Study on Connotation and Comprehensive Evaluation of Modernization Irrigation District

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Abstract: In 2017, the document No.1 of the Central Committee of the CPC explicitly proposed the construction of modernization irrigation district, the large-scale of modernization irrigation district is an important link to achieve the modernization of water conservancy and realize the socialist modernization. In the new era this paper expounded the connotation and characteristic of modernization irrigation district, put forward "safe", "Sound", "advanced", "efficient" and "green" modernization irrigation district, and established the evaluation system of 5 first level indexes and 23 second level indexes. The threshold value of the evaluation index of the modernization irrigation district in 2035 was discussed. Binary fuzzy comparative analysis was used to determine the weight of indexes, and the degree of modernization irrigation district was divided into four levels, which provide a reference for the evaluation of the modernization of large-scale irrigation district.

1 Introduction

According to the data from China's Census of Water Conservancy¹, there are 456 large-scale irrigation districts and over 7293 medium-sized irrigation districts, accounting for 50.1% of the total effective irrigation district and accounting for about 50% of the national grain output. Large and medium-sized irrigation districts are the main force of agricultural production in our country and an important support for the national food security. The 18th National Congress of CPC put forward the "four modernizations". The first choice of agricultural modernization should be in the irrigation district. In 2017, the document No. 1 of the Central Committee of the CPC explicitly proposed the construction of modernization irrigation district. The modernization irrigation district is the key link to realize water conservancy modernization and agricultural modernization, The specific measures proposed by the 19th National Congress of CPC to basically achieve the goal of socialist modernization by 2035. Nowadays, the word "modernization irrigation district" has been constantly appeared at home and abroad. the new concept of irrigation modernization has been put forward by The United States for the first time in the 1980s. Israel used pressure irrigation technology to develop modern agriculture characterized by water saving, efficiency, foreign exchange earning and complete agricultural system and accelerated the modernization irrigation district. Many large-scale irrigation districts in China have been carrying out modernization and upgrading, such as the GanFu Plain Irrigation district in Jiangxi Province, the QuanNan Irrigation district in Jiangsu Province² and the HeTao Irrigation district in Inner Mongolia³.
Domestic and foreign scholars have studied the modernization irrigation district, the characteristics of the modernization irrigation district has been described by X G Wang[4]. The Sichuan irrigation district has been studied and the content of the modern irrigation district has been put forward by Y H Lou[5] and others. A farmland water conservancy modernization evaluation system of three layer indicators has been established by J X Mu[6] and others, according to the proportion of different regions to calculate the three layer indicators index value. A large-scale irrigation district modernization construction evaluation system composed of 5 first level indexes and 20 second level indexes has been established by Z Z Han[7]. W H Wang [8] and others were interested in the variable fuzzy set theory, and established a new and effective method for comprehensive evaluation of water-saving transformation in irrigation district. C. M. Burt [9] studied the low-pressure irrigation in the irrigation district to water-saving efficiently through the modernization Irrigation district in the western United States. C. Rocamora[10] took the case of the Spanish Irrigation District as an example, and put forward corresponding solutions to the energy conservation of modernized irrigation districts. At present, the connotation of the modernization irrigation district is not comprehensive, the characteristics and requirements of the new era are not reflected, and there is no unified and definite index system. This paper try to study the modernization irrigation district under the new era and establish the evaluation index system of the modernization irrigation district and carry out evaluation.

2 The Connotation Characteristics and Evaluation Index System of Modernization Irrigation district

2.1 Connotation and Characteristics of Modernization Irrigation district

The irrigation district generally refers to an farmland area with reliable water sources and diversion channels, drainage channels, and distribution channels[11] and undertakes such functions as national food security, water diversion irrigation, flood control and drainage and ecological restoration. According to the document spirit No. 1 of the Central Committee of the CPC in 2017, water conservancy modernization in the process of agricultural modernization has settled down into irrigation districts, which is to realize the modernization irrigation district. The modernization irrigation district under the new era refers to applying advanced technology, novel materials (equipment), innovative management system and information technology to irrigation districts and strengthening the construction of ecological civilization and security in irrigation districts.

