Calculation and Analysis of Agricultural Water Flow in Huangqin Reservoir Irrigation Area in Zhongxian County

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Abstract. This paper takes the Huangqin Reservoir irrigation area in Zhongxian County as the research object, and uses the terminal water flow calculation system to measure the water flow at the end of the canal system in the irrigation area. After calculation, the terminal water flow of the final canal system in the Huangqin Reservoir irrigation area after water-saving transformation is 0.053 per ton, which is lower than the farmers’ water tolerance of 0.355 per ton. The results show that the water flow calculated by the terminal water flow calculation system is feasible. However, in the actual implementation process, it is still necessary to continuously adjust and optimize the agricultural water reform measures to promote the development of high-efficiency water-saving agriculture.

1. Introduction
The shortage of agricultural water, the low efficiency of agricultural water use, the decline of the benefits of irrigation projects, the low enthusiasm of farmers to save water, and the sharp decline in agricultural water fee income of water pipe units have become increasingly prominent [1]. Therefore, the comprehensive reform of agricultural water prices has become an important measure to allocate water resources rationally to ensure the sustainable use of water resources.

At present, according to different water resource value theories, there have been a variety of water price setting methods, such as environmental value theory pricing, marginal cost pricing method, supply and demand pricing method, willingness to pay method and shadow price method, etc. [2,4]. The domestic water price accounting methods currently used mainly include: opportunity cost pricing, marginal cost pricing, planned pricing, cost accounting, etc [5,6]. Therefore, in order to further encourage farmers to save water and promote the transformation of agricultural water use from extensive to intensive, combined with Zhongxian's practice of promoting agricultural water price reform and optimization analysis, the terminal water price of Huangqin Reservoir Irrigation Area in Zhongxian County is measured and calculated. And formulate corresponding optimization measures for the problems existing in the current agricultural water price reform process.

2. Profile of study area
China Citrus City-Zhongxian County, located in the heart of the Three Gorges Reservoir area in the northeast of Chongqing City, presents the surface morphology of "three mountains, two troughs and..."
one river”. The county covers an area of 2,174 km² and has a subtropical southeast monsoon mountain climate with average annual rainfall 1198 mm, rainfall was concentrated in May to July. Huangqin Reservoir is located in Huangqin Community, Maguan Town, Zhongxian County. It covers an area of 854 acres and has a storage capacity of 8.8 million m³. It is a small second-type backbone water conservancy project with comprehensive utilization of breeding, flood control, irrigation, and water supply. At present, the daily water supply capacity of the reservoir is 15,000 m³, which solves the drinking water problem of more than 200,000 people in the Houxiang districts such as Maguan, Bashan and Xinli in Zhongxian County.

3. Methods

3.1. Water supply cost accounting for agricultural terminal

Based on the three parts of resource water price, project water price and environmental water price, a sustainable development water price model with farmers’ affordability as the boundary condition is established based on the price elasticity of agricultural water demand, namely, full-cost water price, partial-cost water price, Plan water price. Finally, it is determined that the terminal water price system can be used at the end of the canal system in the Huangqin Reservoir irrigation area in Zhongxian County [7,8].

Taking into account the small irrigation area and the principle that the national agricultural water price does not count profits and taxes, the Huangqin Reservoir canal system property rights boundary is taken as the boundary, and the water price of the state-managed water conservancy project above the boundary point is calculated as follows:

$$P_{mc} = \frac{(C_{wp} + C_{rc})}{Q_w}$$  \hspace{1cm} (1)

Where: $P_{mc}$ is the water price of the state-managed water conservancy project in the irrigation area, $C_{wp}$ is the cost of the water source project of the Huangqin Reservoir, $C_{rc}$ is the cost of the canal system, and $Q_w$ is the amount of water available for irrigation. According to calculations, the agricultural water supply price of the state-managed water conservancy project in the Huangqin Reservoir irrigation area is 0.169 yuan/m³.

The water supply price of the end-canal system below the property right boundary is determined in accordance with the principle of compensating the operation, management and maintenance costs of the end-canal system, without engineering depreciation. The price of the end-canal system water supply is composed of management costs, water distribution personnel labor costs, and maintenance costs, calculated as follows:

$$P_{rc} = \frac{C_{rc}}{Q_l \cdot S}$$  \hspace{1cm} (2)

Where: $P_{rc}$ is the water supply price of the end canal system, $Q_l$ is the comprehensive gross irrigation quota of farmland in the irrigation area; $S$ is the area of the end canal system in the pilot irrigation area (9743 m²).

The grain crops in the irrigated area are mainly rice, supplemented by wheat and corn, and the cash crops are citrus, bamboo shoots, and rape. The planting structure and water quota are reflected in Table 1. According to calculations, the water supply price of the final canal system in the Huangqin Reservoir irrigation area is 0.053 yuan/m³.
Table 1. Comprehensive net irrigation water quota calculation table.

