A case study on water price calculation of key projects at Fenglinwan irrigation areas in JiangXi Province, China

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Abstract. Reasonable water price plays an important role in the healthy operation of an irrigation area. This study evaluates the current operation and management of Fenglinwan irrigation area in JiangXi Province, including implementation of agricultural water price, employee salary, current comprehensive agricultural water price and investment of engineering facilities. The cost of agricultural water supply of key project in irrigation area and the total cost of irrigation area were calculated to measure the agricultural water price. The result shows that the cost which has been spent for operation and maintenance of irrigation area was about 3.76 million yuan per year and the total cost for irrigation area was about 5.33 million yuan per year. The excessive number of employees and low wage level have greatly affected the work enthusiasm of employees. The cost of engineering maintenance was too small to guarantee the good operation of irrigation and water conservancy projects. The current implementation of agricultural water price which is about 20 yuan per mu is lower than the evaluated operation and maintenance cost for agricultural water supply which is 71.13 yuan per mu. A part of that, the current comprehensive agricultural water price which is 49.20 yuan per mu is also lower than the whole cost for agricultural water supply which is about 100.87 yuan per mu. Neither the current implementation of agricultural water price nor the current comprehensive agricultural water price can meet the basic requirements of operation and management.

Keywords: Fenglinwan, irrigation areas, Jiangxi province, water supply cost, water price calculation

Track Name: Land, Water, Forests and Food Security
1. Introduction

Water is the most crucial thing for human life [1-5] and aquatic life [6-8] as well as for agriculture [9-10]. Reasonable setting price for agricultural water supply is an extremely important thing in the process of implementing the comprehensive reform of agricultural water price. It further can effectively exert the leverage of water prices, promote the transformation of agricultural water uses from extensive to be intensive, improve the enthusiasm of farmers to save water and maintain the farmland water conservancy facilities to continue healthy operation [11]. Fu et al. [12], Yu [13], Jia [14] and other researchers [15-18] proposed the calculation method of terminal water price in irrigation area. Li and Wang [19] analyzed the formation mechanism of agricultural water price from the evaluation of water price affordability of users.

Besides, Li and Meng [20] analyzed the sensitivity of each component of agricultural water supply cost; while Du and Zhang [21] and Yuan [22] analyzed the price of agricultural water and the affordability of farmers. Then, Anhui Water Conservancy Accounting [23] investigated and studied the agricultural two-part water price in Pishihang Irrigation area. The direct management of some authority in large and medium irrigation areas in South China is the key project, but there are few studies focusing on the analysis and measurement of water price from the cost of key projects. This study evaluates the current operation and management of Fenglinwan Irrigation area; calculates the cost of agricultural water supply; and measures the water price in the irrigation area, so as to provide some reference for developing the formulation of water price of similar projects.

2. Overview of irrigation areas

Fenglinwan irrigation area is located in Guixi City, northeast of Jiangxi Province, with a designed irrigation area of about 75,400 mu and an actual irrigation area of about 52,800 mu. The total arable land area is 79,000 mu, of which 77,300 mu paddy field is a medium-sized irrigation area. The key project of Fenglinwan irrigation area consists of 3 medium-sized reservoirs and 1 main canal (7 main canals, 61 branch canals, more than 300 canal buildings). The total length of the main canal is 134.9 km, and the total length of the branch canal is 211.25 km (Figure 1).

Figure 1. General layout of main and branch canals.
3. Evaluation of operational management

3.1 Execution of water price
According to Government of Guixi City, 2009 [24] about improvement of water fee collection in Guixi City, the standard of water charge for farmland irrigation is about 24 catties of rice/mu. In principle, water charge is mainly levied in kind. If farmers are willing to pay in cash, it is collected according to 20 yuan per mu. So far, the water uses for Fenglinwan irrigation area have not paid the water fees.

3.2 Personnel structure and salary level
A total of 32 public welfare posts and engineering operation management staff are in each water pipe unit. By the end of 2018, the actual number of posts in the three reservoir management committees was 41. By calculation, the average wage of 2016-2018 is 1,568,000 yuan per year, and the average wage level of personnel is 38,200 yuan per year/per person according to the actual number of people, which is far less than the average salary of 58,600 yuan of water conservancy practitioners in 2017 according to the 2018 Yingtan Statistical Yearbook [25-26].

