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Original Research Paper

The Challenge of Water Resources Management in Sichuan Province: Research on Water Resources Management and Water Allocation Based on Water Quality, Water Volume and Water Use Efficiency

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ABSTRACT

In order to achieve the scientific water resources management in Sichuan province, by adopting the relevant data from Integrated Planning Report of River Basin in Sichuan province and by researching the 21 cities (states) in Sichuan province as well as water resource divisions, the volume and quality of water resources in the whole province were found out. The available surface water and the total available water resources in the whole province were calculated; water use, water use efficiency, change process of water use, water consumption and other water use statuses were analysed; water resource demands of life (including both urban and rural areas), production (including farm irrigation, plantation and pasturage, fishing and livestocks, industry, construction industry and tertiary industry) and ecological environment were predicted; and control indexes of the total water allocation and total water drawing were calculated. Thus, the scientific basis for enforcing the scientific management of water resources is provided.

INTRODUCTION

Although Sichuan province's total water resources are rich, the amount of water per capita is inadequate; control utilization of surface water is quite low; and the distribution of water resources in different regions during the year and in different years is uneven, which do not match the industrial and agricultural layout, resulting in seasonal and regional water shortage highlighted. Aimed at the issues of frequent extreme climate, low level of water supply security, severe water and soil loss as well as arduous task of management reform, and based on the water resource management concepts of water quality, water volume and water use efficiency, and around water resource allocation, water resource saving, water resource protection, water demand management and the control of total water use is implemented. Wastewater is restrained; the sewage into rivers is strictly controlled, which are very essential to the realization of scientific water control, scientific water use, scientific water management and Sichuan's long-term development backed by water resources.

MATERIALS AND METHODS

By adopting the relevant data from Integrated Planning Report of River Basin in Sichuan Province (Qin & Li 2011, Sichuan Provincial Government 2005, He 2007, Office for Sichuan Provincial Government 2011) and by researching the 21 cities (states) in Sichuan province as well as water resource divisions, the volume and quality of water resources in the whole province are found out. The available surface water and the total available water resources in the whole province are calculated. The water use status based on the analysis of effective irrigation area of farmland, population, urbanization, social and economic development and other social and economic development indicators, water resource demands of life, production as well as ecological environment are predicted, and the demands for water in the whole province is also predicted depending on available water resources and water supply capacity (Sun & Chen 2011). By analysing the predicted water demands and the regional available water resources, the control indexes of total water allocation and total water drawing were calculated.

RESULTS AND ANALYSIS

The quantity of multi-year mean total water resources and the water quality: The total water resources in Sichuan province is 261.57 billion m^3, including 261.45 billion m^3 surface runoffs, and 61.64 billion m^3 groundwater resources.

1. River water quality: In 2005, the evaluation of surface water quality totally chose 146 monitoring stations and the length of the rivers evaluated was 2467 km, including 1643 km of II class rivers, 367 km of III class rivers, 218 km of IV class rivers, 189 km of V class rivers and 50 km of poor V class rivers.

2. Evaluation of the water qualities of lakes and reservoirs: According to the survey of 12 lakes and reservoirs totalling 19 sections, 6 of them meet the standard of II class surface water; 5 of them meet the standard of III class water quality; 1 of them has the standard of IV class water quality.
3. Groundwater quality: According to the analysis of the monitoring data in 2002, the three areas of the poor groundwater zones are all VI class, the area of the poor water zones including Min river in Chengdu area, Tuo river in Chengdu area and Tuo river in Deyang area is 792.38 km^2, 502.82 km^2 and 1298.55 km^2 respectively.

Water use efficiency: From 1980 to 2005, the GDP water use per 10 thousand Yuan in Sichuan was decreased from 2394 m^3 to 349 m^3, down by 85.4%. The GDP output for per cube was increased from 4.18 Yuan to 28.64 Yuan. At the same period of time, water use for every 10 thousand Yuan worth of industrial value added was reduced from 990 m^3 to 247 m^3, down by 75.0%. The average water use of farmland irrigation per acre had little change. City water supply network's leak rate (running, emitting, dropping and leaking) in Sichuan province was 12% to 59%. Although the water resource use level and efficiency in Sichuan province have been improved for nearly 20 years, overall, the water resource use efficiency was low.

Change process of water use: The total water use of national economic industries in Sichuan province was increased from 17 billion m^3 in 1980 to 259 m^3 in 2005.

Urban life water use in the province (including the water uses of the tertiary production, construction industry and urban ecological environment) was increased from 0.488 billion m^3 in 1980 to 2.43 billion m^3 in 2005; and the water use of rural life (including the water use of all livestocks) was increased from 1.51 billion m^3 in 1980 to 2.18 billion m^3 in 2005.

Industrial water use increased from 1.39 billion m^3 in 1980 to 6.41 billion m^3 in 2005, and the annual average increase rate was 6.29%.

Farmland irrigation water use increased from 13.1 billion m^3 in 1980 to 13.7 billion m^3 in 2005; the water use of plantation, and pasturage and fishing was increased from 0.512 billion m^3 in 1980 to 1.16 billion m^3 in 2005.

