



Research on the Integration of Structural Design of Urban Irrigation Buildings and Water Saving Technology Based on the Concept of Sustainability

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Abstract: In the process of urban development, the shortage of water resources has brought obstacles to urban development, and it is urgent to realize the structural innovation design of urban irrigation buildings and the effective application of water-saving technical measures. This paper establishes a structural system of urban irrigation buildings by combining the concept of sustainable development with highly efficient water-saving irrigation technology as an entry point. For the comprehensive benefits of water saving under this structural design, the evaluation index system of water saving benefits of irrigation buildings is designed, and the weights of the evaluation indexes are solved by the improved entropy weighting method. Combining the improved entropy weight method with the close value method, an evaluation model for the comprehensive benefits of water conservation of urban irrigation building structures was established, and the relevant factors affecting the structural design and water conservation benefits of urban irrigation buildings were analyzed through the obstacle degree factor model. The weight of each evaluation index of water saving benefits of urban irrigation building structures varies greatly, among which the weight of social benefits accounts for the largest proportion of 0.2049. After the implementation of the irrigation building structure system in the sample cities, their comprehensive benefits of water saving showed an overall increasing trend during 2015-2023. The social and economic benefits become important factors hindering the deep integration of urban irrigation building structure design and water-saving technology. Therefore, further development of high-standard urban irrigation building structure design, combined with sustainability impact assessment and increased investment in irrigation building structure renovation, is needed to provide a guarantee for realizing the improvement of water-saving benefits of urban irrigation building structures.

Keywords: sustainability concept; irrigation buildings; water saving technology; close value approach



1. Introduction

In recent years, the construction of garden green space and other green landscapes in the city has gradually become one of the criteria for evaluating the development of urbanization, and more and more cities have begun to add the construction of green landscapes, which has brought about an increase in the amount of water used for urban maintenance [1-2]. Irrigation of green landscape is an important part of the whole urban greening project, and the rationality of irrigation system design directly affects the use of water resources and the maintenance cost of green landscape [3-4]. China's water resources are scarce, and the construction of water-saving urban irrigation buildings can alleviate China's water shortage problem to a certain extent, and water-saving irrigation systems are its important technical support.

Reclaimed water is an important water source for water-saving irrigation systems, and the key to utilizing reclaimed water lies in the recycling of water resources, which can not only alleviate the problem of water shortage, but also improve the ecological environment [5-6]. For urban green landscape irrigation, reclaimed water mainly refers to the reuse of river water and stored rainwater, and on the basis of urban irrigation buildings, it is able to meet the water demand of plants without human influence, which reflects a certain practical value and economic value [7-10]. In addition, the integration of water-saving technology in the design process of urban irrigation building projects not only helps to enhance people's awareness of water conservation, but also significantly improves the irrigation efficiency of the buildings [11-13]. Based on this background, an irrigation model that integrates the structural design of urban irrigation buildings with water-saving technologies is an important way of urban green landscape conservation. Designing specific irrigation building structures according to the characteristics of different vegetation and formulating scientific water use systems, such as water-saving irrigation supplementation system, automatic plant water demand adjustment system, and soil water replenishment system in dry time, can effectively guarantee the water demand of vegetation [14-17].

The article proposes a structural system design of urban irrigation buildings based on the concept of sustainability and combines it with water-saving technology, aiming at realizing the sustainable development of urban irrigation buildings and reducing the loss of water resources.

The acceleration of the social construction process promotes the rapid development of cities, and irrigation buildings play an increasingly important role in urban construction work. This paper combines intelligent water-saving irrigation technology with the concept of sustainable development, and introduces intelligent technology to design a framework of urban irrigation building structure system. In



order to better verify the comprehensive water-saving benefits under this structural system, an evaluation index system for the comprehensive water-saving benefits of urban irrigation building structures was established, and the weights of the indexes were calculated using the improved entropy weighting method. The city of H was selected as the research object, and the close value method was introduced to establish an evaluation model for the comprehensive benefits of water conservation of urban irrigation building structures, and the related factors affecting the structural design and water conservation technology of urban irrigation buildings were analyzed by combining with the obstacle degree factor model.

2. Consider sustainable structural design of urban irrigation buildings

With global climate change and population growth, water scarcity has become a global challenge. In the field of urban development, traditional irrigation methods often lead to a large waste of water resources, which not only increases urban production costs, but also causes serious damage to the ecological environment. High-efficiency water-saving irrigation technology, through the use of modern agricultural irrigation equipment and water-saving technology, can minimize the amount of irrigation water consumption and improve irrigation efficiency and water resource utilization under the premise of ensuring urban water demand. Therefore, the promotion and application of high-efficiency water-saving irrigation technology has become an important way to solve the shortage of water resources, improve the efficiency of urban production and promote the sustainable development of the ecological environment.

2.1 Efficient water-saving irrigation technology

2.1.1 Principles of water-saving technologies

The basic principles and characteristics of high-efficiency water-saving irrigation technology are the core of it as a modern irrigation means [18]. This technology is mainly based on two main principles, one is the principle of decision optimization, that is, through the irrigation and drainage system scheduling and pipeline network, control equipment and other optimal configuration, to achieve the scientific deployment and effective use of irrigation water. The second is the principle of water conservation, which is mainly reflected in the improvement of irrigation efficiency and reduction of leakage and evaporation losses through land improvement, improving crop drought resistance, and improving and adjusting irrigation methods.

