Application Progress of Comprehensive Evaluation Model in Irrigation District Water-Saving Reform

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Abstract. Water-saving reform in irrigated districts is of great significance to agricultural water-saving and production increase, and to promote economic development. Hence, a reasonable evaluation of the comprehensive benefits of irrigation district water-saving reform is conducive to the planning and management of the water, and to the modernization of irrigation districts. Through the collation of relevant literature, the necessity and feasibility of water-saving reform in irrigation districts were briefly described, and the application progress of different evaluation models in the benefit evaluation of water-saving reform in irrigation districts was clarified. The problems and development trends of benefit evaluation of water-saving reform in irrigation districts are put forward, and the benefit evaluation model widely used at present is described. Benefit evaluation has involved all aspects of human life, and its application fields have become wider and wider, and more and more methods have been adopted. Therefore, it is of great importance to summarize the evaluation methods and theories.

1. Introduction

The rationality of the evaluation model is directly related to the accuracy and credibility of the final result. As a systematic evaluation method, the comprehensive evaluation model has a very important position in the relevant management and engineering fields, and has a very wide range of applications and prospects in the relevant decision-making or management[1]. In recent years, the contradiction between the supply and demand of water resources has become increasingly acute, with the proportion of industrial, domestic and ecological water continuously increasing and the competition with agricultural water becoming increasingly serious. Therefore, strengthening the management and supervision of agricultural water, especially the irrigation water with the largest proportion, has become the key measure to alleviate the contradiction between supply and demand of water resources in regions and even countries. For this, in view of the serious aging of water conservancy facilities in the old irrigation districts, backward irrigation technology, low degree of original supporting facilities, and serious water waste in all old irrigated districts, each irrigated district carried out water-saving transformation projects with the support of the government, to minimize the waste of water resources and improve the utilization rate of limited irrigation resources. Therefore, to evaluate the operation and comprehensive benefits of irrigation districts after water-saving transformation treatment, and also to further improve the irrigation efficiency and management level of irrigation district water conservancy facilities, some scholars apply comprehensive evaluation mathematical theories and models to actual irrigation district management. Through the comprehensive analysis of the statistical data of all aspects of the irrigation area after the water-saving transformation, and then the rational and scientific evaluation of the work efficiency and quality of the irrigation area management departments, so we
can start from the actual situation of water-saving transformation to make an objective evaluation of comprehensive benefit, and give corresponding guidance for irrigation district operation management. This paper analyzes the necessity and feasibility of water-saving reform in irrigated areas, expounds different comprehensive evaluation models and their application in the benefit evaluation of water-saving reform in irrigated areas, and puts forward the existing problems and prospects for the future.

2. The necessity and feasibility of water-saving reform in irrigated districts

2.1. The necessity of water-saving reform in irrigation district
Most of China’s irrigation districts were built in the 1950s and 1970s, and played a huge role in agricultural production, and regional and even national economic development. However, but on the one hand, from the perspective of the irrigation area itself, due to the material conditions of the construction era, the design standards are low, the irrigation area has been operating for a long time with diseases, the water conservancy project is seriously aging, the leakage loss is large, the utilization rate of irrigation water resources is low, and the irrigation efficiency is significantly reduced, combined with water, the labor situation has changed along with the actual needs, the requirements of the agricultural production also corresponding increase, and the engineering management system and backward management facilities also caused the contradiction in water management and information transmission difficult, respectively; On the other hand, from the perspective of water resources, with the rapid development of population scale and social economy, the total water consumption increases year by year, and the shortage of available water resources in the region becomes increasingly severe[2-3]. The above-mentioned internal and external factors have made the current situation of old irrigation districts unable to meet the requirements of my country's agricultural and national economic development in the 21st century. There is an urgent need to continue the construction of supporting facilities and water-saving reform to put them on the track of benign operation and make them more effective.

