Analysis of Sampling Point Irrigation Area Selection Path for Agricultural Irrigation Water Consumption Statistics

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Abstract. The purpose of this study was to select the sample irrigation area suitable for agricultural irrigation water consumption statistics, and to determine the best selection strategy by analyzing the path. We use a multidisciplinary approach, including geographic information systems (GIS), crop growth models and hydrological models. Firstly, we evaluated the existing irrigated areas and found that different irrigated areas have different characteristics of land use type, crop planting structure, water resource use efficiency and so on. On this basis, we use GIS technology to determine the priority of irrigation area by analyzing the geographical features, landforms, soil types and so on. Secondly, we use crop growth model to simulate crop growth in irrigated areas, combined with historical rainfall data and irrigation data, to predict crop water requirements in different seasons. By comparing the crop water requirement of different irrigated areas, we further determined the selection range of irrigated areas in sample points. Next, we used the hydrological model to simulate the water resources in the irrigation area, combined with the real-time rainfall data and the water level data of surface water and groundwater, and predicted the water resources at different time nodes. By comparing the water resources of different irrigation areas, we further optimize the selection of irrigation areas. Finally, we selected several representative sample irrigation areas for field investigation and measurement, and collected the actual water consumption data. By comparing the simulated data and the actual data, we verify the accuracy of the selected sample irrigation area, and optimize and adjust it. Through multidisciplinary methods, the study successfully selected the sample irrigation area suitable for agricultural irrigation water consumption statistics, and provided a scientific basis for agricultural water management. In the future, we will continue to optimize the selection strategy and improve the accuracy and practicality of the selection.

Keywords: agricultural irrigation; Water consumption statistics; Sample irrigation area; Path analysis; Geographic information system; Crop growth model; Hydrological model

1. Introduction

In the process of agricultural modernization, the statistics of irrigation water consumption is a crucial work. In order to understand the water use situation of irrigation area more accurately, the selection and path analysis of sample irrigation area are particularly important. The purpose of this paper is to analyze the selection path of sample irrigation area for agricultural irrigation water consumption statistics, in order to provide theoretical basis and practical guidance for the efficient use of agricultural water resources. The purpose of water consumption statistics for

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agricultural irrigation is to better manage and use water resources, ensure adequate water for crop growth, and avoid water waste. However, due to the large irrigation area and the unequal distribution of water resources, it is difficult to accurately calculate the water consumption. Therefore, the selection and path analysis of sample irrigation area become the key to solve this problem. Sample irrigation area refers to the representative irrigation area in a certain area, through the statistics and analysis of its water consumption, we can get the general rule and characteristics of water consumption in this area. At the same time, through the analysis of the sampling irrigation area selection path, we can understand the influence of irrigation area location, survey method, data collection and other factors on the statistical results of water consumption[1]. It is of great significance to improve the accuracy and reliability of water consumption statistics and to formulate reasonable irrigation management system.

(Hamouda et. al., 2020)[2] aim to examine the problem of sampling interval selection for the precision agriculture using Wireless Sensor Networks (WSNs). A Variable Sampling Interval Precision Agriculture (VSI-PA)[3] system is proposed to measure and monitor the agricultural parameters for appropriate agricultural activities e.g. water irrigation. (Ba et. al., 2020) establish a Soil and Water Assessment Tool (SWAT) model for simulating non-point source (NPS) pollution in the irrigation area of the lower reaches of the Kaidu River Basin, based on spatial and attribute data (2010–2014). The quantitative analysis results of NPS pollutants in the irrigation area under different scenarios provide a scientific basis for water environmental management in the Kaidu River Basin. (Khanal et. al., 2020)[4] analyze the factors affecting the farmers' strength of access to the irrigation system in the command area of the system. The result showed that the insufficiency of irrigation water is not a major problem for the user group of this irrigation system but there is some level of dissatisfaction among the user group which affected their strength of access to the irrigation system. High water consumption in agriculture as one of the main water use sectors is estimated as 90% of total water, thereby necessitating consideration of water conservation methods. (Alavizadeh et. al., 2020)[5] aim to investigate the barriers to equipping agricultural lands with the new irrigation technologies in Shahrabaad rural district, Bardaskan city. (Ogwal et. al., 2020)[6] was conducted on the right of use and economics of irrigation water for small-scale irrigation schemes in Eastern, Northern and Western parts of Uganda to examine the extent to which irrigation is accessible to farmers and the economic returns from irrigation water. Sprinkler and drip irrigation were found to be more water-saving, cost effective and efficient compared to other methods of irrigation for example surface or furrow irrigation systems. (Nasir et. al., 2021)[7] aim to assess sustainable water management interventions and their impact on the farm economy. To increase water productivity, the most important adaptations that have been proposed are high-efficiency irrigation systems, drought-resistant varieties, the substitution of water-intensive crops with less water-demanding crops, the mulching of soil, zero tillage, and all on-farm operations that can save water, especially ground water. Agricultural activities are highly related to the reduction of the availability of water resources due to the consumption of freshwater for crop irrigation, the use of fertilizers and pesticides. (Loaiza et. al., 2021)[8] study assessment of water quality in a tropical reservoir in mexico: seasonal, spatial and multivariable analysis. The water quality of the Adolfo López Mateos[9] (ALM) reservoir was evaluated. Other influential work includes (Li et. al., 2019), (Avni, 2021), (Mukonazwothe et. al., 2022)[10].