Analysis of water resources carrying capacity: The comprehensive per capita water use index in Sichuan province is 380 to 500 m^3, and the GDP comprehensive water use index for every 10 thousand Yuan is 270 to 770m^3, so it is calculated that the population size, which water resources in Sichuan province can carry, is 0.173 to 0.228 billion and the GDP size is 3.21 to 11.1 trillion Yuan. Therefore, the water resources carrying capacity in Sichuan has far exceeded the present economic society's development level. However, according to the features of water resources in Sichuan, it is known that the distribution of available water resources does not match regional economic society, so regional research is necessary. Various water users can be divided into three parts including life, production and ecology. Water demands are predicted by adopting the water demand indexes under strengthening water saving model. The total water demand in Sichuan province and its cities (States) in 2020 will be 42.097 billion m^3.

Predicting water demands according to water supply capacity: On the basis of predicting water demands by using available water, water supply capacity is planned whether it meets water supply requirements according to the province's status and the research on planning water supply capacity. The actual water supply in Sichuan province in 2005 was 21.23 billion m^3.

In 2020, according to the planning requirements of the province's Outline of Water Resources Development and Utilization, at present, under-construction projects and continuation projects are finished, and the hydraulic engineering recommended before 2020 will be finished. Balances in cities (states) are shown in Table 1.

Total distributive water resources: According to the principle of "measure demand before supply" and the data from predicted water demands and available water in basins in 2015, it is shown that the available water will be far greater than predicted water demands in basins and, in principle, the total water allocation will be predicted water demands, which demonstrates that there will be no water resource shortage in Sichuan province in general years, but in some regions there will be water shortage in dry years. Therefore, water saving must be strengthened and corresponding drought contingency measures must be taken. Control indexes of total water drawing are given in Table 2.

DISCUSSION AND SUGGESTIONS

1. Sichuan province's available water can generally support economic and social development, analysed from the perspective of water resource carrying capacity. However, due to the water resource allocation's failure in matching national economic and social development, the poor capacity of intra-regional projects' storage and the shortage of engineering water storage, under the circumstances of not considering water diversion and not increasing new water resource projects, the water demands of Sichuan province's national economic and social development in 2020 still will not be met.
2. Based on the condition of regional water resources, the

Table 1: Supply and demand balances of water in Sichuan Province in 2020 (0.1 billion m^3).

Regions	Present available water supplies	Predicted water demands	Increased water supplies in 2020		Available water supplies	Water supplies balance
			Transfer-in water	Engineering storages		
The Whole Province	250.39	420.9	77.9	45.63	373.92	-46.98
Chengdu City	38.49	77.16	35.7	3.56	77.75	0.59
Zigong City	5.55	11.27	2.83	3.15	11.53	0.26
Panzhihua City	5.86	25.21		1.09	6.95	-18.26
Luzhou City	6.45	14.92	7.23	1.39	15.07	0.15
Deyang City	17.02	28.02	3.5	1.46	21.98	-6.04
Mianyang City	19.78	29.24	2.55	2.58	24.91	-4.33
Guangyuan City	6.74	10.41	0.52	0.57	7.83	-2.58
Suining City	6.58	15.43	5.1	1.22	12.9	-2.53
Neijiang City	8.74	12.46	2.22	1.31	12.27	-0.19
Leshan City	15.5	20.07	0.57	1.24	17.31	-2.76
Nanchong City	22.64	18.77	6.16	3.99	32.79	14.02
Meishan City	23.21	19.3		0.8	24.01	4.71
Yibin City	6.73	23.52	8.47	1.74	16.94	-6.58
Guang'an City	7.44	14.57	4.68	1.63	13.75	-0.82
Dazhou City	7.79	25.79	1.22	2.3	11.31	-14.48
Ya'an City	6.13	7.8		0.52	6.65	-1.15
Bazhong City	4.5	10.66		2.75	7.25	-3.41
Ziyang City	14.1	17.64	15.09	1.26	30.45	12.81
Aba State	1.44	4.47			1.44	-3.03
Ganzi State	5.18	3.87		0.81	5.99	2.12
Liangshan State	20.52	30.39		12.26	32.78	2.39

Table 2: Control indexes of total water drawing in administrative regions in 2015 (0.1 billion m^3).

Administrative	Control	Administrative	Control indexes	Administrative	Control indexes
Aba State	3.15	Guangyuan City	10.6	Nanchong City	19.1
Bazhong City	7.71	Leshan City	18.8	Panzhihua City	18.2
Chengdu City	67.0	Liangshan State	30.7	Suining City	12.6
Dazhou City	25.1	Luzhou City	13.3	Ya'an City	6.53
Deyang City	24.3	Meishan City	16.4	Yibin City	19.0
Ganzi State	3.56	Mianyang City	29.2	Ziyang City	14.9
Guang'an City	12.6	Neijiang City	11.9	Zigong City	11.9
Totals			377		

present situation of development and utilization, development requirements in the future, different water sources' water supply potential and the situation of water demands in the future, control indexes are established which not only can meet the requirements of present water resource protection but also can lay a good foundation for the sustainable utilization of water resources and regional economic development in the future.

3. At present, water resource management implements the system that the control of total water use and the management of water use quota are combined. Based on the water quality, water volume, water use efficiency's water resource management and water allocation are still in the exploration stage. Scientific control targets should be determined based on the survey and calculation of regions' present water use and sewage situation.
4. The reasonability of the results of total water use control, water use efficiency control as well as the reasonable control standards of water function zones' restraints of pollutants remain to be further verified. At the same time, in order to effectively implement the "three red lines", relevant safeguard measures should be taken.

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