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Study on Sustainable Development of Water Resources in Water-Scarce Villages in Hebei Province

-- Taking the Eastern Qing Tombs Area as an Example

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Abstract: In today's society, water scarcity has become a critical bottleneck constraining the development of rural areas in China. This study takes the Qingdongling region in Hebei Province as a typical case, combining the current status of rural water environment governance nationwide. Through multi-dimensional research methods, it analyzes the supply and demand contradictions and management shortcomings of rural water resources, proposing systematic optimization strategies. The results show that water resource issues in the Qingdongling region are widespread and urgently require technological upgrades, management optimization, and public participation to achieve sustainable development.

Keywords: Water Resources Management; Water Shortage; Water Quality; Water Quantity; Sustainable Development; Qingdongling.

1. Research Background

1.1. Background Information

The "Key Points of Water Resource Management Work in 2024" clearly states the water management policy of "giving priority to water conservation and achieving spatial balance," requiring all regions to strengthen the rigid constraints on water resources [1]. Currently, rural areas in China face three major challenges: water scarcity, deteriorating water quality, and outdated facilities, with about 30% of villages experiencing unstable water supply [2]. The Qingdongling area, as a typical agricultural heritage site, confronts dual contradictions between ecological protection and public welfare needs, making it valuable for national research.

1.2. Research Objectives

Table 1. Research objectives

fundamental purpose	concrete content
Protect the health of residents	The quality of rural water is related to the health of residents. Poor water quality can easily lead to water pollution and related diseases. Research on improvement methods can prevent pollution and protect health
Promote rural economic development	High-quality water resources are the industrial foundation of many villages. Research on water quality can find appropriate ways to use it, improve irrigation efficiency, ensure the quality of agricultural products and promote sustainable development
Maintain ecological balance	Good water environment is the key to ecological balance. Research on water quality can help to find out the problems of water ecology, protect water ecological environment, maintain biodiversity, promote soil protection and sustainable utilization of water resources
Water resources management and planning	In-depth study of rural water quality can understand the distribution, quality and utilization status of local water resources, which is conducive to scientific planning and management, formulate effective policies to improve utilization efficiency, ensure sustainable utilization, reduce waste and pollution
Supporting the Sustainable Development Goals	Water quality research in rural areas is closely related to the goal of sustainable development. Improving water quality can promote social and environmental sustainable development and achieve equitable distribution and rational utilization of water resources
Social equity and sustainability	Water quality research can find and solve the problem of uneven water resources distribution, promote fair utilization and management, improve water quality can improve the quality of life of rural residents, narrow the gap between urban and rural areas, and realize social equity and sustainable development
Water resources education and awareness raising	In-depth research on rural water quality can enhance the public's awareness of the importance of water resources, improve environmental awareness, carry out educational and publicity activities, guide the public to treat water resources correctly, but also promote water-saving and environmental protection lifestyle, and promote the whole society to establish the concept of sustainable utilization

2. Water Resources in the Eastern Qing Tombs Area

2.1. Village Water Supply

According to our group's investigation, it is found that the Qingdongling is mainly composed of four villages: Yuda, Yuxiao, Dingda and Dingxia, and it is found that each village uses different water supply methods, as shown in the following table:

Table 2. Each village uses different water supply methods

Village name	Coverage area (m2)	Water supply method
Yuda village	139500	The village shares two shallow groundwater Wells [3]
Yuxia Village	72000	Each household has a pipe well [4] in the yard
Dingdazhuang	88000	The village shares a shallow groundwater well [5]
Jingxiaocun	63000	Residents build deep groundwater Wells by themselves

2.2. Water Quality and Quantity

Because the depth of well drilling in different villages is different, resulting in different water quality.

Yuda Village: Wells are generally 20-30 meters deep, and the possibility of contact with pollution is relatively large. The water quality is relatively poor, hard and has more scale. As it is shallow water, the amount of water is small, so it is not suitable for long-term water supply to residents.

Yuxia Village: Wells are generally 20-30 meters deep and are seriously polluted. However, since every household has a well, the per capita water consumption is sufficient.

Dingdacun: Wells are generally more than 100 meters deep and far from the ground. The water quality is relatively good. Residents can use the well water as drinking water source, but only one well is used in the whole village and the per capita water consumption is small.

Dingxiaocun: every household has a deep well, and the per capita water consumption is sufficient and the water quality is good.