2.2. The feasibility of water-saving reform in irrigation district
At present, the general keynote of water conservancy reform and development in China is to strengthen the weak links of water conservancy projects and the supervision of water conservancy industry[4]. Firstly, from the national strategy of regional development, the water-saving reform in irrigated areas has responded positively to the general policy of water conservancy reform and satisfied the reasonable demand of economic and social development. Secondly, water-saving reform in irrigated areas is also the basic work of modernization construction of irrigated areas. By adopting modern technology and management level, it is a powerful measure to alleviate the contradiction between water resources supply and demand, and plays an important role in promoting the modernization of irrigation areas. At the same time, the people in the irrigation area showed great interest in the implementation of the project, and the relevant government also actively supported, which laid a foundation for the smooth implementation of the project.

3. The brief introduction and application of comprehensive evaluation model
In the research on the benefit evaluation of water-saving transformation in irrigated areas, scholars have conducted a large number of studies and reports, and their evaluation methods and applications mainly include:

3.1. The Analytic Hierarchy Process
Hong et al. (2009) established the genealogical structure of the investment benefit analysis of water-saving transformation in large irrigated areas by using AHP, and found the corresponding evaluation index system and parameters of investment benefit evaluation of water-saving transformation in large irrigated areas according to the knowledge of fuzzy mathematics[5]. Wang (2014) used AHP to evaluate the comprehensive benefits of the irrigated areas, analyzed the main problems existing in the
irrigated areas, and studied the important significance of supporting facilities and water-saving transformation of the irrigated areas[6]. He (2019) took large-scale irrigation areas as an example, introduced the application of AHP in the comprehensive post-evaluation index system, and obtained good evaluation results, which provided reference for the evaluation of similar projects[7].

3.2. The technique for order preference by similarity to an ideal solution
Liang (2014) applied the improved TOPSIS model to evaluate and analyze the comprehensive benefits of water-saving transformation in the irrigation area on the south bank of the Yellow River from 2000 to 2012, it was found that the comprehensive benefits of the irrigation area in 2000 were the worst, and the benefits of water-saving transformation were the best in the whole 13 years of evaluation in 2012[8]. In view of the multi-attribute and multi-index characteristics of benefit evaluation of water-saving transformation projects in large irrigated areas, Fang et al. (2011) proposed an improved TOPSIS evaluation method, which used information entropy to calculate weights and established a comprehensive evaluation model based on entropy weights, and the practice showed that the model calculation was simple and convenient, and the results were reasonable[9].

3.3. The Fuzzy comprehensive evaluation
Zhang (2008) established a multi-level and multi-objective fuzzy evaluation model for water-saving reform effects in irrigation districts by using multi-level and multi-objective fuzzy theory and methods, and this model was used to evaluate and rank the effects of water-saving transformation in some irrigation areas of Yellow River Basin, and the results showed that the transformation effect was related to the scale, conditions and investment of the irrigation area[10]. Huang et al. (2018) applied the FCE method to combine qualitative and quantitative methods, which provided theoretical basis for the social impact evaluation of the continuation of supporting facilities and water-saving transformation projects in irrigated areas[11]. Ma (2019) integrated game theory into the FCE method, and found that the evaluation results were consistent with the actual situation after the application of practical projects, indicating that the comprehensive evaluation system of water-saving transformation projects in irrigated areas based on game theory has strong practicability[12].

3.4. The grey relation analysis
Zhu et al. (2004) combined the AHP and information entropy theory to determine evaluation index weights, the basis of using the GRA to evaluate the operation condition of irrigation area, found that the GRA and approximate ideal point sorting method to the evaluation results was basically consistent with the sorting of each irrigation areas, showed that using the GRA for comprehensive evaluation of irrigation district operation was an effective method[13]. Li (2012) and Yang (2013), on the basis of the subjective and objective combination weights of indexes obtained by AHP and entropy weight method, comprehensively evaluated and compared the water-saving transformation benefits of key irrigated areas by using GRA and fuzzy comprehensive evaluation method respectively[14-15].