In terms of characteristics, high-efficiency water-saving irrigation technology shows the following advantages, firstly, the water-saving effect is remarkable, which can effectively reduce urban irrigation water consumption and solve the problems of repeated irrigation and excessive leakage. The second is the improvement of urban crop growth environment, through the reasonable allocation of irrigation, to

ensure that the crop water demand to improve crop drought resistance, reduce the adverse effects of irrigation. Third, the protection of urban land, water-saving irrigation technology can effectively reduce the land degradation caused by repeated irrigation.

2.1.2 Classification of water-saving technologies

High-efficiency water-saving irrigation technology refers to the technology that minimizes the amount of irrigation water and maximizes the benefits of irrigation by adopting scientific and reasonable irrigation methods, approaches, equipment and management under the premise of meeting the urban irrigation demand. High-efficiency water-saving irrigation technology is a comprehensive technology, involving hydrology, soil science, agronomy, mechanical engineering, electronic engineering, information technology and automatic control and other disciplines, it is the core technology of urban irrigation building engineering, and it is an effective means to improve the efficiency of water resources utilization and protect the ecological environment. Efficient water-saving irrigation technology is categorized as shown in Figure 1, mainly including sprinkler irrigation technology, micro-irrigation technology, drip irrigation technology, and intelligent irrigation technology. Different technologies endow urban irrigation buildings with different water-saving performance, providing a guarantee for realizing the water-saving efficiency of urban irrigation buildings.

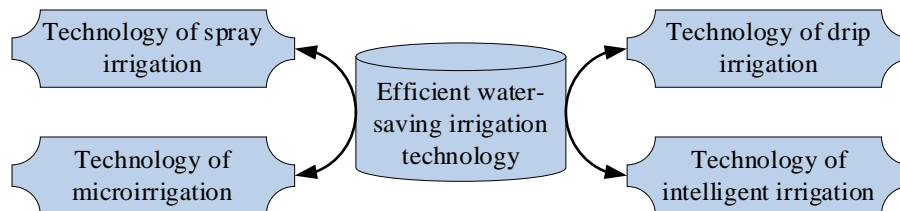


Figure 1 The classification of efficient water-saving irrigation techniques

Intelligent irrigation technology is a modern irrigation method that uses information technology, control technology, Internet of Things technology and other means to realize real-time monitoring, intelligent analysis and precise regulation of the water condition of irrigation buildings. By accurately predicting the water demand of irrigation buildings, smart irrigation technology can effectively reduce water waste and achieve significant water saving effect.

2.2 Structural design of urban irrigation buildings

2.2.1 The concept of sustainable development

The theory of sustainable development refers to meeting the needs of current generations without



compromising the ability to meet the needs of future generations. It emphasizes the balance between the economic, social and environmental dimensions and pursues the integrated goals of economic prosperity, social justice and environmental health. Its main aspects include the following:

(1) Sustainable development emphasizes comprehensiveness and wholeness. It emphasizes the interconnectedness and interaction of the economic, social and environmental dimensions, recognizing that the development of these dimensions is interdependent. Economic development should be integrated with social justice and environmental protection to promote each other and coordinate development, forming an overall sustainable development model.

(2) Sustainable development emphasizes the long-term and future-oriented. It pays attention not only to the needs and interests of the present generation, but also to the protection and fulfillment of the needs and interests of future generations. Sustainable development pursues long-term stability and continuous improvement of the economy, society and the environment, and ensures sustainable resource utilization through rational use and protection of resources.

(3) Sustainable development emphasizes equity and balance. It emphasizes the fair distribution of resources and social inclusiveness, and pursues socially just and equitable development. Sustainable development requires solving the problems of poverty, inequality and social exclusion, promoting the participation of all sectors of society and sharing of benefits, and realizing social harmony and stability.

(4) Sustainable development emphasizes ecological environmental protection and sustainable use. It calls for the protection and restoration of ecosystems and the reduction of damage to the environment and consumption of resources. Sustainable development requires that environmental protection be taken as a prerequisite and basis for development, and that the harmonious coexistence of human beings and nature be realized through ecological restoration and environmental management.

2.2.2 Structural systems for irrigation buildings

Urban irrigation buildings are an important foundation to ensure the sustainable development of the city, based on efficient water conservation technology and aiming at the sustainable development of the city. Based on the consideration of sustainable development, this paper introduces multi-source sensing technology and intelligent irrigation technology to construct an intelligent application system for irrigation buildings, and its specific architecture is shown in Figure 2. It adopts a five-layer structure design, with the IOT perception layer, data warehouse layer, service support layer, business application layer and end-user layer from the bottom to the top in order.

