The Connotation, Characteristics, Main Contents and Evaluation Research System and Construction of Ecological Irrigation District

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Abstract. Due to the construction of irrigation districts always aims at maximizing project benefits, coupling with the impact of climate change and human activities, the ecological environment of the irrigation areas has faced severe challenges, so, the construction of ecological irrigation areas and the formation of a systemic ecological production view are essential for realizing the modernization of irrigation areas and sustainable agricultural development. This paper briefly introduced the connotation, characteristics, main contents and evaluation research system of ecological irrigation districts by consulting literatures, summarized the current research and construction of ecological irrigation districts facing problems, and the inevitability of ecological transformation of irrigation districts. Integrating the overall development of irrigation areas and the harmonious coexistence concept of human and nature, the construction of ecological irrigation areas in the future will continue to move forward, and the research on relevant theories and technical systems has broad prospects.

1. Introduction
The construction of irrigation districts is the lifeblood of ensuring food security in China. According to statistics [1], every year, the irrigated area accounts for approximately 49% of the national arable area, which produces grain output accounts for 75% of the national total output, and economic crop accounts for 90%. For a long time, irrigation districts have always occupied a higher position in the process of social and economic development in China, but the characteristics of traditional irrigation districts limit the effectiveness of irrigation district. The gradual enhancement of agricultural production capacity in irrigation district engineering construction has brought certain negative effects on the natural ecosystem [2], and makes the development of irrigation districts gradually become an important factor restricting the sustainable development of society, economy and environment. Therefore, it is very significant to transform the concept of the irrigation district construction, especially integrating ecological construction into the development of the irrigation district, and forming an ecological irrigation district that is suitable and coordinated with the environment.

Ecological irrigation district is a composite system engineering based on the concept of ecological civilization and focusing on maintaining and promoting the virtuous cycle of the irrigation district [3], pursuing the mutual benefit and win-win of ecology and economy [4]. At present, although the theoretical research of ecological irrigation district is still in the preliminary stage and practical experiences are also no enough, the analysis of the achieved relevant results has shown that its future development direction should be comprehensive in resources, environment, society and economy.
because it is determined jointly by the frontiers of the discipline and the actual productions. This paper discusses the connotation, characteristics, main contents and evaluation research of ecological irrigation district.

2. The connotation and characteristics of the ecological irrigation district

Up to now, there is no unified answer to the definition of ecological irrigation district at home and abroad. Our country's research on it has a short period of time, roughly more than 10 years [5], but in recent years, many experts and scholars have defined ecological irrigation district from different perspectives. Han et al. (2009) believed that the goal is to achieve ecological and economic win-win, and follow certain ecological laws, creating a compound system with higher productivity [6]. Peng et al. (2014) thought that it refers to the integration of the concept both water ecological civilization and the construction, management of irrigation district, forming in an organic whole that an engineering system is in harmony with the natural environment and highlighted the theme of efficient use of water resources and ecosystem health [4]. Chang et al. (2019) was based on the development concept and principle of ecological irrigation area construction, and defined it as: building water-saving and modern humanistic irrigation areas with ecological channels [5]. In short, ecological irrigation districts refer to high-efficiency and high-quality irrigated areas that taking the concept of harmony between man and nature as the core and coordinating the development of water resources, agricultural production and the ecological environment.

The characteristic of an ecological irrigation area is a horizontal and specific description of its connotation, involving many aspects which affect the development of the irrigation area, such as the improvement of the irrigation and drainage engineering system, scientific management, efficient use of water and soil resources, and maintenance of the ecological environment. Therefore, the construction of ecological irrigation districts should have two main characteristics: on the one hand, high efficiency, which is manifested in the supporting of irrigation district engineering facilities, advanced and scientific management concepts, technology, efficient use of water and soil resources, and effective improvement of water resources and comprehensive agricultural productivity; On the other hand is sustainability, the ecological irrigation district is based on the concept of water-saving social development while introducing the concept of ecological civilization to establish an irrigation district that integrates social, economic, and environmental overall interests and develops in harmony, reflecting the sustainability of the coupled response of water resources, agricultural production, and ecological environment.

