



Restriction factors and improvement paths of ecological environment and water resources protection in Qinghai Section of the Yellow River basin

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ABSTRACT

Background: With the promulgations and implementation of “The Outline of the Plan for Ecological Protection and High-quality Development of the Yellow River Basin” and “The Yellow River Protection Law of the People’s Republic of China”, all provinces along the Yellow River need to actively carry out ecological protection and high-quality development, and Qinghai Province, as the source of the Yellow River, will also be duty-bound to carry out ecological protection. **Subjects and Methods:** This paper systematically analyzes the problems in ecological protection and high-quality development of Qinghai Province in Qinghai section of the Yellow River Basin, and summarizes the measures to promote ecological protection and high-quality development of Qinghai Province in the Yellow River Basin. **Results:** After analysis, there are six factors restricting ecological protection and high-quality development in Qinghai Province: (1) There are great differences in water intake among the provinces and regions in the Yellow River basin, and the distribution of water resources is uneven. (2) The spatial and temporal distribution of water resources in Qinghai province is uneven, which is not conducive to redevelopment and utilization. (3) The control of soil erosion on the Loess Plateau is unbalanced, and soil erosion in Qinghai section is still serious. (4) The lack of funds between ecological protection and high-quality development in the Yellow River Basin. (5) The lack of new media channel construction in Qinghai province is relatively serious, and the excavation and publicity of the Yellow River culture is not enough. (6) Soil erosion is serious, and sudden geological disasters occur from time to time. **Conclusions:** The ecological protection and high-quality development of the Yellow River basin in Qinghai Province are restricted by six aspects: reduction of water rights, limited water intake, uneven spatial and temporal distribution of water resources, serious water erosion, shortage of funds, ineffective construction of new media channels, and frequent sudden natural disasters. Therefore, national ministries and provinces along the Yellow River need to make joint efforts to achieve ecological protection and high-quality development. This report presents solutions from nine aspects of the sustainable utilization of water resources in the Yellow River basin.

Keywords: Yellow River; Ecological protection; High-quality development; Qinghai Province

1. Introduction

1.1. Background of ecological protection and high-quality development in the Qinghai section of the Yellow River Basin

Since the ecological protection and high-quality development of the Yellow River basin became a major national

strategy in 2019, all provinces and cities along the Yellow River have attached great importance to the ecological protection and high-quality development of the Yellow River. As the source of the Yellow River in Qinghai province, the implementation of the Yellow River national high quality development strategy, responsibility, must tree prison

upstream consciousness, good upstream responsibility[1], show the upstream, adhere to the protection as a priority, the upper Yellow River basin soil and water conservation and pollution prevention and control work, actively promote the Yellow River basin ecological protection and high quality development, efforts in the “make the happiness of the benefit of the people” the great practice of the power of Qinghai.

Qinghai province is duty-bound to implement the national high-quality development strategy of the Yellow River. Qinghai province needs to strengthen the consciousness of the upstream, shoulder the responsibility of the upstream, show the upstream achievement, adhere to the protection and management as the primary task, effectively grasp the water and soil conservation and pollution prevention and control in the upper Yellow River basin. We will actively strive to contribute to Qinghai in the great practice of “making the Yellow River a happy river for the benefit of the people”. However, with high political standing, we need to recognize the difficulties in the high-quality development of the Yellow River in Qinghai Province. At present, there are some restrictive factors in Qinghai Province, which restrict the high-quality development of the whole Yellow River basin.

2. Restrictive factors on ecological protection and high-quality development in Qinghai Section of the Yellow River Basin

2.1. Uneven distribution of water resources among all provinces and regions in the Yellow River Basin

In the Yellow River basin, different provinces and regions vary greatly, the distribution of water resources is uneven [2], and the level of economic development is also obvious differences.

Since the implementation of the Distribution Plan of Water Supply of the Yellow River (referred to as “87” water diversion plan), the inconsistent economic and social development degree, water use level and engineering conditions among the provinces and regions in the Yellow River basin have changed the spatial pattern of water use: the water consumption of Gansu, Ningxia, Inner Mongolia,

Shandong, Shanxi, Shaanxi and other provinces and regions often exceeds the water diversion index, while only Sichuan province has not reached the water diversion index. In 2019, the total water intake in the Yellow River water supply area was 55.642 billion m³, and the average water intake in the nine provinces and regions was 6.182 billion m³. The water intake in the Yellow River basin was greatly different, and the distribution of water resources was uneven. The water intake in Qinghai Province was relatively low, only 1.61 billion m³.