3.5. The principal component analysis
Yao (2004) put forward six indicators used for evaluation of water-saving reform benefits, applied principle of PCA to establish the comprehensive index of evaluating the benefit of the water-saving transformation - comprehensive principal component, the results showed that the application of the model can comprehensively reflect the status of water-saving transformation, well describe the benefits of water-saving level[16].

3.6. The projection pursuit model
Fang et al. (2010) established a projection pursuit model for comprehensive evaluation of irrigated areas reform and optimized its projection direction with ant colony algorithm, according to the projection value, scientific evaluation of water-saving reform benefits was carried out[17]. Lu et al. (2009) comprehensively analyzed the connotation of the sustainable development of the irrigation area,
the evaluation target requirements and related documents, and put forward the benefits of water-saving transformation of the irrigation area from five aspects: social, resource, economic, technical and ecological environment, proposed the water-saving transformation benefit comprehensive evaluation index system, established the comprehensive evaluation of irrigation improvement projection pursuit model of artificial fish algorithm was used to optimize the projection direction, according to the projection value science evaluation of water-saving transformation efficiency[18].

3.7. The artificial neural network method
Gao et al. (2003) combined the fuzzy theory with the neural network and proposed the fuzzy neural network comprehensive evaluation method for water-saving agricultural irrigation engineering, the network recognition rate of this method exceeds that of traditional methods, overcomes the accuracy problem in the fuzzy system, and its effect is superior to only using artificial neural network system theory[19]. Xu et al. (2001) proposed to build a set of comprehensive indicators and indicator grading system on the basis of the statistics of reconstruction planning data of irrigation areas, and by using the improved BP algorithm with additional momentum/adaptive learning rate, an artificial neural network comprehensive evaluation model was established and two actual irrigation areas were evaluated[20].

4. The existing problems and prospects
At present, the research on the comprehensive benefit evaluation methods of water-saving reform in irrigation districts has achieved certain results and formed corresponding theories and methods. However, evaluation is a complex and comprehensive work because it often involves many subjects such as society, economy, computer and mathematical statistics. Therefore, there are still some problems in the study of comprehensive evaluation of water-saving transformation benefit in irrigated areas, which need further study by scholars. First, there is a strong arbitrariness and subjectivity in the selection of evaluation index and weight of comprehensive benefit of water-saving reform. Second, the post-evaluation means and methods are relatively simple, and it is urgent to be integrated and practical. In this regard, it is necessary to strengthen interdisciplinary joint research in the future, scientifically select the influencing factors of the comprehensive benefits of water-saving reform in irrigation districts, and rationally construct an index system for evaluating the benefits of water-saving reform in irrigation districts. In addition, the evaluation index system should also consider the specific characteristics of different functions and types of irrigation areas in different regions to establish evaluation models.
5. Conclusions
Water-saving transformation in irrigated areas is an important part of water-saving agriculture, which is of great significance to saving water resources, increasing grain output and ensuring national food security. Through the scientific evaluation, we can make clear the reform effect and the related restriction factors, provide the decision basis for the decision-making department to perfect the reform measures, and provide the basis for the construction of the intelligent irrigation district, the digital irrigation district and the ecological irrigation district.