3. The main contents of the ecological irrigation district construction

The construction of ecological irrigation district is an irrigation area transformation proposed under the constraints of ecological environment factors and improved resource utilization efficiency. It specifically includes the construction of engineering facilities, irrigated technology, management, environment and culture.

3.1. The irrigation district engineering system

Irrigation area engineering facilities are the aorta of the irrigation area system, especially water transmission and distribution channels. However, traditional lined channels blocked the natural connection between water system, soil and ecology, and reduced regional biodiversity. Nowadays, the development of anti-seepage materials, lining and cross-section forms of ecological canal systems have not only created a suitable habitat for organisms and increased the diversity of biological communities, but also ensured the integrity of the ecosystem in the channel [7]. In terms of lining materials, the concept of green and environmental protection is integrated, such as sand-free porous concrete, environmentally friendly green vegetation concrete, etc. Meanwhile, the lining and section forms are gradually diversified, such as plant-type impervious block technology, original ecological vegetation protection, three-dimensional geogrid technology and U-shaped, compound section, etc. [4].
Both concealed pipe drainage technology and channel drainage technology are water conservancy measures used to drain excess water from farmland, but concealed pipe drainage technology is mainly used to improve saline-alkali land in arid and semi-arid areas. Practices have proved, the salt discharge through the dark pipe is effective [8-9]. Yu et al. (2020) carried out water-saving irrigation in the jointing stage of oil sunflower on the basis of concealed pipe drainage, the results showed that the soil desalination effect are obvious [10]. Huang et al. (2020) compared the impact of solar concealed drainage area and non-concealed drainage area on the soil environment and found that the average soil desalination rate in 2017 and 2018 was 4.7% and 8.2%, respectively [11].

Drainage is the main source of farmland non-point source pollution. With the deepening of landscape ecology theory, the ecological ditches and irrigation-drainage-wetland coordinated system not only promote the interception, reduction of nitrogen and phosphorus in farmland drainage, but also form a good ecological landscape. Yang et al. (2005) put forward the concept of ecological ditches in the study of farmland non-point source pollution in the Taihu Basin, which realized the effective control of farmland drainage nutrients, and the removal rates of total nitrogen and phosphorus in farmland runoff reached 48.36% and 40.53%, respectively [12]. Dong et al. (2009) introduced and transformed the WRSIS (Irrigation-Drainage-Wetland Integrated Management System), the results showed that the content of total nitrogen and phosphorus in paddy field drainage were significantly reduced, and farmland non-point source pollution and water environment were effectively controlled, repaired [13].

Field irrigation technology is a systematic project in the irrigation district. Since the "Ninth Five-Year Plan", our country has carried out a large number of research work on improving surface irrigation technology, explored and promoted many water-saving irrigation models, comprehensively determined the technical elements of surface irrigation based on local conditions. It not only achieved water saving, fertilizer saving and increased crop production, but also reduced the loss of farmland fertilizers, pesticides and non-point source pollutants [14]. At present, the promotion of irrigation technology has gradually shifted to a comprehensive integration model, especially in combination with agronomic measures, for example, the application of drip irrigation technology and plastic film mulching technology in the arid areas of Northwest China. Insist on water-saving transformation of key channels, standardized construction of field water-saving projects, and water users to participate in the management of comprehensive development of the Yellow River irrigation area [4].

3.2. The irrigation district management
The implementation of modern management is one of the important contents of ecological irrigation district construction. Based on the concept of sustainable agricultural development, our country actively explores effective ways to realize a virtuous circle of irrigation district management, promotes the standardization of irrigation and drainage facilities management, and establishes the benign operation mechanism in the management system and mechanism aspects of irrigation districts. With the rapid development of the Internet of Things, big data and artificial intelligence, the construction of the irrigation district information platform enables the managers to timely control the operation status of the irrigation district project, crop growth, and water users’ demand for water resources, so that the irrigation district’s water resources can be deployed, more scientific, more reasonable. However, the degree of information of irrigation areas is still relatively low in China, which is mainly reflected the poor durability products, insufficient funds, lower management and maintenance, and lack of human resources. [15].

