Research on Water Allocation Method of Juzhang River in Yichang City

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Abstract: Water allocation refers to the gradual allocation of the total available water resources or the amount of water that can be allocated to the administrative area, and determines the share of water consumption or the share of water used for living and production in the administrative area. The total amount of available water resources includes the amount of surface water resources and the amount of groundwater resources that can be exploited, minus the overlap between the two. Aiming at the water allocation problem of the Juzhang River, this paper discusses the basic principles of water allocation and the technical route of water allocation plan formulation. A water allocation plan for the Juzhang River Basin was drawn up through steps such as supply and demand forecasting and supply and demand balance analysis. The research can provide a certain reference for the development of water allocation schemes in small and medium-sized river basins.

1. Introduction

A combined system of total amount control and quota management on water use is implemented in China. Regulating runoff and allocating water should be based on river basin planning and long-term water supply and demand planning, and basin-based water allocation plans should be formulated [1-3]. Carrying out water allocation work and formulating river basin water allocation plans are the basic requirements for implementing the Water Law of China and advancing administration according to law [4]. They are the objective need to strengthen macro-control of water resources and achieve sustainable use of water resources [5-6]. They are necessary measures to avoid and eliminate water conflicts, and maintain social harmony and stability [7-8]. It’s the foundation for implementing the most stringent water resources management system and establishing a red line for the control of water resources development and utilization.

In order to strengthen the unified management and dispatch of water resources and ensure the safety of water supply of the Juzhang River in Yichang city, it is necessary to develop a water allocation plan for the Juzhang River in Yichang city. It can provide a reference for the compilation of the water allocation plan of the Juzhang River Basin in the later period.
2. Research area and hydrological analysis

2.1 Study area
The Juzhang River is a tributary of the northern bank of the middle reaches of the Yangtze River. It originates from the Helinggou in Baokang County. The river basin spans the four cities of Xiangyang, Yichang, Jingmen, and Jingzhou. The length is 341.5 km and the drainage area is 7284 km². The Juzhang River in Yichang is 221 km long and its drainage area is 3480 km². It involves 17 towns in 3 counties (cities) of Yichang City. Among them, the Ju River is 236 km long, with a catchment area of 3360 km², and 67 tributaries. The Zhang River in the east branch is 196.7 km long, which has a catchment area of 2965 km². A hydrological station is located 81 km upstream of the Juzhang River estuary, with a controlled area of 6325 km². The river above Herong Station is 245 km long, the slope of the river channel is 0.8‰, the density of the river network is 0.3km/km², the length is 157 km, the average width is 40.4%, the average elevation is 451m, and the river bending coefficient is 1.9.

Figure 1. Map of Juzhang River Basin.

2.2 Surface runoff and available water amount
According to 15 hydrological station data in Juzhang River basin, monthly runoff at multi-year average frequency of the Ju River, Zhang River, and the Juzhang River are obtained as shown in Figure 2. The flood volume that is difficult to control and use during the flood season refers to the flood volume that cannot be controlled and controlled by engineering measures during the foreseeable period. The amount of flood that is difficult to control during the flood season is calculated based on the analysis of the total storage capacity and the availability of water above the control node at the lowest downstream of the basin. Subtract the natural runoff from the river basin control station during the flood season and subtract the maximum amount of water that can be stored and consumed in the river basin. The maximum amount of water that can be stored and consumed during the flood season is the maximum value of the total amount of water consumption, reservoir storage, and adjustable external basin water in the flood season.

Based on the multi-year average runoff results in the Juzhang River Basin and calculation results that are difficult to control during the flood season in the Juzhang River Basin. The available water volume in the Juzhang River Basin is calculated as shown in Table 1.

Table 1. Available water amount of Juzhang River (10⁸ m³).

| Station          | Frequency | Runoff | Minimum ecological water demand | Water amount that is difficult to control during the flood season | Available water amount |
|------------------|-----------|--------|----------------------------------|-----------------------------------------------------------------|-----------------------|
|                  |           |        |                                  |                                                                  |                       |

Figure 2. Monthly runoff at multi-year average frequency of the Ju River, Zhang River, and the Juzhang River.
3. Allocation of water resources based on total water use control

3.1 Water demand forecast
The water demand of the Juzhang River in Yichang city is mainly Mingfeng town, Hualinsi town, Jiuixian town, Yangping town, Maopingchang town, Hekou town of Yuan'an county, Yuyang office, Yuquan office, and Baling office, Yuxi town, Miaoqian town, Herong town, Lianghe town, Caobuhu town of Dangyang city, including domestic water, agricultural water, industrial water and ecological water. The water demand results are shown in Table 2.