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References
[1] Guo, Y.J. (2010) Comprehensive evaluation theory, method and application. Science Press Publishing, Beijing.
[2] Huang, F.X., Yang, J.H., Zhang H.C. (2000) Implementation of water-saving technology transformation in irrigation areas to promote comprehensive utilization of water conservancy projects-Wuhumiao irrigation area in Luohe City to achieve technological transformation and efficiency improvement. J. Henan Water Resources., (02): 30.
[3] Sun, J. (2000) How to solve the prominent problems in the water-saving transformation of irrigation districts. J. Jiangsu Water Resources., (04):43.
[4] Pu, Ch.Y. (2019) Seriously carry out general tone and general idea of water conservancy reform and development in new period, promote strict supervision, filling weaknesses and strengthening implementation of soil and water conservation. J. China Soil and Water Conservation., (01): 1-4.
[5] Hong, L., Xiong, Y.J., Lu, J., Niu, Q.F., Li, Y.H. (2009) Economic evaluation of large-scale irrigation district water-saving rehabilitation in China. J. Water-saving Irrigation., (06): 1-3+7.
[6] Wang, L.W. (2014) Study on the continue to build form a complete set and water-saving transformation project comprehensive evaluation of Wutong River irrigation area. D. Northeast Agricultural University.
[7] He, Zh.Q. (2019) Application of Analytic Hierarchy Process in Comprehensive Post-Evaluation of Irrigation District Water-saving Improvement Projects. J. Pearl River Water Transport., (17): 13-14.
[8] Liang, T.Y. (2014) The calculation and analysis of irrigation efficiency and the evaluation of water-saving reconstruction at the south bank irrigation district of the Yellow River in Inner Mongolia. D. Inner Mongolia Agricultural University.
[9] Fang, Ch., Zhang Ch.L., Lu, M.B. (2011) Application of TOPSIS method based on entropy weight coefficient in comprehensive evaluation of water-saving reconstruction benefit in Youjiang Irrigation District. J. Water-saving Irrigation., (02): 52-54+65.
[10] Zhang, H.M., Li, Zh.B, Yao, W.W, Jing, M. (2008) Multi-level and multi-objective fuzzy method for evaluation of water saving reform and irrigation district reconstruction effect. J. Journal of Hydraulic Engineering., (02): 212-217.
[11] Huang, L.L, Deng, Sh., Liu, X.P., Mo J.W. (2018) Social impact comprehensive evaluation on continuously constructing the supporting and water-saving improvement project of irrigation district. J. Jiangxi Water Conservancy Science and Technology., 44(02): 91-95.
[12] Ma, Zh.H. (2019) Study on evaluation method of water saving reform project in Wangshi irrigation area of Suizhong County. J. Heilongjiang Water Conservancy Science and Technology., 47(12): 102-104+196.
[13] Zhu, X.Zh., Li, Y.H., Cui, Y.L., Chen, Zh.M. (2004) Application of grey relation method for
comprehensive evaluation of irrigation scheme. J. Journal of Irrigation and Drainage., (06): 44-48.

[14] Li, X.B. (2012) The evaluation of water-saving irrigation transformation benefit and transformation pattern research in major medium-size irrigation areas. D. Hebei Agricultural University.

[15] Yang, S.Y. (2013) The study on evaluation method and application of water-saving transformation benefits of large irrigation districts in inner mongolia. D. Inner Mongolia Agricultural University.

[16] Yao, J., Guo, Z.L., Lu, Q. (2004) Comprehensive principal component analysis on technical and economic index of water saving reform in irrigation area. J. Journal of Hydraulic Engineering., (10): 106-111.

[17] Fang, Ch., Cai, X.Ch., Zhang, Ch.L. (2010) A comprehensive evaluation of projection pursuit evaluation based on ant colony algorithm in water-saving improvement in irrigation districts. J. China Rural Water and Hydropower., (03): 62-65.

[18] Lu, K.F., Fang, Ch., Zhang, Ch.L. (2009) Study on the evaluation method of projection pursuit based on artificial fish swarm algorithm. J. Journal of Anhui Agricultural Sciences., 37(23): 11321-11323.

[19] Gao, F., Lei, Sh.L., Pang, H.B. (2003) Model of fuzzy nervous network integrated assessment of water-saving irrigation projects. J. Journal of Agricultural Engineering., (04): 84-87.

[20] Xu, J., Lei, Sh.L. (2001) Evaluation of irrigation district reconstruction effects with artificial neural network. J. Irrigation and Drainage., (02):1-4+12.