The absolute value of water intake and water consumption in Qinghai province are relatively low. From Table 1 and Table 2, we can see that: the water intake and water consumption of Qinghai Province rank eighth, and the water intake and water consumption per unit area of Qinghai Province are the lowest. However, Qinghai’s contribution to the Yellow River is enormous, precipitation in 2021 is valued at 78.13 billion m³, Qinghai province accounted for 17.69% of the total precipitation of the Yellow River, which is the largest proportion among the nine provinces and regions. But the proportion of water intake and water consumption in Qinghai province is not high. Therefore, it is necessary to strive to increase the proportion of water distribution right in Qinghai Province.

2.2. Spatial and temporal distribution of water resources in Qinghai province is uneven, which is not conducive to redevelopment and utilization

According to statistics, the water resources in the eastern Huangshui River Basin and the Chaidamu Basin, which are relatively developed in Qinghai Province, only account for 3.5% and 8.4% of the total, respectively. The sanjiangyuan region in the southern part and the Qilian Mountains in the northern part of Qinghai are sparsely populated and small, but the water resources account for more than 80% of the total. In particular, the Yangtze River and Lancang River in the south are outflow rivers, most of which flow out of Qinghai Province and cannot be used by the province. The water resources in the province are unevenly distributed, and the development and utilization is small.

Taking the Huangshui River as an example, nearly 60% of the population, 52% of the arable land and more than

Table 1
Water intake from all provinces and regions along the Yellow River

Order number	Province	Water intake (100 million m ³)	Yellow River basin area (10,000 km ²)	Water intake per unit area (100 million m ³ /10,000 km ²)
1	Shandong	78.53	1.36	57.74
2	Henan	61.07	3.62	16.87
3	Ningxia	68.10	5.14	13.25
4	Neimenggu	112.17	15.10	7.43
5	Shanxi	51.39	9.71	5.29
6	Shaanxi	65.85	13.33	4.94
7	Gansu	40.02	14.32	2.79
8	Qinghai	13.75	15.22	0.90
9	Sichuan	0.33	1.70	0.19

Source: The Yellow River Water Resources Bulletin in 2021.

Table 2
Water consumption of all provinces and autonomous regions along the Yellow River

Order number	Province	Water consumption (100 million m ³)	Yellow River basin area (10,000 km ²)	Water intake per unit area (100 million m ³ /10,000 km ²)
1	Shandong	75.80	1.36	55.74
2	Henan	53.44	3.62	14.76
3	Ningxia	42.28	5.14	8.23
4	Neimenggu	86.25	15.10	5.71
5	Shanxi	43.71	9.71	4.50
6	Shaanxi	50.98	13.33	3.82
7	Gansu	32.37	14.32	2.26
8	Qinghai	9.94	15.22	0.65
9	Sichuan	0.24	1.70	0.14

Source: The Yellow River Water Resources Bulletin in 2021.

Table 3
Comparison of measured water and sand characteristic values of important hydrological stations on the Main stream of the Yellow River in 2021

Hydrologic station	Tang-naihai	Lanzhou	Shizuishan	Toudaoguai	Longmen	Tongguan	San Menxia	Xiao Langdi	Huayuankou	Gaocun
Water sand quantity										
Volume of runoff (100 million m ³)	222.9	353.1	298.1	222.1	237.2	395.1	403.3	421.2	509.7	483.4
sediment runoff (million tons)	0.096	0.058	0.333	0.461	0.763	1.71	2.64	0.785	1.77	2.68

Source: The Yellow River Water Resources Bulletin in 2021.

70% of the industrial and mining enterprises in Qinghai province are distributed in the Huangshui River basin. The 60% of the grain output and the 60% of the industrial output are also distributed on both sides of the Huangshui River. So the pollution caused is also the largest in the province. The wastewater discharge of the Huangshui River has accounted for 70% of the total amount of the province, the pollutants has far exceeded the pollution discharge capacity of the Huangshui River itself.

2.3. Control of soil erosion on the Loess Plateau is unbalanced, and the soil erosion in Qinghai section is still serious

The Tangnaihahi Hydrological Station in Qinghai Province transported 0.096 million tons of sediment (Table 3). The sediment concentration of Tang Naihahi per cubic meter was 0.431 kg, which was only less than Lanzhou Hydrological Station. Qinghai province has made its own contribution to the clear Yellow River. The downstream Aishan and Huayuankou hydrological stations contained 5.58 kg and 5.54 kg of per m³. However, the sediment control of Qinghai Province still needs to be strengthened.