Up to now, at the national level, the standards and specifications that have been issued or will be issued include the Standard for Urban Residents' Water Consumption GB/T 50331-2002, which stipulates that the per capita daily water consumption in Hebei Province is 85~140 (L/ person · d) [6]. The following table shows the per capita daily water consumption in Qingdongling village:

Table 3. The per capita daily water consumption in Qingdongling village

village	Yuda village	Yuxia Village	Dingdazhuang	Jingxiaocun
Per capita daily water consumption (L/ person d)	55	90	70	100

3. Problems of Water Resources in Eastern Qing Tombs

3.1. Water Quality Issues

1. The water quality of Yudaicun and Yuxiaocun is poor:

Both villages are shallow wells (20·30 meters), which are prone to pollution, and the water quality is hard and [7] more scale.

Although each household in Yuxia village has its own well (with sufficient water), the pollution is serious and there are drinking water safety risks.

2. The water quality of Dingda village and Dingxia Village is better:

Dingdazhuang is a deep well (100 meters), with excellent water quality, but only one well is used by the whole village;

In Dingxiaocun, each household built a deep well with good water quality and sufficient water quantity, without significant problems.

3.2. Water Issues

1. Insufficient water supply in Yuda Village:

The shallow well water is small, and the per capita daily water consumption is only 55 L/ person · d, far below the national lower limit standard (85 L/ person · d), which cannot meet the long-term water supply demand.

2. Water supply shortage in Dingda Village:

The village shares a deep well, and the per capita daily water consumption is 70 L/ person · d, which is lower than the national standard limit, and there is an uneven distribution problem.

3. Water quantity of Yu Xiaocun and Ding Xiaocun meets the standard:

The per capita water consumption in Yuxia village is 90 L/ person · d (close to the lower limit of the standard), and that in Dingxia village is 100 L/ person · d (in line with the standard). The water quantity is sufficient, but the water quality in Yuxia village needs to be paid special attention.

4. Rx

4.1. Measures Proposed for Each Village

4.1.1. Water Shortage in Yuda Village

1. Development of new water sources:

Deep Wells (over 100 meters) are drilled to use deep groundwater, increase water quantity and improve water quality. If geological conditions permit, water diversion projects [8] (such as nearby rivers and reservoirs) can be explored to establish a centralized water supply system.

2. Short-term emergency measures:

Set up temporary water storage facilities [9] (such as water tanks and water towers), replenish water sources regularly, and relieve water shortage. Promote water-saving measures [10], and guide residents to use water reasonably through publicity and education.

4.1.2. Water Supply is Tight in Dingda Village

1. Increase the number of wells:

The village is reasonably planned to add 12 deep Wells to

distribute water pressure and ensure that the per capita water consumption meets the standard.

2. Optimize water distribution:

Install smart water meter [11], allocate water supply in different periods to avoid waste. Establish village-level water management system to fairly distribute daily water quota.

4.1.3. Water Quality Problems in Yu Xiaocun

1. Water purification and monitoring:

Install simple water purification equipment (such as activated carbon filter [12], reverse osmosis device [13]) for each household to reduce the risk of pollution. Regularly test water quality indicators (such as hardness [14], microbial content) to ensure the safety of drinking water.

2. Pollution source control:

Identify pollution sources around the shallow well (such as garbage stacking and agricultural sewage), delimit water source protection areas, and prohibit pollution activities.

4.2. Measures for Long-Term Sustainable Development

1. Infrastructure upgrading:

Promote the "Clear Water Pollution Control" initiative in government projects, effectively advancing our city's high-level ecological civilization construction and completing the "13th Five-Year Plan" water pollution control campaign[15]. Construct centralized water supply networks to cover shallow well villages (Yuda and Yuxiao), ensuring unified management of water quality and quantity. The introduction of resource utilization and intelligent technologies has improved governance efficiency and economic benefits, providing scientific evidence for enhancing rural water environment quality[16].

2. Resident participation and training:

Organize villagers to learn about water source protection, cultivate awareness of water saving [17] and encourage participation in the maintenance of water supply facilities.

3. Policy and financial support:

We will apply for special subsidies for rural drinking water safety, and use them to build deep Wells and purchase water purification equipment. We will encourage local policies to give priority to solving the problem of water supply in villages with substandard water quantity.

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