3.3 Current comprehensive water price
So far, farmers in the Fenglinwan irrigation area have not paid the water fees. According to the policy requirements of the comprehensive reform of agricultural water price at the present stage, in order to meet the requirements of engineering operation, the way of charging water fee and government subsidy operation cost is adopted to implement the operation and maintenance of engineering. According to this requirement, combined with the actual situation of Fenglinwan irrigated district, the effective irrigation area of Fenglinwan irrigation area is about 52,800 mu. The water fee from 2016 to 2018 is 0 yuan, and the three-year irrigation water fund allocated by the government subsidy and maintenance fund is 2,597,900 yuan, which is converted into the comprehensive water price of 49.20 yuan per mu.

3.4 Engineering facilities
The average expenditure from 2016 to 2018 was 3,844,700 yuan, of which the engineering maintenance fund was 953,100 yuan, accounting for 24.79 % of the total expenditure. Due to the lack of funds, channel congestion, damage, poor operation of buildings, serious corrosion and other phenomena, seriously affecting the benign operation of irrigation projects.

4. Cost calculation for water supply

4.1 Cost Allocation
Fenglinwan Irrigation area is a medium-sized irrigation area with multiple hubs, simultaneous storage and diversion, and combination of reservoir and canal. The main function of the key project and sluice in the irrigation area is irrigation, without other functions. Therefore, in the cost calculation, the cost of the key project does not need to be shared; The main functions of the reservoir are flood control and irrigation, so cost allocation should be carried out when calculating direct wages and management costs. The reservoir capacity proportion method is used for allocation, and the allocation coefficients of Fenglinwan Reservoir, Daheyuan Reservoir, Taipingfan Reservoir and Fenglinwan Irrigation area are 0.85, 0.91, 0.83 and 0.86.
4.2 Water supply cost analysis

4.2.1 Employee compensation

Total approved wages for staff and workers were based on the average standard wages and number of staff and workers. The total employees for reservoirs management are 32 staffs (Table 1), including 10 staffs for Fenglinwan Reservoir Management Committee, 10 staffs for Taipingfan Reservoir Management Committee, and 10 staffs for Daheyuan Reservoir Management Committee. Based on Yingtan Statistical Yearbook [26], the average salary of water conservancy employees in 2017 was 58,623 yuan, and the monthly salary was 4,885.25 yuan.

Table 1. The calculation table of the number of employees to share the salary of the reservoir in Fenglinwan irrigation area.

| Serial number | Reservoir name | Number of employees (people) | Apportionment factor | Apportionment number (people) |
|---------------|----------------|-----------------------------|----------------------|------------------------------|
| 1             | Fenglinwan     | 12                          | 0.85                 | 10.2                         |
| 2             | Daheyuan       | 10                          | 0.91                 | 9.1                          |
| 3             | Taipingfan     | 10                          | 0.83                 | 8.3                          |
| **Total**     |                | 32                          |                      | 27.6                         |

As shown in Table 1, the approved apportion number of Fenglinwan irrigation area is 27.6 people, so the employee salary is: average salary * approved number = 5.8623 * 27.6 = 1.618 million Yuan.

4.2.2 Direct material cost

Direct material costs include raw materials, raw water, auxiliary materials, spare parts, fuel, power and other direct materials consumed in the operation and production of water supply projects [24]. Fenglinwan irrigation area belongs to self-flow irrigation, there is no material cost in the actual operation process, so, the cost is calculated at 0 yuan.

4.2.3 Depreciation of fixed assets

Depreciation fee of fixed assets refers to the depreciation amount of water supply fixed assets calculated according to the prescribed depreciation method [25]. Medium-sized reservoirs in Fenglinwan irrigation area are depreciated according to the 40-year standard, irrigation channels are depreciated according to the 50-year standard, and sluices (small) are depreciated according to the 40-year standard. The residual rate is calculated at 5%.

The annual depreciation is calculated by the net value of fixed assets * (1 – residual rate) * sharing coefficient / depreciation years, and the residual rate is calculated by 5%. The fixed assets of the three reservoirs are 76,500,000 yuan, the average apportionment coefficient is 0.86, and the depreciation of fixed assets is 76,500,000 * 0.95 * 0.86 / 50 = 1,250,000 yuan. The capital used for water-saving supporting renovation in irrigation area is 1,684,790 yuan, and the depreciation of fixed assets is 16,847,900 * 0.95 / 50 = 320,100 yuan; that is, the total depreciation of fixed assets in Fenglinwan Irrigation area is 1,570,100.

4.2.4 Cost of major repairs

In principle, the cost of major repairs of fixed assets is calculated according to 1.4% of the value of...
fixed assets after audit [26], considering the allocation coefficient of large and medium-sized reservoirs, so the cost of major repairs is 1,156,900 yuan.