Therefore, the connotation of modernization irrigation district can be summarized as:①Strong flood prevention and disaster mitigation, irrigation districts should have safeguards to build strong flood control and disaster mitigation facilities;②Sound engineering equipment is mainly reflected in the soundness of water source projects, water distribution and drainage works, irrigation and drainage works, canal structures and equipment in irrigation water conservancy projects; ③ advanced information management system, reflected in the irrigation district information monitoring, collection and management, water metering facilities, and irrigation district of the modern management system; ④ efficient irrigation, irrigation districts should take water resources conservation and efficient production as the core, come into a modern high-efficiency irrigation district;⑤green ecological environment, taking into account water purification to reduce non-point source pollution, saline-alkali land management, and etc. to create a green, water clear, bright view and modern water-saving eco-irrigation.

The characteristics of the modern irrigation district under the new era can be summarized as follows: Through the construction of water conservancy projects, informatization construction, water ecological management, adding new process, new technologies and new equipment, adopting advanced and perfect management modes, the irrigation districts are transformed into "safe", " Sound "," advanced "," efficient ", and " green "type of modernization irrigation district.

2.2 Modernization irrigation district index system

According to the connotation and characteristics of irrigation district, the index system of
modernization irrigation district should be established from five aspects of safety protection, engineering construction, information management and service, efficiency and benefit and ecological civilization. Following the principles of the scientificness, systematicness, comprehension, hierarchy, simplicity and others, these five aspects were used as first level index of modernization irrigation district. The relationship between the connotation and evaluation index of modernization irrigation district is shown in Fig.1.

![Fig.1 The relationship between the connotation and the evaluation index of modernization irrigation district](image)

Based on the first level index, 41 indexes had been collected from domestic and foreign references and documents, then 23 second level indexes is selected from these indexes by Delphi method to constitute the second evaluation index system of modernization irrigation district.

The connotation of modernization irrigation district has gradually evolved and will develop and change over time. With the continuous development of society, the irrigation district modernization has a different meaning at different time periods. According to the strategic goal of basically realizing the socialist modernization in 2035 in our country, the time point for building a modernization irrigation district will be set in 2035. Referring to relevant codes and standards, learning from the development experiences of developed countries and regions, and collecting nearly 30 years data from 15 large-scale irrigation districts in China the target value of the evaluation index to in the next 20 years were analyzed by using the trend method. The threshold of the evaluation index of modernization irrigation district by 2035 were comprehensively determined on above factors and methods. The evaluation index system of modernization irrigation district is shown in Table 1.

### Table 1 Evaluation Index System of Modernization Irrigation District

| First level index | Second level index | definition | threshold |
|-------------------|--------------------|------------|-----------|
| Safety protection A | Irrigation dikes, water storage projects, gate stations and farmland flood control compliance rate \( A_1 \) | Length of embankment (number of works, farmland area) / length of embankment (total number of works, total farmland area) | 90% |
|       | Waterlogged town area than the standard rate \( A_2 \) | The area required to meet the standards of drainage and drainage of villages and towns / the total area of living in villages and towns | 100% |
|       | Drought and flood disaster area ratio \( A_3 \) | Average annual flood and drought affected area in the recent five years / area of cultivated land in the same period | 5% |
|       | Water protection rate \( B_1 \) | The actual water supply / the corresponding level of annual design water supply | 95% |
| Engineering construction B | Lose (row) canal (tube) Road intact rate \( B_2 \) | Drainage canal (canal) intact length / canal (tube) the total length of the road | 95% |
|       | Drainage (ditch) Road buildings (including water projects) intact rate \( B_3 \) | Drainage (ditch) road building (including water engineering) intact seat / building total number of seats | 95% |
|       | Improve the degree of supporting facilities \( B_4 \) | Meet the number of modern agricultural road and bridge / should be set up | 100% |
|       | Metering facilities supporting rate \( B_5 \) | Fighting level above the inlet metering settings / bucket above all levels of the total number of inlet | 95% |
The indexes are compared one by one, and the value of the qualitative sorting scale obtained by comparison is selected between three values of 0, 0.5 and 1.0. The \( n \times n \) order binary comparison matrix \( E \) about importance can be obtained by comparing the indexes. According to the sums of row of the matrices the order are sorted from largest to smallest. According to Chen S Y \[13\], the relationship between the tone operator and the relative membership degree is given in the following table, the relative membership degree of the index is determined. The weights of non-normalized indexes are obtained.