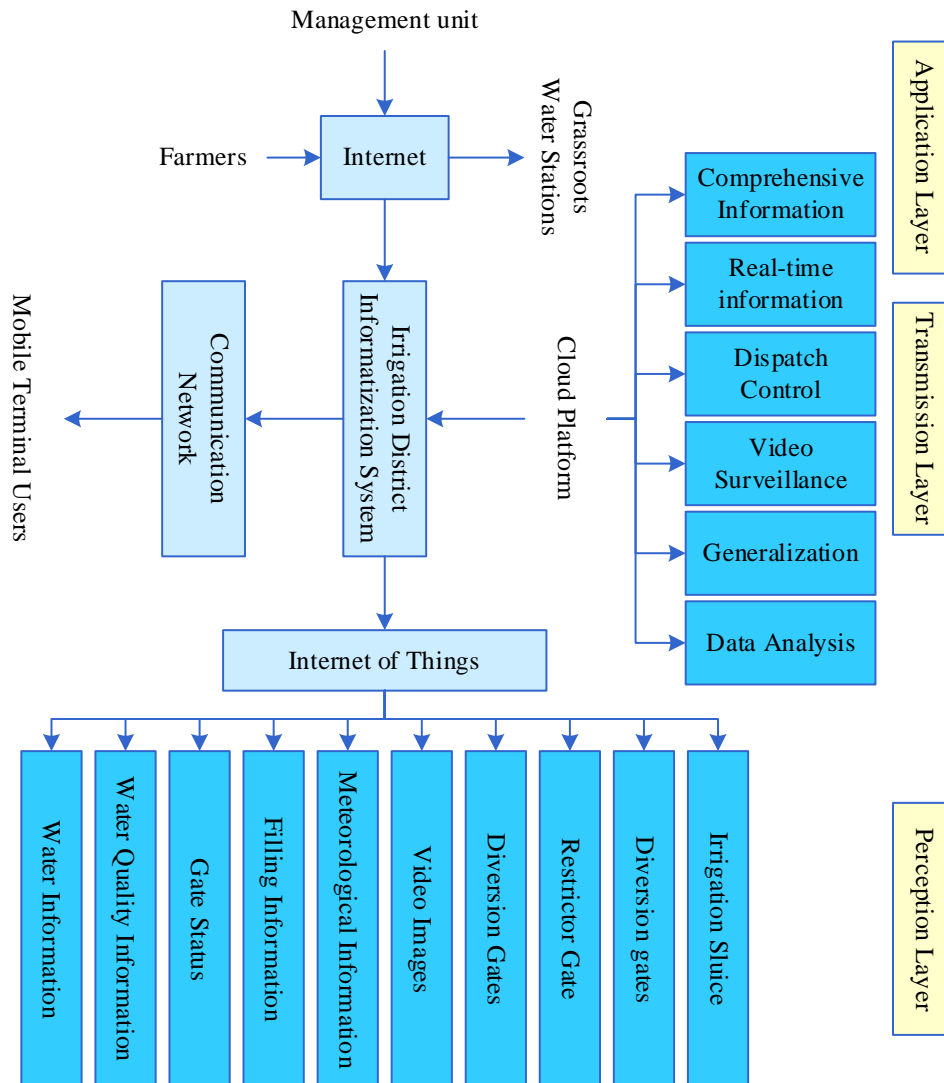


Figure 2 Irrigation building structure system

The IoT sensing layer consists of multi-source sensing devices distributed throughout the irrigation building, including water level meters, flow meters, water quality monitors, etc., which are responsible for collecting various types of data. The data warehouse layer aggregates, cleans and processes the collected data through the network to form different types of data resource pools. The service support layer provides basic services such as computing, storage, network, etc. to support the construction of the



informationization platform. The business application layer is the core of the system, realizing functions such as full overview of irrigation buildings and water management around various models. The end-user layer provides interactive interfaces for users through PC and mobile.

This layered architecture ensures system modularity, scalability and smooth data processing, and lays a solid technical foundation for intelligent management of irrigation buildings. The design of the system architecture fully considers the complexity and diversity of irrigation building management, and realizes comprehensive data collection, efficient processing and intelligent application through the organic combination of each layer, providing strong support for the refined management of irrigation buildings and scientific decision-making.

3. Evaluation of the comprehensive benefits of water conservation in urban irrigation buildings

Against the background of the current implementation of the idea of sustainable development, improving the efficiency and level of irrigation in urban production through water-saving techniques not only avoids the waste of water resources, but also promotes the sustainability of urban development. In practice, water-saving measures must be rationally selected according to the characteristics and requirements of the structural design of urban irrigation buildings, while taking into account the coordination of various economies and benefits, and constantly developing new structural systems of urban irrigation buildings in accordance with the actual situation so as to make them steadily and sustainably develop.

3.1 Evaluation system establishment and dimensionless quantification

3.1.1 Water saving evaluation system for irrigation buildings

In order to deeply analyze the water saving benefits of the urban irrigation building structure system designed in this paper in the process of urban development, this paper establishes a set of scientific and comprehensive evaluation index system for the comprehensive benefits of water saving of urban irrigation buildings from seven aspects: engineering, society, economy, resources, ecological environment, management and sustainability. The content of the evaluation system is shown in Table 1.

