

SUSTAINABLE EXPLOITATION AND UTILIZATION OF WATER RESOURCES IN THE INLAND RIVER BASIN OF ARID NORTHWEST CHINA

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ABSTRACT: Calculated in terms of surface runoff plus irrepeated groundwater, there is about $8.67 \times 10^{10} \text{m}^3$ of total available water resources in the inland river basins of arid Northwest China. Water resources is the decisive factor for survival of oases and human being. But there have arisen several aspects of serious eco-environment problems resulted from irrational exploitation and utilization. From now on, the development and utilization of water not only requires to promote regional economy, but also needs to protect and improve the environment based on their potential. Sustainable utilization needs to broaden new sources and saving water at first. Then three measures are recommended.

KEY WORDS: water resources, sustainable exploitation and utilization, inland river basin

I. INTRODUCTION

The arid land in Northwest China, rich in light, heat, land and mineral resources, is one of the biggest potential regions for economic development in the future. It is characterized by drought climate, scarce precipitation and there is no agriculture without irrigation (Liu, 1980). Water is not only the most valuable natural resources, but also very important environmental factor in this area. The oases and water resources for human survival and development are distributed mainly in the inland river basins. At present exploitation and utilization of water resources are getting more and more important in pace with the economic development and face a lot of challenges. Therefore it is necessary to sum up the research findings, analyze the problems and the potential of water utilization in order to make overall planning and rational allotment, and sustainable exploitation of water resources in accordance with the major problems of environment and development in the 21st century.

II. WATER RESOURCES IN THE INLAND RIVER BASINS

In the inland river basins of arid Northwest China, there are various water resources such as rainwater, glacier, surface runoff and groundwater. All kinds of water resources come from rainwater which is a decisive element for formation, distribution and transition of water resources in the inland river basins. But the majority of rainwater and glacier are distributed in the mountainous regions with an elevation of more than 4000 m and can not be used directly for industry and agriculture etc. in large area of plain. Only when it is transformed into surface runoff and flowing out mountains, can they realize the value of being utilized (Qu *et al.*, 1996). Therefor surface runoff and natural groundwater in the plain are really available water resources.

1. Surface Runoff

According to hydrological survey data, the mean annual surface runoff is up to 7.87×10^{10} m³ in the inland river basins of arid Northwest China, of which Xinjiang accounts for 84.4%, with the volume of 6.68×10^{10} m³, Hexi Corridor of Gansu accounts for 9.1% (Table 1). These resources belong to high quality fresh water which can satisfy with all purpose water supply.

Surface runoff can be divided into three parts:

$$Y = B + R_s + R_g \quad (1)$$

where, $B = Y_c + I + F$

Then total surface runoff is the sum of the five components after flowing out Mountains.

$$Y = Y_c + I + F + R_s + R_g \quad (2)$$

where Y —surface runoff, B —canal system water, R_s —natural channel water, R_g —channel seepage, Y_c —field consumption net water, I —canal system seepage, F —field seepage.

2. Natural Groundwater Resources in Plain

Natural groundwater resources can be classified into two parts: repeated and irrepeated groundwater. The former, transformed by surface runoff, is recharged by seepage of natural channel, canal system and field irrigation. The latter is recharged by side ground runoff and rainfall penetration. Calculated according to hydrological survey and water balance, the total natural groundwater resources are 4.069×10^{10} m³, of which the irrepeated resources accounts for 10% (Table 1).

Natural groundwater resources in the inland river basin is written as:

$$G = R_g + I + F + G_t + X \quad (3)$$

where G —natural groundwater resources, G_l —side ground runoff, X —rainwater penetration.

3. The Total Water Resources

Water resources have the characteristic that surface runoff and groundwater belong to the same water body in the arid China. Therefore they can be calculated in terms of the sum of surface runoff and irrepeated groundwater which includes side ground runoff and the recharge of rainfall penetration (Cheng *et al.*, 1992). It is given as:

$$W = Y + G_l + X \quad (4)$$

Calculated according to formula (4), the total water resources is $8.67 \times 10^{10} \text{ m}^3$ (Table 1).

Table 1 The total water resources in the inland river basins of arid Northwest China (10^8 m^3)

Region	Surface runoff*	Repeated groundwater	Irrepeated groundwater		Groundwater resources	Total water resource
			G_l	X		
Hexi corridor	71.32	37.22	2.51	3.39	43.12	77.22
Qinghai	47.20	28.44	6.50	6.02	40.96	59.72
North Xinjiang	282.31	76.27	15.69	15.96	107.92	313.96
South Xinjiang	386.38	184.87	12.23	17.77	214.87	416.38
Total	787.21	326.80	36.93	43.14	406.87	867.28

* Source: Qu Yaoguang, Gao Qianzhao *et al.*, Lanzhou Institute of Desert Research, Academia Sinica.

