Calculation and Analysis of the Effective Utilization Coefficient of Irrigation Water in Kaizhou District of Chongqing

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Abstract. The paper takes Kaizhou District of Chongqing as the research object, and 6 sample irrigation districts were selected as a representative. And calculate the effective utilization coefficient of irrigation water in the sample point irrigation area of Kaizhou District by using the head-tail method. The effective utilization coefficient of irrigation water in the whole district is based on that of in the sample irrigation area. Through statistical analysis, it is concluded that the effective utilization coefficient of irrigation water in Kaizhou District in 2019 is 0.4994. The research results can effectively support the assessment of the most stringent water resources management system in Kaizhou District, and can also provide a certain reference for the development of agricultural efficient water-saving irrigation.

1. Introduction
The effective utilization coefficient of irrigation water is a key indicator to measure the efficiency of agricultural irrigation water, and it is also an important basic data to evaluate the development effectiveness and potential of water-saving irrigation in a region. Otherwise, it has been listed as an important water conservancy indicator in the national and regional national economic and social development plans [1].

On the basis of work in recent years, Kaizhou District has seriously organized and carried out the calculation and analysis of the effective utilization coefficient of irrigation water in Kaizhou District in 2019. The work is carried out in accordance with the requirements of the "Guidelines for the Technical Analysis of the Calculation and Analysis of the Effective Utilization Factors of Irrigation Water in the Country" [2] and the "Detailed Implementation Rules for the Evaluation and Analysis of the Effective Utilization Factors of Farmland Irrigation Water in Chongqing". This work is carried out in order to track and analyze the changes in the effective utilization coefficient of irrigation water, to reasonably evaluate the potential of water-saving and the development effect of water-saving irrigation, and to promote the healthy development of irrigation water-saving.

2. Profile of Study Area
Kaizhou District is located in the northeast of Chongqing, with an area of 3959 km² and abundant rainfall. The annual average rainfall is 1201.5 mm for many years, but the spatial and temporal distribution is uneven, mostly concentrated from May to September.
2.1 Irrigation of the Whole District

According to the survey statistics in 2019, the total cultivated area of Kaizhou District is 66.2 thousand hm², of which effective irrigation area is 28600 hm², actual irrigation area is 18100 thousand hm², and water-saving irrigation area is 9593 hm². The irrigation water consumption of farmland in Kaizhou District in 2019 is 103.51 million m³.

2.2 Irrigation districts of different sizes and water types in the district

All irrigation districts use surface water for irrigation. As shown in table 1, there are 430 irrigation districts in the whole district, without large-scale irrigation districts; among them, 6 medium-sized irrigation districts, all are gravity irrigation districts; 424 small-scale irrigation districts, including 301 gravity irrigation districts and 123 non-gravity irrigation districts.

| Scale               | Gravity irrigation districts | Non-Gravity irrigation districts | Total |
|---------------------|-----------------------------|---------------------------------|-------|
| Large-scale         | 0                           | 0                               | 0     |
| Medium-sized        | 6                           | 0                               | 6     |
| Small-scale         | 301                         | 123                             | 424   |
| Total               | 307                         | 123                             | 430   |

2.3 Various Types of Irrigation Districts

In 2019, the effective irrigation area of Kaizhou District is 28,600 hm², the actual irrigation area is 18,100 hm², the water-saving irrigation area is 9,593 hm², and the irrigation water volume of farmland is 103.51 million m³. Among them, the effective irrigation area, actual irrigation area and water-saving irrigation area of medium-sized irrigation districts are 7,500 hm², 6,200 hm², 4,647 hm² respectively, and the gross irrigation water of farmland is 36.15 million m³. The effective irrigation area, actual irrigation area and water-saving irrigation area of the small-scale irrigation districts are 21,000 hm², 11,900 hm², and 4,900 hm² respectively, and the gross irrigation water of farmland is 67.36 million m³. The specific information is shown in table 2.

| Types of irrigation districts | Number | Effective irrigation area(hm²) | Actual irrigation area(hm²) | Water-saving irrigation area(hm²) | Irrigation water consumption (million m³) |
|------------------------------|--------|--------------------------------|----------------------------|-----------------------------------|------------------------------------------|
| Medium-sized districts       | 6      | 7500                           | 6200                       | 4647                              | 36.15                                    |
| Small-scale districts        | 424    | 21000                          | 11900                      | 4946                              | 67.36                                    |
| The whole district           | 430    | 28600                          | 18100                      | 9593                              | 103.51                                   |

3. Methods

3.1 Select Sample Irrigation Districts

Select sample irrigation districts with representative, feasible and relatively stable, based on the "Guidelines for Technical Analysis of the Calculation and Analysis of Effective Utilization Factors of Irrigation Water in the Country"[3]. When selecting irrigation districts, methods such as combination of points and surfaces are used so that the selected sample irrigation districts can comprehensively represent the average situation of the type of irrigation district in the whole district.

Therefore, in Kaizhou, one medium-sized sample irrigation district was selected as the Longan
Reservoir Irrigation District, and five small-scale sample irrigation areas were Zaojiaoping Reservoir Irrigation District, Wanchanggou Reservoir Irrigation District, Mingyue Non-gravity Irrigation District, Tanyin Reservoir Irrigation District, and Tanshui Reservoir Irrigation District.