Table 1 Water saving evaluation system for irrigation buildings

Primary index	Secondary index	Code
Engineering	Improvement rate of engineering	T1
	Channel lining completion rate	T2

	The degree of utilization of water-saving irrigation projects	T3
	Irrigation water utilization coefficient	T4
Society	The degree of adjustment of regional agricultural structure	T5
	Promotion of social climate improvement	T6
	The extent to which the local economic development is promoted	T7
	The degree of water saving technology promotion	T8
Economy	Economic internal rate of return	T9
	Efficiency cost ratio	T10
	Investment recovery	T11
	Urban per capita net income	T12
	Industrial output improvement rate	T13
Ecological environment	Groundwater improvement	T14
	Improvement of soil structure	T15
	The degree of improvement of waterlogging, stains, and salt alkali	T16
Resources	Per mu Water-saving rate	T17
	Per mu yield	T18
	Irrigation assurance rate of project beneficial area	T19
	The reduction rate of irrigation cycle in the project's beneficial area	T20
	The proportion of irrigation area of water-saving irrigation	T21
Management	Water association coverage	T22
	Water efficiency	T23
	The irrigation plan is reasonable	T24
	The management system is perfect	T25
Sustainability	The current rate of water is the proportion of the cost of water	T26



	Local government support	T27
	Mass approval rating	T28
	Water erosion increase	T29

3.1.2 Programmelessness of evaluation indicators

Since the data of different indicators in the evaluation index system have different types, units and natures, there is no metricity, so in order to reach our research purpose, it is necessary to homogenize different types of indicators. And for the indicators of different measurement units it is necessary to carry out dimensionless processing, transforming the original data into homogeneous values that can be directly summed up.

For different types of indicators, we refer to the method of extreme value difference, and set the following function after revision to carry out homothetic processing and dimensionless processing for evaluation indicators at the same time.

Let the interval of variation of the j st indicator be $[f_{j\min}, f_{j\max}]$, i.e. $f_{j\min}$ is the minimum of all possible values of the j th indicator and $f_{j\max}$ is the maximum of all possible values of the j th indicator. f_0 is the moderate value. The value of the indicator after dimensionless quantization $U_j^n \in [0,1]$.

When the value of the indicator is extremely large (positive), i.e., “the larger the better” is required, then:

$$U_j^n = \frac{f_j^n - f_j \min}{f_{j\max} - f_{j\min}} \tag{1}$$

When the value of the indicator is a very small indicator (inverse indicator), i.e., when “smaller is better” is required:

$$U_j^n = \frac{f_{j\max} - f_j^n}{f_{j\max} - f_{j\min}} \tag{2}$$

When the value of the indicator is a medium-sized indicator, i.e., when the requirement is “moderate



is appropriate”:

$$U_j^n = 1 - \frac{|f_j^n - f_0|}{\max(|f_j(\max, \min) - f_0|)} \quad (3)$$

3.2 Comprehensive evaluation model for water saving in irrigation buildings

3.2.1 Determination of evaluation indicator weights

Due to some of the missing data, there are some parameter indicators missing data, so the improved K nearest neighbor filling method (KNN) is used, that is, based on the Euclidean distance or correlation analysis to determine the closest K cases to the case with missing data, and the weighted average of these K values to estimate the data to be filled in, the method has the point of high accuracy of filling, insensitive to outliers, and can be used to predict the missing attributes as a prediction target for the Prediction.

Let a term to be filled $x_i = (x_i^c, x_i^m)$, where x_i^c is the complete part of it, x_i^m is the missing part, D_{ij} denotes the distance between the term i and the term j , k is the record that takes k the nearest distance x_i and the value of x_i^m the fill is:

$$\hat{x}_{ik} = \frac{\sum_{j=1}^k D_{ij}^{-1} x_{jk}}{\sum_{v=1}^k D_{iv}^{-1}} \quad (4)$$

In order to reflect the water saving benefits of urban irrigation building structure design under different indicators more objectively, this paper improves the weights on the basis of the traditional entropy weighting method, so as to obtain more objective weights to reflect the water saving benefits of urban irrigation building structure design [19]. Specifically as follows:

Solve for the information entropy value of the indicator e and the information utility value d , that is:

The information entropy of the j rd indicator can be expressed as:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^m X_{ij} \ln X_{ij} \quad (5)$$

The information utility value can be expressed as:

$$d_j = 1 - e_j \quad (6)$$

Indicator weights can be expressed as follows:

$$\omega_j = \frac{d_j}{\sum_{j=1}^n d_j} \quad (7)$$

The weighting improvement can be expressed as:

$$\omega_{1j} = \frac{\sum_{j=1}^n e_j + 1 - 2e_j}{\sum_{k=1}^n \left(\sum_{j=1}^n e_j + 1 - 2e_k \right)} \quad (8)$$

$$\omega_{2j} = \frac{(1 + \bar{e}_j - e_j)}{\sum_{k=1, e_k \neq 1}^n (1 + \bar{e}_j - e_k)} \quad (9)$$

where \bar{e}_j is the average of all entropy values that are not 1, ω_{1j} is the first improvement weight,

and ω_{2j} is the second improvement weight. Then:

$$w_j = \begin{cases} (1 - \bar{e}_j)\omega_{1j} + \bar{e}_j\omega_{2j} & e_j < 1 \\ 0 & e_j = 1 \end{cases} \quad (10)$$

3.2.2 Integrated benefits evaluation model

The close value method divides the evaluation indicators into positive and negative indicators, standardizes all indicators in the same direction, finds out the “best point” and “worst point” of each indicator to be evaluated, and calculates the distance (i.e., closeness coefficient) between each evaluation unit and the “best point” and “worst point”, and then calculates the distance between each evaluation unit and the “best point” and “worst point”. The distance between each evaluation unit and the “best point” and “worst point” (i.e. the closeness coefficient) is calculated respectively. These distances are converted

into the close value of the comprehensive indexes that reflect the advantages and disadvantages of each sample, and the size of the close value is used to determine the order of the advantages and disadvantages of each unit to be evaluated.