3.3 The irrigation district environment and culture
To a certain extent, the construction of irrigation districts is part of the construction of landscape ecology, so the construction of ecological irrigation districts with pastoral scenery is not only a material manifestation of water culture, but also a comprehensive reflection of the sustainable development concept [4]. The Xiaokaihe irrigation district uses water as the carrier and adheres to the concept of harmony between man and nature, water, and has realized the construction of a modern
irrigation area with typical characteristics of "resource-saving, ecological protection, and circular economy" [16]. The second main canal of Weishan irrigation district has built an ecological park with green development, highlighted the theme of water culture, and complementation of culture and landscape by comprehensively improving the dikes of the city section [17]. Now, although it has adopted corresponding technical measures for comprehensive management of ecological protection and restoration in irrigation areas, the task of ecological construction is long-term and arduous. Therefore, persisting in the principle of equal emphasis and balance between water conservation and ecological protection, and integrating certain water culture and water landscape elements, which are essential to form a unique ecological irrigation area.

4. The evaluation of ecological irrigation district

Ecological irrigation area is a green, high-efficiency and high-quality agricultural area with reasonable allocation of resources, optimization of the ecological environment, modernization agricultural development. Therefore, the evaluation and research of its operation status can reflect the benefits of irrigation area construction [6], and it can also provide a reference for the subsequent improvement of the construction and management of ecological irrigation areas [18].

Due to the construction of ecological irrigation area is a composite systems engineering, its evaluation process has the characteristics of multiple factors, levels and indicators [19], so it necessary to establish a complete and scientific indicator system in actual evaluation [4]. There are few research reports on the evaluation system of ecological irrigation areas [20], but the evaluation indicators selected in the existing studies are basically the same at the macro level, mainly in the four aspects of engineering, economy, society, and ecology [4-21], and the related evaluation methods mainly include: analytic hierarchy process, principal component analysis, grey correlation method, etc.; comprehensive evaluation method: such as secondary fuzzy comprehensive evaluation [22]; evaluation model: dynamic based on shapely value combination evaluation model [20], gray evaluation model of triangular whitening weight function based on center point [5].

Li et al. (2018) analysed and evaluated the ecosystem health of the Shenwu irrigation area in Hetao irrigation district of Inner Mongolia from 2000 to 2015 by using the spatial autocorrelation analysis method combined with RS and GIS technology, the ecosystem health level was a trend of slow improvement first and then rapid improvement during the year [23]. Zhao et al. (2019) selected the evaluation indicators of Qing 'an Heping irrigation district including engineering, social economy, biology and environment, and used the analytic hierarchy process to evaluate the health of the irrigation district's ecosystem that showed it is better than before the ecological renovation [21]. Xu et al. (2020) evaluated the ecological irrigation area in Helan county of Ningxia, by using 5 single methods and a combined method based on the selected 5 single methods, the results showed no matter which method was used to evaluate, the effect are consistent and consists with the actual operation status of the irrigation area, showing a trend of optimization year by year [24].

Different irrigation districts have different natural conditions and social backgrounds. Therefore, when constructing an evaluation index system for ecological irrigation districts, specific issues need to be analysed in accordance with local conditions. Meanwhile, the evaluation system and methods should be further explored and researched, and closely integrated information technology and relevant products to ensure the accuracy and reliability of information, data sources and evaluation results.

5. Conclusions

Ecological irrigation district is a major infrastructure facility that integrates agriculture, society, economy, ecology and other fields. And the construction process requires high technology, high investment, needs to combine the application of advanced scientific theories and technology to guide practice, as well as the active cooperation of relevant administrative supervisors departments, and extensive attention. The research on ecological irrigation districts is still in the development stage, and there are still many problems, such as the lower degree of large-scale application of information technology, lower automation technology products, incomplete implementation of the concept of
ecological civilization, and insufficient research on ecological environment impact assessment, etc. Since the implementation of the transformation and construction, the results have been remarkable, which not only adds assistance to the promotion of ecological construction, but also provides strong support for the sustainable development of various irrigation areas. With the continuous improvement of people's material living standards, the concept of ecological civilization gradually gains popularity. As the main base of agricultural production and important guarantee for national food security, the implementation of ecological construction in irrigation areas has been driven by the trend. The ecological irrigation district construction is not only an inevitable requirement for sustainable agriculture, but also an objective choice, then, its research and construction prospects are broad.

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