3.2 Calculation Method
Carry out the necessary field observations on the sample point irrigation district, and obtain the irrigation water effective utilization coefficient of the sample point irrigation district through analysis. On that basis, the average value of the irrigation water effective utilization coefficient of the Kaizhou district is obtained.

Calculate and analyze the irrigation district using the head-to-tail calculation and analysis method [4-6], see equation 1.

\[ \eta_s = \frac{W_{s,n}}{W_{s,a}} \]  

Where: \( \eta_s \) refers to the effective utilization coefficient of irrigation water in the sample point irrigation district, \( W_{s,n} \) is the net irrigation water consumption in the sample irrigation district, \( W_{s,a} \) is water consumption for gross irrigation in sample irrigation district.

Gross farmland irrigation water refers to the total amount of water used for irrigation of farmland in the irrigation area throughout the year from the water source and other irrigation systems, and its value is equal to the total water withdrawal deducting the amount of channel waste water required for project protection, flood prevention, the amount of backwater outside the irrigation area and the amount of non-agricultural farm irrigation water.

The calculation method of net irrigation water consumption in the sample irrigation district is shown in equation 2[5].

\[ W_{f,n} = 0.667(H_2 - H_1) \]  

Where: \( W_{f,n} \) is net irrigation water consumption per hectare in a typical field, \( H_2 \) is surface water depth of typical field after a certain irrigation, \( H_1 \) is surface water depth of typical field before a certain irrigation.

Given the average farmland irrigation water effective utilization coefficient and annual gross farmland irrigation water volume of irrigation areas of various sizes and types, the average value of farmland irrigation water effective utilization coefficient in Kaizhou District is calculated according to equation 3.

\[ \eta_d = \frac{(\eta_{d,m} \times W_{a,m} + \eta_{d,s} \times W_{a,s})}{(W_{a,m} + W_{a,s})} \]  

Where: \( W_{a,s}, W_{a,m} \) is the annual gross irrigation water volume of small and medium-sized irrigation districts, respectively. \( \eta_{d,s}, \eta_{d,m} \) is the average utilization coefficient of farmland irrigation water in the small and medium irrigation districts, respectively.

4. Results and Analysis

4.1 Results
The effective utilization coefficient of farmland irrigation water in Kaizhou District in 2019 is shown in table 3.
### Table 3. Effective utilization coefficient of irrigation water in Kaizhou District in 2019

| Types of irrigation districts | Irrigation method | Number | Name of irrigation district | Coefficient of sample irrigation district | Comprehensive coefficient |
|------------------------------|------------------|--------|----------------------------|------------------------------------------|---------------------------|
| Medium-sized districts       | Gravity          | 1#     | Longan Reservoir Irrigation District | 0.4915                                   | 0.4915                    |
|                              | Gravity          | 2#     | Zaojiaoping Reservoir Irrigation District | 0.4918                                   |                           |
|                              | Gravity          | 3#     | Wanchanggou Reservoir Irrigation District | 0.4944                                   |                           |
| Small-scale districts        | Gravity          | 4#     | Dashuicao Reservoir Irrigation District | 0.5096                                   | 0.4994                    |
|                              | Gravity          | 5#     | Tanyin Reservoir Irrigation District | 0.5072                                   |                           |
|                              | Non-gravity      | 6#     | Mingyue Non-gravity Irrigation District | 0.5149                                   |                           |

It can be seen from the above table that in 2019, the effective utilization coefficient of farmland irrigation water in Kaizhou medium-sized sample irrigation district is 0.4915, and that in small-scale sample irrigation district is 0.5036. The comprehensive effective utilization coefficient of farmland irrigation water in the whole district is 0.4994.

#### 4.2 Reasonable Analysis of Results

The basic data for this calculation comes from relevant statistics, field investigations and observations, and existing test results. All data have been verified with relevant water authorities; therefore, the results of the effective utilization coefficient of irrigation water in Kaizhou District are reasonable and reliable.

After continuous irrigation and water conservancy investment in the irrigation area in recent years, the benefits are slowly showing. The area of water-saving irrigation has been improved to some extent. With the continuous promotion of the concept of water saving, especially since the actual measurement of the effective utilization coefficient of farmland irrigation water has been carried out, the management of the irrigation area has been standardized, the water conservation awareness of the water users in the irrigation area has been improved, and the irrigation water has served the farmland better and more effectively.

### 5. Conclusion and suggestion

The calculation and analysis of the effective utilization coefficient of irrigation water is based on the technical requirements of the "Guide Rules" of the Ministry of Water Resources and the actual workload in the Kaizhou District. The average irrigation water utilization coefficient in Kaizhou District in 2019 is 0.4994. The research results can effectively support the assessment of the most stringent water resources management system in Kaizhou District, and at the same time provide a reference for the development of agricultural efficient water-saving irrigation in Kaizhou District.

At present, the continuation of supporting facilities and water-saving reconstruction in irrigation districts are more focused on the renovation and management of backbone projects, while there are fewer supporting facilities in field projects such as buckets and agricultural canals in irrigation districts. There is a leakage problem of the branch canal, which causes the final canal system not to perform its function well. Therefore, we should continue to strengthen the infrastructure supporting work of the irrigation districts in the district, and continue to improve the management level of the irrigation districts and the masses’ awareness of water saving.

### 6. Acknowledgement

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