According to the principle of the close value method, combined with the improved entropy weight method proposed in this paper, the evaluation process of the comprehensive benefits of water conservation of urban irrigation building structures is established as shown in Figure 3 [20]. Among them, oval symbols indicate associations, circular symbols indicate summarized connections, and rectangular symbols indicate a separate step in the process.

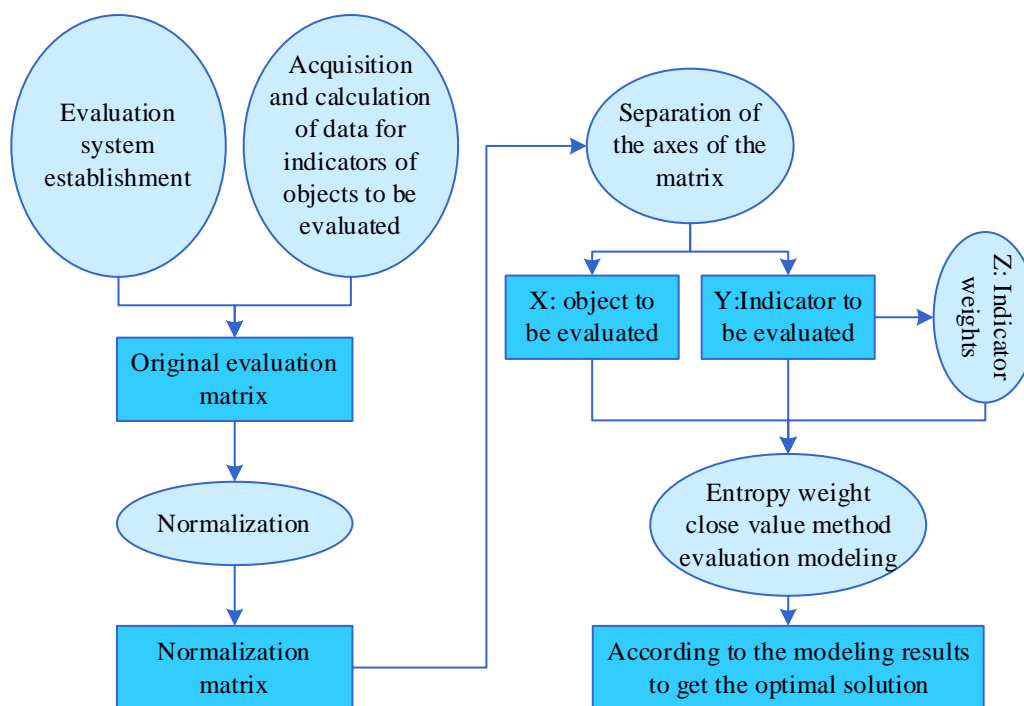


Figure 3 The procedure of osculating value method based on entropy weight

The specific model and steps are as follows:

(1) Numericalization of the original matrix to establish the original matrix representation as:

$$A_{ij} = \{a_{ij}\}_{n*m} \tag{11}$$

(2) Normalization of the numerical matrix model, viz:

$$r_{ij} = \frac{s_{ij}}{\sqrt{\sum_{i=1}^n s_{ij}^2}} \quad (12)$$

The normalization can be expressed as:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1j} & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2j} & r_{2m} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ r_{n-11} & r_{n-12} & \cdots & r_{n-1j} & r_{n-1m} \\ r_{n1} & r_{n2} & \cdots & r_{ij} & r_{nm} \end{bmatrix} \quad (13)$$

(3) Selection of optimal evaluation points and worst evaluation points

Determine the optimal evaluation point and the worst evaluation point optimal point selection principle for each indicator in the numerical matrix, namely:

$$g_j = \max_{1 \leq i \leq n} \{r_{ij}\} \quad j = (1, 2, 3 \cdots m) \quad (14)$$

The principle of worst point selection is:

$$b_j = \min_{1 \leq i \leq n} \{r_{ij}\} \quad j = (1, 2, 3 \cdots m) \quad (15)$$

Then the optimal point set is:

$$G = \{g_j\} \quad j = (1, 2, 3 \cdots m) \quad (16)$$

Then the set of worst points is:

$$B = \{b_j\} \quad j = (1, 2, 3 \cdots m) \quad (17)$$

(4) Calculate the closeness coefficient

The closeness coefficient of the optimal evaluation point is:

$$y_i = \sqrt{\sum_{j=1}^m w_j (r_{ij} - g_j)^2} \quad (18)$$

The closeness factor for the worst evaluation point is:



$$l_i = \sqrt{\sum_{j=1}^m w_j (r_{ij} - b_j)^2} \quad (19)$$

Where w_j is the weight value of indicator j .

(5) Calculate the close value and derive the optimal evaluation unit

The close value of each evaluation unit is:

$$c_i = \frac{y_i}{y'} - \frac{l_i}{l'} \quad (20)$$

Among them:

$$y' = \min_{1 \leq i \leq n} \{y_i\} \quad l' = \max_{1 \leq i \leq n} \{l_i\} \quad (21)$$

The closeness value method takes the minimum distance of each evaluation unit from the optimal point and the maximum distance from the worst point as a reference, and comprehensively compares its degree of closeness to the optimal point and the worst point. The smaller the value of c , the closer the evaluated unit is to the optimal point and the more distant it is to the worst point. When $c = 0$, the evaluated unit means that it is optimal among all the evaluated units.