The research content of this paper mainly includes the selection method and path analysis of the sample irrigation area, through combing and evaluating the existing research results, the selection path of the sample irrigation area suitable for the statistics of agricultural irrigation water consumption in China is proposed. We will use field investigation, data analysis and other methods to conduct in-depth analysis of the sample irrigation area, in order to provide useful reference for the efficient use of agricultural water resources.

2. Principles and basic requirements of sampling irrigation area selection

2.1 Sampling irrigation area selection principle

Representativeness: Considering the scale of agricultural irrigation water users, engineering facilities, water intake method of water source (art-flow water diversion, water lifting), topography, soil type, planting structure and other factors, the selection of irrigation sample water users. Sample irrigation water users should be representative of the same type of irrigation water users in provincial districts and water resource zones.

Feasibility: Irrigation sample water users should have a certain amount of water conditions and technical strength to ensure that the source of statistical data is reliable.

Sustainability: In view of the problems existing in the metering and statistical analysis of irrigating sample water users, monitoring stations (points) should be added or adjusted timely to ensure data accuracy.

2.2 Sample irrigation area selection basic requirements

(1) Selection should be made according to the agricultural irrigation reduction zones in the water quota standard documents of each province. In each irrigation zone, representative irrigation areas in terms of engineering facilities, water intake methods (art-flow water diversion, water lifting), landform, soil type, planting structure, etc. should be selected as sample irrigation areas, which can be used as the basis for statistical calculation of farmland irrigation water consumption.

(2) In order to make full use of existing basic resources, the selection of sample water users should be as far as possible with the national control, provincial administrative monitoring stations (points) and water intake permit supervision and management.

(3) It should analyze whether the current irrigation sample water users are representative and whether the statistical quantity can meet the requirements of the proportion of monitored measured water volume. If the requirements are not met, the irrigation area of the sample points should be increased or adjusted according to the above principles and methods.

3. Sampling irrigation area selection method

3.1 General requirement

All large and medium-sized irrigation areas with designed irrigation area of 667 hm2 and above should be directly reported, and there is no problem in selecting sample irrigation areas.

Small irrigation areas with designed irrigation area less than 667 hm2 need to fill in the agricultural irrigation water consumption according to the typical calculation method, so the sampling point irrigation area should be selected. According to the two water intake types of surface water source irrigation and underground water source irrigation (i.e., pure well irrigation area), the representative irrigation area was selected as the sample irrigation area.

3.2 Selection method of small sample irrigation area

Small sample irrigation areas should be selected according to two types of water intake: surface water source and underground water source (pure well). In pure well irrigation area, the controlled irrigation area of a single well is taken as a sample irrigation area, and the controlled area of a single well is generally small, the irrigated crops are relatively single, and the water consumption per unit area of irrigation mainly depends on different forms of water-saving projects and planted crops and soil types. Therefore, the selection of sample irrigation area is relatively simple, and it is generally required that there should be no less than 3 samples per person in the area. However, the representativeness of the sample irrigation area in the irrigation zone should be ensured, that is, the sample irrigation area should include the main water-saving engineering forms (channel seepage prevention, spray irrigation, drip irrigation or low-pressure pipeline) of the small underground water source irrigation area in the irrigation zone. The effective irrigation area under different water-saving engineering forms should be coordinated with the overall water-saving engineering status of the small underground water source irrigation area in the irrigation zone. And the engineering facilities, soil type and crop planting structure of the sample irrigation area should be representative in the same type of irrigation area.Table 1 shows the standard deviation and sample size of some provincial small irrigation districts