### 3 Determine the index weight

Currently there are many ways to determine the weight of indexes, like subjective empowerment and objective empowerment. Commonly subjective empowerment methods are expert survey method, analytic hierarchy process, binary coefficient method and so on. Experts mainly determine the order of the weight of each attribute according to the actual decision-making problems and experts’ own knowledge and reasonable experience not to attribute discrepancies to its actual importance. However, the decision-making or evaluation results have strong subjective and arbitrary. Commonly objective weighting methods are the principal component analysis, entropy method, dispersion method and so on. The weight is determined mainly based on the relationship between the irrigation district original data, those methods have some shortage which the irrigation district needs to be determined before obtaining the index weight, and the weight of the evaluation index is not universal, it is not suitable for the evaluation of the degree of modernization in other large-scale irrigation districts. Therefore, this paper mainly used the binary fuzzy comparative analysis\[13\] in the subjective weighting method. This method can eliminate the value difference from different experts effectively. The fuzzy scale of the linear change was given to find the corresponding membership by quantifying the index through the matrix.

#### 3.1 Binary Fuzzy Comparative Analysis

Using binary fuzzy comparative analysis to determine the weight. Let \( n \) basic units be compared to form an indicator set (\( n \) is the number of indicators): \( F = \{ f_1, f_2, \ldots, f_n \} \). The indexes are compared one by one, and the value of the qualitative sorting scale obtained by comparison is selected between three values of 0, 0.5 and 1.0. The \( n \times n \) order binary comparison matrix \( E \) about importance can be obtained by comparing the indexes. According to the sums of row of the matrices the order are sorted from largest to smallest. According to Chen S Y \[13\], the relationship between the tone operator and the quantitative scale and the relative membership degree is given in the following table, the relative membership degree of the index is determined. The weights of non-normalized indexes are obtained,
and the weights of the indexes are normalized to obtain the weights of the first-level indexes and the second-level indexes.

Table 2: Tone operator and quantitative scales and relative membership degree relationship

| Tone operator | Same | A little | Slightly | Relatively | Obvious | Remarkable |
|---------------|------|----------|----------|------------|---------|------------|
| Quantitative scale | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 |
| Relative membership degree | 1.0 | 0.818 | 0.667 | 0.538 | 0.429 | 0.333 |
| Tone operator | Fully | Very | Exceedingly | Extremely | Incomparable |
| Quantitative scale | 0.80 | 0.85 | 0.90 | 0.95 | 1.0 |
| Relative membership degree | 0.250 | 0.176 | 0.111 | 0.053 | 0 |

First level index weight: \( w = (0.271, 0.187, 0.164, 0.223, 0.155) \)

Second level index weight: Safety and security indexes: \( w_A = (0.536, 0.256, 0.208) \)

Engineering construction indexes: \( w_B = (0.193, 0.154, 0.141, 0.134, 0.128, 0.126, 0.124) \)

Information management and service indexes: \( w_C = (0.216, 0.199, 0.216, 0.202, 0.165) \)

Efficiency and benefit indexes: \( w_D = (0.290, 0.332, 0.378) \)

Ecological civilization indexes \( w_E = (0.169, 0.222, 0.203, 0.203, 0.203) \)

3.2 Evaluation of the classification

The evaluation modernization of irrigation districts is divided into four levels: I (full realization of modernization), II (basic realization of modernization), III (partial realization of modernization), IV (non-realization of modernization). After the reverse index in the index system was normalized, the integrated evaluation method was used to evaluate the irrigation district. Compare the original data of a certain irrigation district index with the corresponding index threshold, and multiplied by the weight of the indexes, the 23 indexes calculated are added up to obtain the hierarchical eigenvalue of the irrigation district. The degree of modernization irrigation district will be determined according to the scope of eigenvalue and corresponding result. Seen Table 3.

Table 3: Degree of modernization realization level characteristic value H

| Grade | H   | the degree                        |
|-------|-----|-----------------------------------|
| I     | 0.8–1.0 | Full realization of modernization |
| II    | 0.5–0.8 | Basic realization of modernization |
| III   | 0.2–0.5 | Partial realization of modernization |
| IV    | 0.0–0.2 | Non-realization of modernization |

4 Conclusion

By analyzing the connotation and characteristics of the modern irrigation district under the new era, a more complete evaluation system of the irrigation district has been established and the threshold reached by the evaluation index in 2035 has been determined. By binary comparative analysis, the weights of indicators were determined at all levels, subjective differences by subjective empowerment method were eliminated. The fuzzy scales of linear changes correspond to different levels and adjectives respectively. It is reliable and scientific to carry out a comprehensive evaluation of the modernization irrigation districts by using index weights, the evaluation results are more scientific and accurate.
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