3.2.3 Barrier factor analysis model

Using the barrier factor model is to comprehensively diagnose the barrier factors of the structural water-saving design of urban irrigation buildings in the sample by integrating the degree of barrier and deviation of the indicators and the degree of contribution of the factors. Ranking the influence degree of the obstacle factors helps to recognize the main and secondary obstacle factors in the water-saving design of urban irrigation buildings, and to explore the key factors affecting the water-saving efficiency of irrigation buildings, so as to put forward targeted countermeasures and suggestions.

Borrowing the obstacle factor model, the shortcomings and deficiencies in the structural water-saving design of the sample urban irrigation buildings can be very intuitively reflected as the obstacle factors restricting the structural water-saving benefits of urban irrigation buildings, which can help the decision-making department make timely adjustments to the general direction of the structural water-saving design of the urban irrigation buildings and the stage of the special management, so as to achieve the effect of scientific and effective management to achieve the goal of sustainable development of the



urban irrigation buildings. The goal of sustainable development of urban irrigation buildings can be achieved through scientific and effective management.

Introducing factor contribution degree (F_i), indicator deviation degree (I_i), obstacle degree (O_i) 3 basic variables, the factor large subcontribution degree F_i indicates the magnitude of the influence of a single indicator C_i on the total objective, which is expressed by weight w_i . Indicator deviation I_i is the gap between the actual value of each indicator and the optimal target value, and the magnitude of obstacle degree O_i can indicate the degree of influence of each indicator on the water-saving efficiency of urban irrigation building structure design. Then:

$$O_i = \frac{I_i \cdot w_i}{\sum_{i=1}^m I_i \cdot w_i} \quad (22)$$

where $I_i = 1 - a_{ij}$, a_{ij} are the values after normalization of the data for each indicator.

4. Examples of structural water saving benefits of urban irrigation buildings

In the context of ecological environmental protection and sustainable development, the use of water-saving measures in urban production to improve the irrigation effect and level of urban irrigation buildings can not only prevent the waste of water resources, but also help to realize the sustainable development of the city. In practice, it is necessary to choose the correct water conservation measures in accordance with the irrigation needs and requirements of urban irrigation buildings. In addition, it is also necessary to take into full consideration the economic and effect coordination factors, and from the actual situation, constantly promote the innovative design of urban irrigation building structure, promote the effective development of urban irrigation mode, so as to realize the stable and sustainable development of urban irrigation buildings.

This paper takes City H as the research object, which carried out the optimization design of irrigation building structure in 2018, introduced many different types of water conservation measures and technologies to realize the intelligent design of irrigation building structure, and its basic principle is similar to the irrigation buildings designed in this paper. Taking the water-saving data of irrigation



buildings in City H from 2015 to 2023 as an example, quantitative analysis of the data is carried out to explore the path of integrating the structural design of urban irrigation buildings with water-saving technologies under the support of sustainable concepts.

4.1 Structural water-saving benefits of irrigation buildings

4.1.1 Calculation of evaluation indicator weights

In this paper, when determining the index weights of urban irrigation building water saving comprehensive benefit rating system, the improved entropy weight method is selected for weight calculation, whose calculation principle is scientific and easy to understand and can avoid subjective errors. Based on the solving steps of the improved entropy weight method, the weight distribution of the evaluation indexes for the structural water saving benefits of irrigation buildings is obtained as shown in Figure 4.

From the results of the weight analysis, it can be seen that the weights of the seven level evaluation indicators of water saving benefits of urban irrigation building structures vary greatly, among which the weights of social benefits and economic benefits are the largest, and the weights of the two weights account for a total of 38.85%, while the weight of engineering benefits accounts for a minimum of only 8.26%. This indicates that social and economic benefits have a greater impact on the comprehensive water saving benefits of urban irrigation structures, while the construction works of urban irrigation structures have not been paid much attention to, and although they account for a lower proportion of the total weight, they also affect the comprehensive water saving benefits of urban irrigation structures to a certain extent. In addition, among the secondary indicators, the degree of promoting local economic development (T7), urban per capita net income (T12), and the degree of improving urban soil structure (T15) rank among the top three, with weights of 14.71%, 11.59%, and 10.38%, respectively. To a certain extent, this illustrates that the economic and social benefits of the city will have a greater impact on the water-saving design of urban irrigation buildings, and the higher the degree of economic development, the more resources will be invested in the optimization of the structure of the irrigation buildings, so as to better achieve the intensive use of urban water resources and provide a guarantee for the realization of the sustainable development of the city.