Table 2. Water demand forecast result.

| District                   | Frequency   | Water demand (2025) | District                   | Frequency   | Water demand (2025) |
|----------------------------|-------------|---------------------|----------------------------|-------------|---------------------|
| Mingfeng town              | multi-year average | 1448                | Yuquan office              | multi-year average | 2913                |
| Hualinsi town              |             | 924                 | Baling office              |             | 2546                |
| Jiuixian town              |             | 1006                | Yuxi town                  |             | 4259                |
| Yangping town              |             | 1488                | Miaoqian town              |             | 3768                |
| Maopingchang town          |             | 1586                | Herong town                |             | 3237                |
| Hekou town                 |             | 829                 | Lianghe town               |             | 1525                |
| Yuyang office              |             | 2937                | Caobuhu town               |             | 1336                |
| Total                      |             | 29801               |                            |             |                     |

3.2 Water supply forecast
Combined with the water conservancy census data of Yuan’an county and Dangyang city and statistics of water supply capacity of water conservancy projects in the Juzhang River Basin, the water supply capacity is analyzed and calculated for the surface water storage, diversion, water lifting, water pond and weir projects. The available water supply amount at different frequencies are calculated as shown in Table 3.

Table 3. Water supply forecast amount at different frequencies.

| Year  | Frequency | Available water supply amount (10^4 m³) |
|-------|-----------|----------------------------------------|
|       | multi-year average | 89654                                |
|       | 50%       | 88495                                  |
|       | 75%       | 76952                                  |
|       | 95%       | 60581                                  |
|       | multi-year average | 93326                                |
|       | 50%       | 91569                                  |
|       | 75%       | 80659                                  |
|       | 95%       | 62948                                  |

3.3 Water allocation scheme
The total water use control indicators of Yuan’an county in 2020 and 2030 are 165 and 176 million m³, respectively. The total water use control indicators for Dangyang city in 2020 and 2030 are 330.3 and 350 million m³, respectively. Taking into account the population, area, socio-economic, and water use levels, the total water use control index of districts is decomposed into the Juzhang River Basin. The
The water allocation scheme is shown in Table 4.

| Frequency | District          | 2030 |        |        |        |
|-----------|-------------------|------|--------|--------|--------|
|           | Domestic water    | Production | Industrial water | Agricultural water | Ecological water | Total |
|           | Mingfeng town     | 254.96 | 1174.80 | 156.74 | 11.03 | 1597.52 |
|           | Hualinsi town     | 77.29  | 446.41  | 451.66 | 4.19  | 979.55  |
|           | Juxian town       | 106.04 | 632.72  | 341.53 | 5.94  | 1086.23 |
|           | Yangping town     | 158.47 | 944.20  | 497.04 | 8.87  | 1608.57 |
|           | Maopingchang town | 105.69 | 627.12  | 923.95 | 5.89  | 1662.65 |
|           | Hekou town        | 64.53  | 380.48  | 427.20 | 3.57  | 875.79  |
|           | Subtotal           | 766.99 | 4205.72 | 2798.13 | 39.49 | 7810.33 |
| multi-year average |          |        |        |        |        |
| Dangyang city | Yuyang office    | 458.27 | 1823.07 | 1040.81 | 23.11 | 3345.26 |
|           | Yuquan office     | 150.77 | 734.19  | 2177.25 | 9.31  | 3071.52 |
|           | Baling office     | 254.69 | 1150.11 | 1381.94 | 14.58 | 2801.32 |
|           | Yuxi town         | 237.40 | 1151.14 | 3105.67 | 14.59 | 4508.80 |
|           | Miaoqian town     | 170.97 | 862.80  | 2908.48 | 10.94 | 3953.19 |
|           | Herong town       | 242.93 | 1173.72 | 2063.87 | 14.88 | 3495.40 |
|           | Lianghe town      | 146.28 | 737.38  | 796.96  | 9.35  | 1689.97 |
|           | Caobuhu town      | 111.04 | 509.10  | 821.60  | 6.45  | 1448.20 |
|           | Subtotal           | 1772.36 | 8141.50 | 14296.58 | 103.21 | 24313.65 |
|           | Total              | 2539.35 | 12347.23 | 20670.06 | 142.70 | 35699.34 |

4. Conclusions
As the recommended water allocation scheme proposed in this paper is only a water distribution scheme with three frequencies of 50%, 75%, and 95%, and the actual water flow situation in the basin often does not correspond to these three frequencies, Water distribution should be based on the proportion of water distribution. The negotiation of the water allocation plan confirmed that the participation of relevant prefecture-level and county-level governments and their water administrative departments is needed to coordinate water conflicts in the basin. When it is difficult to reach consensus, an authoritative ruling body should be established to determine the plan agreed by the majority, so as to improve the efficiency of the initial water right allocation and prevent long-standing disputes. Water administrative departments at all levels should actively exercise their administrative management and technical guidance functions, give full play to the regulation and storage function of water storage projects, strive to realize flood resource utilization, and try to avoid conflicts in water supply due to uneven spatial and temporal distribution of water resources.

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