| Project area                                      | Rice | Wheat | Rape | Corn | Vegetables | Sweet potato | Tangerine | Bamboo shoots |
|---------------------------------------------------|------|-------|------|------|------------|--------------|-----------|---------------|
| Planting area of crops in Helin Village (hm²)     | 142  | 9     | 0.8  | 13.3 | 0.8        | 5.4          |           | 120           |
| Crop planting area in Shuangbai Village (hm²)     | 136.7| 6.5   | 5.5  | 9.3  | 9.4        | 6.7          |           | 170           |
| Total planting area of crops in the demonstration area (hm²) | 278.7| 15.5  | 6.3  | 22.6 | 10.2       | 12.1         | 170       | 120           |
| Proportion of planting area of each crop (%)      | 42.9 | 2.4   | 2    | 3.5  | 2.7        | 1.8          | 26.2      | 18.5          |
| Water quota for each crop when P=75% (m³/hm²)     | 13.9 | 4.7   | 5    | 4    | 12.3       | 5            | 9.3       | 6.7           |
| Comprehensive net irrigation water quota (m³/hm²)  |      |       |      |      |            |               |           | 12.7          |
| Comprehensive gross irrigation quota (m³/hm²)      |      |       |      |      |            |               |           | 18.1          |

3.2. Calculation of Water Charge Ability

Calculate the range of farmers’ water fee tolerance based on a certain percentage $R$ of the water fee accounting for the average output value $V$ per 667 m² and a certain percentage $r$ of the net income per 667 m² [8]. According to various crop yields, crop planting structure and agricultural product price data, it can be calculated that the average output value per 667 m² in the demonstration area $V$ is 2250 yuan, and the water intake fee accounts for the lower limit of the average output value per 667 m². $R=3\%$; the average net income per 667 m² in the demonstration area $B = 1020$ yuan, the lower limit of the water intake fee to the net income per 667 m², $r=6\%$. The calculation formula of water fee bearing capacity is as follows:

$$C = \max(V \times R, B \times r)$$  \hspace{1cm} (3)$$

Where: $C$ is the calculation of water fee bearing capacity, $V$ is the average output value per 667 m², $R$ is the ratio of water fee to average output value per 667 m², $B$ is the net income per 667 m², and $r$ is the net income of water fee in $B$ proportion.

4. Results and Analysis

The water price is calculated according to the cost water price, and the final water price paid by the farmers is: the water price above the bucket canal is combined by the state financial subsidy and the management unit maintenance, and is not included in the farmers’ end water price. The actual water price paid is the end canal water price. After the institutional reform of the Huangqin Reservoir’s water source project in 2008, personnel salaries, management costs, and maintenance costs are all included in the financial budget. The daily maintenance of the canal system is maintained by the Huangqin Reservoir organization, and the larger maintenance is funded by the Huangqin Reservoir’s declaration plan; The end-canal system engineering maintenance part of the project construction and the maintenance and management of the end-canal system by the Farmer Water User Association are the part that farmers bear. The terminal water price is charged by the Farmer-Water User Association at the end-canal water supply price of 0.053 yuan/m³ for maintenance to maintain the operation of the project.
Table 2. Calculation and analysis of water fee bearing capacity.

|                      | Irrigation water fee as a percentage of output value per 667 m² | Irrigation water fee as a percentage of net income per 667 m² |
|----------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Proportion (%)       | 3                                                             | 6                                                             |
| Water fee (yuan/667 m²) | 67.5                                                          | 61.2                                                          |
| Water charge ability (yuan/m³) | 0.355                                                        | 0.322                                                         |

According to the calculation of farmers’ water fee bearing capacity C (Table 2), according to the comprehensive irrigation quota of this demonstration area is 12.7 m³/hm², the farmer’s water fee bearing capacity of the project irrigation area after calculation is 0.355 yuan/m³. After the implementation of the water price reform in the project area, the terminal water price of the irrigation area is charged at 0.053 yuan/m³, and the terminal water price is 0.053 yuan/m³, which is far lower than the farmers’ water fee bearing capacity of 0.355 yuan/m³, indicating that the irrigation area’s agricultural water price is calculated based on the terminal water price system Practical.

5. Conclusion and Suggestion
On the basis of resource water price, project water price and environmental water price, combined with the price elasticity of agricultural water demand, a sustainable water price model with user affordability as the boundary condition was established, and the terminal water price calculation method can be adopted at the end of the canal system of the Huangqin Reservoir irrigation area. The terminal water price after the water-saving transformation of the final canal system in the Huangqin Reservoir irrigation area is 0.053 yuan/m³, which is in line with the farmers’ affordability. However, in the actual implementation of the agricultural water price reform, the effect is not obvious. The main problems are that the opportunity cost of rain irrigation is not significant, such as the choice of farmers, and the lack of incentives for irrigation. The top-down government promotes irrigation projects for farmers, Irrigation projects are out of touch, and farmers’water user associations lack interest mechanisms.

In view of the problems in the current agricultural water price reform, we can improve the full-cost water price mechanism of the canal system and the self-financing mechanism of farmers, and establish an irrigation project fund bank to compensate for the difference between the actual water price of farmers and the estimated water price, and change the unified farmers in the past. The single account mechanism of the water user’s association establishes a fee payment and counter-compensation mechanism for each beneficiary farmer. The management unit of the irrigation area is supervised by the beneficiary farmers of the irrigation area, and changes the operation of the farmer water use associations, so as to optimize the agricultural water price reform measures and Strategies to achieve the purpose of promoting efficient water saving.

Acknowledgements
This research is financially supported by Zhongxian Decision Making, Consultancy and Management Innovation Project (ZXXJ202002), Southwest University Teaching Reform Program (2019JY148) and Southwest University Experimental Teaching Reform Program (SYJ2020021), and the supports were gratefully acknowledged.
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