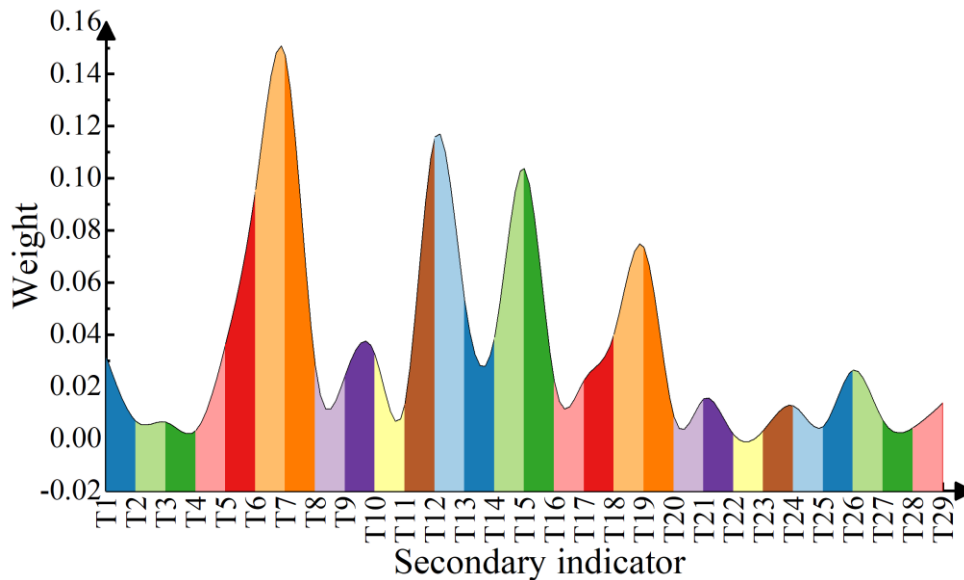


Figure 4 Evaluation index weight distribution

4.1.2 Comprehensive evaluation of water conservation benefits

(1) Grading standards for comprehensive benefits of water conservation of urban irrigation building structures

Scientific evaluation index grading standards can avoid subjective arbitrariness and improve the credibility and reliability of the evaluation results of the comprehensive benefits of water conservation of urban irrigation building structures. Through the reasonable index grading standard, the weak points of the project benefit exertion can be accurately analyzed, and the exact improvement direction and solution measures can be provided for the construction and management of irrigation building structures, so as to promote the sustainable development of irrigation buildings. It can fairly compare and evaluate the comprehensive benefit utilization among different irrigation buildings, and provide theoretical basis for the exchange of experience among irrigation buildings on their respective advantages and disadvantages. It can provide reliable data support and scientific basis for project decision makers, provide practical and reliable decision basis for the construction and management of irrigation buildings, and promote the sustainable development of high-efficiency water-saving irrigation technology.

Based on analyzing and sorting out the research results obtained by many researchers on the actual verification of the comprehensive benefits of water conservation of various urban irrigation building structures, referring to the relevant standards and technical specifications at home and abroad, some regional regulations, and after field investigation and monitoring of the sample cities, combining the

subjective and objective ideas, the division standard of each index is determined. In this paper, the assessment criteria are divided into five levels from I to V, representing five levels of very poor, poor, medium, good and excellent, as shown in Table 2. Relying on the urban irrigation building structure water saving comprehensive benefit evaluation standard, combined with the close value method can realize the comprehensive evaluation of the urban irrigation building structure water saving benefit.

Table 2 The comprehensive evaluation grade division of water-saving efficiency

Grade	Close value	Comprehensive benefit
I	[0,0.22)	The water-saving efficiency is very low, the irrigation building structure and the water-saving technology are in the absence of coordinated development.
II	[0.22,0.48)	The water saving efficiency is low, the irrigation building structure and the water-saving technology are coordinated and developed.
III	[0.48,0.56)	The water saving efficiency is medium, the irrigation building structure and the water-saving technology are in the medium coordinated development state.
IV	[0.56,0.75)	The water saving efficiency is good, the irrigation building structure and the water-saving technology are in good coordination and development.
V	[0.75,1.00)	The water saving efficiency is excellent, the irrigation building structure and the water-saving technology are in the excellent coordinated development state.

(2) Evaluation of comprehensive benefits of water saving of urban irrigation building structures

On the basis of the determination of the weights of the evaluation indexes, the close value method is selected to calculate and analyze the comprehensive benefits of water conservation of urban irrigation building structures in City H in combination with the Euclidean distance, so as to derive the graded advantages and disadvantages of the structural water conservation benefits of urban irrigation buildings in City H in the years from 2015 to 2023. According to the calculation steps of the close value method given in the previous section the close values of different years can be calculated. The size of the close value is the size of the degree of proximity and is ranked, and the larger the value of the close value is, the better the evaluation results are, and the better the comprehensive benefits of water saving of urban



irrigation building structures are. The close value of the comprehensive efficiency of water saving of urban irrigation building structures is based on the optimal solution of the Euclidean distance calculated by 29 indicators, which objectively reflects the order and development trend of the area to be evaluated. Figure 5 shows the trend of Euclidean distance and close value, and Table 3 shows the results of the ordering and evaluation of close value.

The relative closeness of the optimal solutions of the samples clearly reflects the results of the evaluation of the comprehensive benefits of water saving of urban irrigation building structures. As can be seen from the table, the Euclidean distance of the optimum point decreases from 0.236 in 2015 to 0.196 in 2023, indicating that the comprehensive benefits of water saving of urban irrigation building structures are getting closer to the positive ideal value. The Euclidean distance of the worst point increases from 0.171 in 2015 to 0.203 in 2023, indicating that the comprehensive benefits of water saving of urban irrigation building structures are getting farther away from the negative ideal value. The optimal year during the period of 2015-2023 is 2023 with a close value of 0.636, which is about 4.13 times. And the overall trend of urban irrigation building structure water conservation comprehensive benefit from 2015 to 2023 shows an upward trend. Among them, in 2015, the carrying capacity grade is III, and the comprehensive benefit of water conservation of urban irrigation building structures is shown to be medium. The grade of the comprehensive benefit of water conservation of urban irrigation building structures from 2016 to 2017 is degraded to I-II, which belongs to the range between very poor and poor grades. After the implementation of intelligent management of water-saving design of irrigation building structures started in 2018, the close value was improved to a great extent compared with 2016, and the comprehensive benefit grade of water-saving was grade II. After 2021, the comprehensive benefit grade of water-saving of urban irrigation building structures was kept at grade IV, and the comprehensive benefit of water-saving was a good grade, and the integration of the design of urban irrigation building structures and water-saving technology was in a state of good and coordinated development .