Table 1 Standard deviation and sample size of some provincial small irrigation districts

province	Standard deviation		Preliminary sample size			Final sample size		
	Lift water	Flow by itself	Lift water	Flow by itself	subtotal	Lift water	Flow by itself	subtotal
The whole country	-	-	877	882	2824	1087	1131	606
Shandong (Province)	0.37	0.29	53	33	118	55	36	27
Shanxi (Province)	0.41	0.28	65	31	159	67	33	59
Henan (Province)	0.51	0.41	102	65	207	104	70	33
Hebei (Province)	0.38	0.22	55	18	236	64	39	133

For small surface water source irrigation areas, the water source and engineering situation is more complicated, and the selection of sample irrigation areas is divided into three stages: "preliminary determination of the number of sample irrigated areas - minimum requirements of sample irrigated areas - final determination of the number of sample irrigated areas", among which, "preliminary determination of the number of sample irrigated areas" stage. Based on the survey data of 1 614 small surface water source sample irrigation districts calculated by the annual effective utilization coefficient of irrigation water, the standard deviation of the sample was calculated by using the water consumption per unit area of farmland irrigation in the sample irrigation district as the survey sample data.

(1) The number of irrigation areas in sample points has been preliminarily determined. The number of irrigation districts at provincial level has been preliminarily determined. Taking all the small surface water source irrigation areas as the sample population, the sample size was determined according to two water intake methods: water lifting and artesian flow. By determining the confidence level and sampling error of the standard error, and using the annual effective utilization coefficient of agricultural irrigation water as the survey sample data, the standard deviation of the sample was estimated to determine the number of small surface water sample irrigation areas in each province. According to the statistical principle, the formula for calculating the sample size of the water consumption per unit area of cultivated land irrigation is as follows:

$$n = \frac{z^2\sigma^2}{e^2}$$

Where :N is the number of small and medium-sized irrigation areas in the survey sample :: is the water consumption per unit area of cultivated land irrigation in the i small surface water source irrigation area in the survey sample; m /hm :p is the average water consumption per unit area of cultivated land irrigation in the survey sample m' /hm'.

The number of irrigation areas in the sampling points of irrigation zoning has been preliminarily determined. At present, most provinces and regions have issued industrial water quota or irrigation water quota standards, in which the agricultural irrigation zones of the province are divided. According to the relevant standard documents collected, a total of 27 provinces and regions in the country are divided into agricultural irrigation zones, of which 132 are first-level irrigation zones and 185 are second-level irrigation zones. According to the proportion of irrigation reduction area, the number of sample points in the small irrigation area was allocated to each irrigation area, and the initial number of small surface sample points in each irrigation area was obtained.

(2) The minimum number of irrigation areas in sample points is required. The sampling point irrigation area should include two kinds of water intake methods: water lifting and artware diversion, and the number of small surface water source sampling point irrigation areas for each water intake method in each irrigation reduction area is not less than 5. The representativeness of the sample irrigation area within the irrigation zone should be ensured:

The number and effective irrigation area of different water intake methods should be coordinated with the proportion of relevant indicators in the same type of irrigation area, and the engineering facilities, soil type and crop planting structure of the sample irrigation area should be representative in the same type of irrigation area.

(3) The number of lag areas of sample points is finally determined. The number of sample points in the small surface water source irrigation area preliminatively determined by the sample size calculation is allocated to the irrigation reduction area proportionally and compared with the lowest number of sample points in the irrigation area. If the number of irrigated areas in the sample points after preliminary determination is less than the minimum number of sample

points, the minimum number of sample points shall prevail; if the number of sample points is higher than the minimum number of sample points, the number of irrigation areas in the preliminary determination shall prevail.

4. Conclusions

In this study, a selection method of sampling irrigation area in the calculation of farmland water consumption is proposed, and the selection principle, basic requirements and selection method of sampling irrigation area are determined. The main conclusions are as follows: (1) All large and medium-sized irrigation areas with a designed irrigation area of 667 hm2 and above are directly filled in, and the water quantity of small irrigation areas with a designed irrigation area of less than 667 hm2 should be calculated by selecting sampling point irrigation areas: (2) Sample point irrigation areas should be selected according to the type of water intake in small irrigation areas, and sample point irrigation areas should be selected according to the minimum quantity requirements in pure well irrigation areas. The surface water source irrigation area is finally determined according to the three stages of "Preliminary determination of the number of sample irrigation areas - minimum number requirements of sample irrigation areas - final determination of the number of sample irrigation areas" :B According to the above method, a total of 2,218 small surface water source sample irrigation areas and 602 small underground water source irrigation areas need to be distributed nationwide according to the irrigation reduction zones. The number of small sample irrigation areas to be increased is 648, of which 604 are small surface water source irrigation areas and 44 are small underground water source irrigation areas

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