III. THE PRESENT STATUS AND PROBLEMS ON UTILIZATION OF WATER RESOURCES

Water resource is a decisive factor to exploit Northwest China. It is economic life-line, and the ties of social development and environment protection. The past state of floods and drought has changed initially through building water projects and constructing artificial oases, which have obtained obvious economic and environmental benefit. However, there are a lot of serious problems in exploitation and utilization of water resources.

(1) Resulted from water use gradually increasing in the upper-middle reaches, water resources in the lower reaches were reduced surprisingly, which has caused water quality to deteriorate, lakes to dry up gradually, natural vegetation to degenerate and land to be desertified. These problems have arisen in Minqin basin of the Shiyang River since the end of the 1970s. From then on, they have spread to some other large regions quickly, causing ecological disturbance. Accounting to present statistics, the desertification area amounts to at least $38\,917 \text{ km}^2$ in the inland river basins because of irrational utilization of water resources.

(2) Sustainable rise of groundwater table due to floods irrigation with large amount of water has brought about large area of secondary salinization in plain irrigation area. Salinized soil is estimated about $114.4 \times 10^4 \text{ ha}$, which is about one-third of the total irrigation area.

(3) Local lowering funnel and groundwater drawdown by a big margin resulted from excessive exploitation of groundwater have led to degeneration of original vegetation. Groundwater drawdown averaged about 3–4 m in the 1970s in Minqin basin, and the deepest lowering funnel was up to 15 m in 1990. About 33.3 thousand ha of the narrow-leaved oleaster and sassaoul forest began to wither and deteriorate, more than 10 000 ha of them has disappeared.

(4) There arise serious water allotment contradictions between upper-middle and lower reaches, and that between the industry and agriculture because there is no overall planning of water resources to maintain ecological balance and economic development of the whole basins. In the water use, industry and agriculture are taken seriously, forestry and animal husbandry are taken lightly. On the other hand, the short-term economic benefit is thinking highly and long-term environmental benefit is neglected.

IV. THE WAYS FOR SUSTAINABLE EXPLOITATION AND UTILIZATION OF WATER RESOURCES

Sustainable exploitation and rational utilization of water resources is a great issue in the future. Water is very short and eco-environment is extremely weak in the inland river basins of arid land. To resolve the conflict between large amount of water requirement and shortage of water resources, between economic development and eco-environmental construction, it is extremely necessary to enhance overall water planning and management, to utilize water economically and scientifically with coordinative allotment thoroughly. Five factors are critical to a comprehensive approach to sustainable exploitation and effective management of water resources. They are: water saving; broadening new water sources; protecting water resources; exploiting and allotting water resources in river basin as a unit; improving water coordination among society, economy and environment.

These five keys are simply common sense based on lessons from around the river basins in the arid Northwest China.

Water saving is a key measure to solve the problems of water shortage in the arid Northwest China. At the present, water is wasted seriously and irrigation efficiency is very low due to irrational exploitation, imperfect management and backward techniques. The grain yield average about 0.2–0.5 kg per m³ of water, and biological yield is 0.1–0.8 kg per unit of water. There is considerable Water saving potential. Agriculture irrigation almost consumes 90% of the water availability. If irrigation water reduce quota from present 13 110 m³/ha to 4500–7500 m³/ha, which is the best water quota according to experiment in some advanced irrigation area, it can almost save 1/2 of water consumption. Applying advanced irrigation techniques in agriculture, increasing irrigation efficiency, improving farmland cultivation and adopting crops of drought resistance are some rational measures for saving water. Water resources must be used economically and scientifically in every link from drawing water to plant product in the agriculture. It also needs to take measures to treat wastewater and reuse in irrigation. Control-

ling transeaporation from water surface and soil is another feasible way.

Except for water saving, broadening new sources is practical for increasing water through harvesting rain water, building reservoirs and roof gathering engineering, regulating runoff and groundwater, and utilizing saline water etc.

Besides, it is necessary to concentrate on doing the following works: (1) Enhancing protection and rational utilization of water resources, the glacier and water conservation forest in the mountain regions must be protected. We must also take action to prevent water bodies in the plains from pollution of industry or agriculture, maintain balance between mining and recharging and preserve the environment and resources in the lower reaches of river basin. (2) Exploiting water resources rationally in river basin as a unit, which constitutes an integrated ecological system. Water resources must be allotted quantitatively for industry, agriculture, forestry and animal husbandry as well as ecological environment in the whole basin. (3) Improving water coordination between economy, society and environment with power measures. It is imperative to draw up rational water price, increase investment, enhance water projects construction and its management in order to make up for additional loss of society and environment. On the other hand, water quality is as important as quantity, water resources should be allotted quantitatively with rational price according to quality.

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