WATER RESOURCE SAFETY WITH THE CONCEPT OF SCIENTIFIC DEVELOPMENT

4.1 Build a water saving style society with the principle of sustainable development

Building a water saving-style society with the principle of sustainable development is the most fundamental

and efficient strategy for solving the water resources scarce problem in China. It is the critical period for China to build a water saving-style society in the next 13 years. Building a water saving-style society is not only a complex systematic engineering but also a deep conceptual revolution. It needs common efforts and participation of the whole society.

As the goal of water saving construction, water allocation engineering system of water resources will be basically perfected by 2020. The prevailing custom of self-conscious water saving and the reasonable way of using water will then be cultivated. The balance of water demand and water supply will be realized based on maintaining a sound ecologic system. The active public participation and actions concerned in practicing saving and protecting water resources should be encouraged.

Science and technology innovation should be constantly fastened. New technology, new industrial arts, new equipments of industrial water and agricultural water and domestic water should be further developed. Unconventional new technology of water resources use such as industrial reuse and recycling, rain use, moderated salted water use and so on should be developed.

The policy and law and regulations systems as well as the systematic construction concerned should be further strengthened and perfected. Based on the

water law and the regulations in China, national imposing and supervising regulations of water resources, promoting regulations of water resources industry, regulations of water saving, regulating rules of water resources demonstration of key programs construction should be made out and promulgated. The system of laws and rules and regulations in protecting and saving water should be fairly perfected.

4.2 Guarantee the water quality and water environment safety

It is necessary to reserve and promote water resources and strengthen the comprehensive harnessing of water pollution. As a sustainable development strategy, water resources controlling must be changed into the whole process of pollution controlling and river upstream controlling is the key. Laws and regulations in preventing and treating water pollution must be strictly carried out and the dynamics of prevention and treatment of sewage should be intensified.

We should make great efforts to harness the environment of the important drainage area and pay attention to the water source protection of drinking water. To prevent and treat the water pollution for drainage areas is significant in realizing the objects of the national water environmental protection. We should pay attention to enforce and practice the treating plans, invest more in harnessing, speed up the harnessing engineering construction.

4.3 Develop and utilize the unconventional water resources

Unconventional water resources include industrial reuse and recycling, sewage reuse, development of air water, moderately salty water use and sea water use. At present, the development and use of Chinese unconventional water resources have been launched, but we should do more to create a sound development situation. Sea water resources in China are rich, but average amount per year of direct sea water use for

industry is just 10 billion m³, which is 1/10 of America. The potentiality of direct sea water utilization is very large. The corresponding plan in sea water utilization should be worked well. Moreover, air water is the biggest part of the land freshwater. In future, China should attach importance to the development and use of air water, make out plans in developing and utilizing air water, study the influence of the development and utilization of air water to the surface runoff and ecologic environment.

Sewage water could be reused after being properly reprocessed and big benign water recycling will be realized, which is striking social and environmental and economic benefits. The development and utilization of sewage is an efficient way to relieve the contradiction between water resources demand and supply, improve the situation of the increasingly deterioration of the ecologic environment. We should strengthen the study of the technology of sewage reprocessing and storage of sewage at the political and strategic point.

4.4 Establish the water resources allocation system combining government with market

The marketization of water resources allocation is the direction of water resources allocation system reform. The allocation of water resource innovation of the ownership of water transactions system, water pollution right transactions system, ecologic protection compensation mechanism and payment for the water area occupying system are based on the definition of the ownership of water. Establishing water resources safety system for safeguarding the reasonable use and allocation of water resources should be speeded up and perfected. Reasonable use and allocation of water resources will be realized through the intensity of law system construction of water resources.

4.5 Perfect the decision-making mechanism of water resources management

The study and practice of national safety strategy of

water resources should be strengthened through uniformly arranging the development and utilization and protection of the conventional water resources and unconventional water resources, realizing the integration of water resources management, putting water resources into the compound system of the society-economy-environment, managing water resources high efficiently by a comprehensive and systematic method. The scientific and democratic decision-making systems should be established. Scientifically defining the administrative decision-making right of water resources departments of different levels, and perfecting the internal decision-making rules, decision procedures and supervising systems and mechanism of administrative decisions of water resources departments are necessary. Water resources administrative decision mechanism should be established with participation of the public and combination of specialists' demonstration with government decision. The scientific demonstration of the planning of national economy and social development and the general programming of city and the layout of the key construction program should be strengthened.

5. CONCLUDING REMARKS

According to the 21st century agenda for China and the White Book of China's population, environment and development, the general objectives in water resources protection and sustainable utilization in China are: actively developing and utilizing water resources and practicing all-round water saving, thus to relieve the situations of serious water scarce in cities and countryside, make the development and use of water resources to obtain the largest economic social and environmental benefits, and satisfy the increasingly requirement of water resources and water quality caused by social and economic development. Meanwhile, reasonably and fully utilizing water resources, making economic construction and water

resources protection develop simultaneously under the prerequisite of safeguarding the natural function of water resources, hydrology, biology, chemistry, and safeguarding and improving ecologic environment. It can be believed that our objectives can be realized as long as we take the concept of scientific development as the guideline, stick to the correct principle of water resources, practice water harnessing thinking of the sustainable development, and constantly promote the development and reform of water resources. A glorious blueprint full of life and vigor for water resources modernization adapted to the national economic development level, with more beautiful mountains and waters, with more bright sky and clearer water, sharing the development and reform achievements of water resources, will be realized and presented in near future.

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