2.4. Lack of funds between ecological protection and high-quality development in the Yellow River Basin

Although Qinghai province has invested some funds in ecological protection every year, these funds were still relatively small for the ecological protection and high-quality development of the Qinghai section of the Yellow River

Basin. At present, there are three ecological protection projects involved in the Yellow River basin. Such as the Sanjiangyuan National Park was officially set up, the Qilian Mountain National Park has passed the national evaluation and acceptance, and the Qinghai Lake National Park has officially entered the establishment stage. Qinghai is building a group of national parks on the Qinghai-Tibet Plateau, which will need more funds. In addition, the Outline of the Plan for Ecological Protection and High-quality Development of the Yellow River Basin involves many projects and needs a large amount of financial support. The contents of the Outline of the Plan for Ecological Protection and High-quality Development of the Yellow River Basin are as follows: (1) To organize the ecological protection and restoration of the Yellow River Basin, and implement the integrated protection and restoration of mountains, rivers, forests, farmland, lakes, grass and sand. (2) To protect the water conservation areas of the Yellow River. (3) Carry out key projects of soil and water conservation. (4) Organize the construction of warp land dam. (5) To protect and restore the critically endangered wild animals, plants and habitats in the Yellow River Basin. (6) Carry out the integrity evaluation of aquatic organisms in the Yellow River basin. (7) Construction of the smooth migration and wading project of fish aquatic organisms. (8) Carry out ecological restoration of degraded agricultural land and carry out comprehensive improvement of farmland. (9) Mine pollution prevention and control and ecological restoration. Each of the above nine items is a big project and a big project, which

requires a lot of funds. Therefore, the ecological protection and high-quality development of the Yellow River basin need the financial support of the state and downstream provinces.

2.5. Lack of new media channel construction in Qinghai province is relatively serious, and the excavation and publicity of the Yellow River culture is not enough

Qinghai province is an important birthplace of the Yellow River culture which is an important part of the Chinese civilization. However, due to insufficient publicity, few people know the story of the Yellow River in Qinghai province. It can be seen from Table 4 that the construction of new media channels along the Yellow River is insufficient, and Qinghai Province only has APP mini-programs and public account publicity channels. First of all, we should ensure that all the Yellow River cultural and tourism data in the province can be found on the official website of the government to ensure the disclosure of information. Secondly, in the case of sufficient funds, the Yellow River cultural and tourism special portal website should be established. The website should pay attention to daily maintenance, timely update the data, and improve the introduction of the Yellow River cultural tourism project.

2.6. Soil erosion is serious, and sudden geological disasters occur from time to time

In 2020, 138 geological disasters occurred in the Huangshui River Basin, accounting for 74.59% of the total. 47 occurred in the Yellow River Basin, accounting for 25.41% of the total. In 2020, sudden geological disasters were mainly distributed in the Huangshui River basin, among which Xining city, Huangzhong District and Datong County occurred the most geological disasters. It can be seen that the Huangshui River basin and the 5 districts and 1 county of Xining City are prone to geological disasters, and they are also the key areas for the prevention and control of sudden geological disasters in Qinghai Province.

3. Water footprint calculation of the Qinghai section of the Yellow River Basin

3.1. Accounting method of water footprint

The water footprint of an area refers to the water rights directly or indirectly used by the products or services consumed by the residents in the area. This paper adopts the top-down method [3].

The water footprint is equivalent to the sum of the used water rights and the net virtual water rights (the

Table 4
Current situation of new media digital construction in nine provinces in the Yellow River Basin

New media Province	Build a special website	Whether the website is updated is timely	Whether the official website data disclosure is complete	Whether there is a APP/small program/ subscription number	Whether to set up the brief introduction of the intangible cultural heritage projects
Shaanxi	Yes	Yes	Yes	Yes	Yes
Sichuan	Yes	Yes	Yes	Yes	Yes
Neimenggu	Yes	No	Yes	Yes	Yes
Gansu	Yes	No	Yes	Yes	Yes
Henan	Yes	No	Yes	Yes	No
Shandong	Yes	No	No	No	Yes
Qinghai	No	No	No	Yes	No
Shanxi	No	No	No	Yes	No
Ningxia	No	No	No	No	No

Table 5
Water footprint status of Huang River Basin in Qinghai Province
Unit: 100 million m³

Year	Internal water footprint	External water footprint
	Internal water footprint = agricultural water consumption + industrial water consumption + residential water consumption + ecological water consumption	External water footprint = import virtual water right-export virtual water right
2021	30.62	-243.66
2020	31.09	-206.47
2019	15.67	-307.40
2018	34.38	-265.93
2017	34.51	-159.72