4.2.5 Daily maintenance expenses
Calculation of maintenance cost for channel projects and channel system buildings is based on standard for maintenance quota of water conservancy projects and related provisions [26]. The key project of Fenglinwan irrigation area mainly undertakes agricultural irrigation, and basically has no other function.

In addition, for undertaking the water supply for irrigation, the reservoir also has flood control function. According to standard for water supply price based on water conservancy projects (Trial), the calculation of maintenance costs and agricultural water price should be shared according by the proportion of "Profitable inventory/ (Profitable inventory + flood control storage capacity)". The calculation results are shown in the Table 2 as follow.

| Serial number | Project name                  | Actual cost (yuan) |
|---------------|-------------------------------|--------------------|
| First         | Fenglinwan Irrigation key Project | 385,060            |
| Second        | Taipingfan Irrigation key Project | 209,652            |
| Third         | Daheyuan Irrigation key Project   | 121,191            |
| Four          | Water source (reservoir) project | 470,104            |

In summary, according to the relevant standards, the daily maintenance costs for Fenglinwan Irrigation area is 1186000 yuan.

4.2.6 Other expenses
Other expenditures include engineering observation fees, temporary facility fees, and water quality testing fees which are actually incurred in the water supply project. There are no observation facilities in the irrigation area, and no temporary facility fees, mainly for water quality testing fees. The calculated cost of water quality testing is 48400 yuan per year.

4.3 Period cost analysis
Sales expenses refer to the various expenses incurred by agricultural water supply operators in the process of agricultural water supply sales. The sales expenses of Fenglinwan irrigation area should include depreciation fees, material consumption and other operating expenses of the water fee collection department. In order to ensure the full collection of water fees, without changing the current mode of water fee collection, it is still adopted by township, and 22.5 % is proposed as the principle of management fees. According to the current implementation of water price 20 yuan per mu, the effective irrigation area of Fenglinwan irrigation area is 52,800 mu, that is, the annual water charge is 1,056,000 yuan, and the sales cost is 237,600 yuan per year. Travel expenses, office expenses and transportation subsidies are calculated on the basis of the average value of the average value of the irrigation area for three years. According to statistics, the Fenglinwan Irrigation area has spent about 228,000 yuan per year in average from 2016 to 2018. The average sharing coefficient is taken as the basis of the calculation cost, that is, 228,000 * 0.86 = 196,100 yuan. By the end of 2018, the total number of employees in Fenglinwan Irrigation area
is 41. The management cost of accounting is taken as the management cost of fixed staff, that is, 
$32 \times 196,100/41 = 153,300$ yuan. Fenglinwan Irrigation area has power generation income, with an 
average of 644,400 yuan per year from 2016 to 2018. Through the above analysis and operation cost 
accounting, the running-maintenance cost of Fenglinwan irrigation area is 3,755,800 yuan. Through the 
above analysis and operation cost accounting, the full cost of Fenglinwan Irrigation area is 5,325,900 
yuan.

5. Total water price calculation
According to the calculation, the full cost of Fenglinwan Irrigation area is 5325900 yuan, and the 
effective irrigated area is 52,800 mu. The full cost water price =532.59/5.28=100.87 yuan per mu. 
According to the calculation, the running-maintenance cost of Fenglinwan Irrigation area is 5,325,900 
yuan, and the effective irrigated area is 52,800 mu. The running-maintenance cost water price 
=375.58/5.28=71.13 yuan per mu.

6. Conclusions
The following conclusions and suggestions are drawn from the research and analysis of water price 
calculation in Fenglinwan Irrigation area:
(1) The institutional reform is not in place, and all the reservoir management committees have the 
phenomenon of overstaffing, especially the Fenglinwan Reservoir Management Committee has the 
largest number of overstaffing, which directly leads to the extremely low average wage level and greatly 
affects the enthusiasm of workers;
(2) Water fee is not collected in time, project maintenance funds are less, can't guarantee the benign 
operation of irrigation project;
(3) The current water price of 20 yuan per mu and the current comprehensive water price of 49.20 yuan 
mu$^1$ are both lower than the calculated running-maintenance cost water price of 71.13 yuan mu$^1$, and 
the full cost water price of 100.87 yuan per mu, which cannot meet the basic requirements of operation 
running-maintenance;
(4) It is suggested that the calculation cost should be reasonably considered when determining the water 
price of key projects in irrigation areas

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