Data sources: Agricultural water consumption, industrial water consumption, residential water consumption, ecological water consumption are from the Qinghai Provincial Water Resources Bulletin in 2017–2021. The results in the table are calculated according to Eqs. (1)–(3).

difference between the Import and Export virtual water) in the region. The specific model is as follows:

$$WFP = IWFP + EWFP \quad (1)$$

AWC indicates the water footprint, IWFP indicates the internal water footprint, EWFP indicates the external water footprint.

$$IWFP = AWC + IWC + RWC + EWC - LEVWC \quad (2)$$

AWC represents agricultural water consumption, IWC represents industrial water consumption, RWC represents residential water consumption, EWC represents ecological water consumption, and LEVWC represents local export virtual water consumption.

$$EWFP = IVWR - EVWR \quad (3)$$

IVWR means import virtual water rights and EVWR means export virtual water rights.

3.2. Assessment of water surplus/deficit in Qinghai Province

According to Table 5, from 2017 to 2021, the internal water footprint of Qinghai province was 1.567–3.451 billion m^3 , External water footprint consumption was 15.972–30.74 billion m^3 . The surplus water of Qinghai province was 12.522–29.173 billion m^3 . According to the above results, Qinghai province is rich in water and more water surplus. It is necessary to establish the ecological compensation mechanism of the upper and lower reaches of the Yellow River as soon as possible. The economic and social development of Qinghai province requires a lot of water. If the downstream provinces do not compensate Qinghai province, the economic and social development of Qinghai province will be greatly restricted.

4. Measures of promoting ecological protection and high-quality development in the Yellow River Basin

4.1. Top-level planning the sustainable utilization of water resources in the Yellow River basin

Qinghai province makes full use of the cooperative governance mechanism and organization of the Yellow River basin to give full play to the function of overall planning of state institutions. Article 4 of the newly issued Yellow River Protection Law of the People's Republic of China points out that the state shall establish an overall coordination mechanism for ecological protection and high-quality development of the Yellow River basin, which coordinates major trans-regional and cross-departmental issues [4], and supervise and inspect the implementation of relevant important work. Qinghai province should make full use of this organization and mechanism, refer to the coordination model of "Xin'an River", make use of the overall coordination mechanism of ecological protection and high-quality development of the Yellow River basin, and strive for ecological protection funds from the downstream provinces and the state [5], so as to promote the high-quality economic and ecological development of the Yellow River basin.

4.2. Government needs to do a good job in geological disaster investigation and early warning, and strengthen water and soil conservation work

During the flood season, heavy rain often falls in Qinghai Province, accompanied by geological disasters. Due to short-term heavy precipitation, it may cause secondary disasters such as waterlogging, mountain flood, landslide, debris flow and small and medium-sized river flood. In order to better prevent geological disasters, it is necessary to strengthen the investigation and verification of geological disasters, geological disaster monitoring and prevention [6], and meteorological forecast and early warning of geological disasters in flood season.

The government carries out planned and step-by-step management with soil and water conservation as the fundamental and biological control. Plant trees in places prone to debris flows and landslides, vigorously create dense or deep-rooted shrubs to increase the soil fixation capacity, plant excellent and drought-resistant forage grass, disperse and store water, and reduce the scour force of water flow on the slope soil.

4.3. Actively participate in the formulation of the new water diversion scheme, and strive for more water intake rights

In the "87" water diversion plan, the proportion of water diversion in Qinghai province is 4.03%. In order to meet the needs of the new situation, the society began to hope to reformulate the water diversion plan. Some scholars calculate that the proportion of water diversion in Qinghai Province should be reduced to 2.7% [7], which is the point to be paid attention to. We need to speak out and put forward the Yellow River water diversion plan based on Qinghai Province. Therefore, otherwise it will hinder the economic and social development of Qinghai Province and cause the dilemma of "There is water but no water available" [8].

4.4. Government needs to strengthen the protection of aquatic living resources

In order to protect the Yellow River aquatic biological resources, fishery administrative departments need to actively carry out aquatic biological resources survey and diversity analysis [9], the river aquatic biological integrity assessment and watershed ecosystem health evaluation, aquatic biological protection law mechanism research, aquatic germplasm resources protection management, promote aquatic biological resources into the benign recycling, and realize the sustainable development of fishery.

4.5. Qinghai province needs to actively negotiate with the downstream provinces and regions to strive for ecological protection funds

Referring to the transprovincial compensation model of "Xin'an River", under the coordination of national ministries and commissions, the government of Qinghai province needs actively cooperate with the lower Yellow River provinces to control the Yellow River, and negotiate water compensation funds [10], pollution compensation funds and ecological compensation funds.

4.6. *Actively advise to the national ministries and commissions, and establish a water right market as soon as possible*

As the “87” water diversion plan has not been suitable for the current economic development, it is suggested that the country can consider the establishment of water right market and realize the right transfer of using water resources between upstream and downstream basins through the market mechanism. Promote the free trading of water rights through the construction of water rights market and improve the utilization efficiency of water resources. Through the construction of water right market, regional coordination will promote the improvement of water resources utilization efficiency.

4.7. *Importance of the role of river and lake chiefs needs to be fully played*

In the process of ecological protection and high-quality development of the Yellow River, it is necessary to play the role of river chiefs and lake chiefs, urge river and lake chiefs to strengthen the daily inspection, management and protection of river courses [11], and continuously improve the water ecological environment. To supervise river and lake chiefs to conscientiously perform their duties and promote the implementation of the river and lake chief system, river and lake chiefs at all levels need to carry out regular or irregular river and lake inspection and research activities, so as to realize the early detection, early treatment and early solution of river problems. At the same time, mobilize the area residents to participate in water environment protection, to ensure that the area is clear and green.

4.8. *Strive for funds for mine ecological restoration*

Mining development is one of the main reasons for the damage of the alpine grassland ecosystem in the source area of the Yellow River. The damaged area of mines in Qinghai province accounted for 51.59%, and there are 43 historical mines, covering an area of 15,460.56 mu. The damaged mines seriously threaten the water conservation and biodiversity conservation function in the source area of the Yellow River. The supervision and management of these mines will inevitably affect the economic development of Qinghai Province. The per capita income of Qinghai Province is 60,700 yuan, which is lower than the national per capita income of 85,000 yuan. Therefore, in order to realize ecological protection, it does not affect the local economic development and narrow the gap between the rich and the poor in Qinghai Province and the whole country, state funds and policies are needed to support the ecological restoration of mines in Qinghai Province and increase the ecological compensation to Qinghai Province.

4.9. *Create high-quality cultural tourism routes in the Qinghai section of the Yellow River to promote high-quality development*

There are many scenic spots and allusions about the Yellow River in Qinghai Province. Taking Xunhua County as an example, there are the Yangshao Culture, the Majiayao Culture, the Machang Culture, the Qijia Culture and the Kayue Culture which represent the Stone Age. Our ancestors

created splendid ancient culture at the source of the Yellow River Basin. Under the Jishi Mountain, there are Camel Spring and Jiezi Mosque, which represent the tenacious character of the Salar people, the Wendu Temple, which represents the Tibetan Buddhism, the Jishi Gorge, which represents the Han culture, and the Memorial hall of the Red Army, which represents the spirit of the Red Army. These scenic spots and legends clearly represent the Yellow River culture, but they are little-known. We should intensify the publicity through the new media channels of Qinghai Province, package the distinctive scenic spots, promote and introduce them, and create a beautiful name card of Qinghai.

5. Conclusion

The following problems of ecological protection and high-quality development of the Yellow River Basin in Qinghai Province are found out: (1) The distribution of water resources in all provinces and regions in the Yellow River basin is uneven, and the small water intake right in Qinghai province is not conducive to economic development. (2) The distribution of water resources in Qinghai province is uneven, the development utilization is small, and the water is mainly concentrated in the Huangshui River basin in the eastern region. (3) Qinghai province still lacks funds for ecological protection and high-quality development. (4) The Yellow River culture in Qinghai province is not enough, few people know the story of the Yellow River in Qinghai. (5) Soil erosion in Qinghai Province is still serious, and sudden geological disasters occur from time to time.

In order to better promote the ecological protection and high-quality development of the Yellow River basin in Qinghai Province, the government and enterprises in Qinghai Province should strengthen their efforts in the following aspects: (1) Top-level planning for the sustainable utilization of water resources in the Yellow River basin. (2) Do a good job in the investigation and early warning of geological disasters, and strengthen soil and water conservation. (3) Actively participate in the formulation of the new water separation scheme, and strive for more water intake rights. (4) Strengthen the protection of aquatic living resources. (5) Qinghai province needs to actively negotiate with the downstream provinces and regions to strive for ecological protection funds. (6) Actively advise to national ministries and commissions to establish a water rights market as soon as possible. (7) Give full play to the role of river and lake chiefs. (8) Strive for funds for mine ecological restoration. (9) Build high-quality cultural tourism routes in the Qinghai section of the Yellow River to promote high-quality development.

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