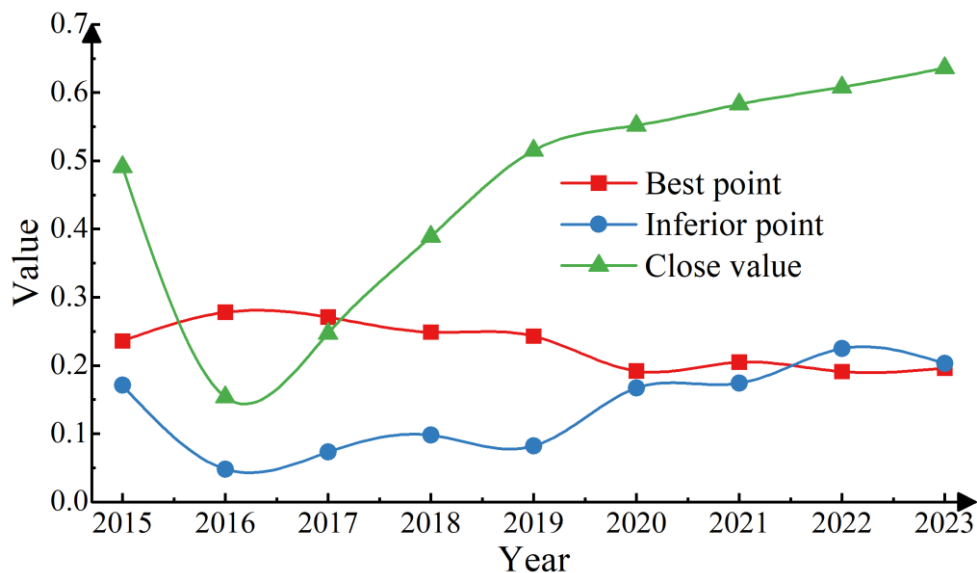


Figure 5 The change in the distance and close values of the European

Table 3 Evaluation results of close value

Year	European distance		c_i	Sort	Grade	Evaluation
	y_i	l_i				
2015	0.236	0.171	0.491	6	III	Medium
2016	0.278	0.048	0.154	9	I	Very low
2017	0.271	0.073	0.247	8	II	Low
2018	0.249	0.098	0.389	7	II	Low
2019	0.243	0.082	0.515	5	III	Medium
2020	0.192	0.167	0.552	4	III	Medium
2021	0.205	0.174	0.583	3	IV	Good
2022	0.191	0.225	0.608	2	IV	Good
2023	0.196	0.203	0.636	1	IV	Good



4.2 Analysis of barriers to water saving in irrigation buildings

4.2.1 Tier 1 Indicator Barrier Factors

Combined with the weights of the evaluation indexes of water saving comprehensive benefits of urban irrigation building structures calculated in the previous section, the obstacle degree model is applied to explore the mastery factors affecting the improvement of water saving benefits of the structural design of urban irrigation buildings in terms of seven first-level indexes, namely, engineering, society, economy, ecology, environment, resources, management and sustainability. Figure 6 shows the results of barrier degree comparison of the first-level indicators.

According to the trend of the data in the figure, it can be seen that the trend of the barrier degree of the seven level one indicators is not consistent in the year 2015-2023, and there is an obvious time difference. In general, the five level 1 indicators of engineering, management, ecological environment, resources and sustainability have a relatively small degree of obstacles in improving the water saving benefits of urban irrigation building structures, and the two level 1 indicators of society and economy have relatively large obstacles. The role of social benefits is the most significant among them. It can be seen that in 2015-2023, the degree of obstacles of the main obstacle factors of the first-level indicators is becoming more and more obvious, and the engineering, social, economic, ecological environment, resources, management, and sustainable development are becoming more and more unbalanced, and the hindering role of the main obstacle factors is shown very significantly. During the period from 2015 to 2023, the first-level indicator with the highest degree of obstacle is the social benefit indicator in 2021 (45.87%), and the lowest is the sustainable benefit in 2019, which is only 0.87%, and the gap between them reaches 45%. In terms of the degree of change in the level 1 indicators, the highest change is in the social benefit indicator, with a difference of 4.95% between 2022 and 2023. The influence of each level of indicators on the degree of obstacles to the water saving benefits of urban irrigation building structures fluctuated to some extent during the study interval.

Since the beginning, the social and economic benefit indicators were the main constraints on the water saving benefits of urban irrigation building structures. In contrast, the first level indicators of engineering, resource and sustainability aspects had the least impact on the barrier to water saving benefits of urban irrigation building structures. The ecological and management benefit indicators fluctuate in the degree of barriers, but the magnitude of comparability is generally constant.

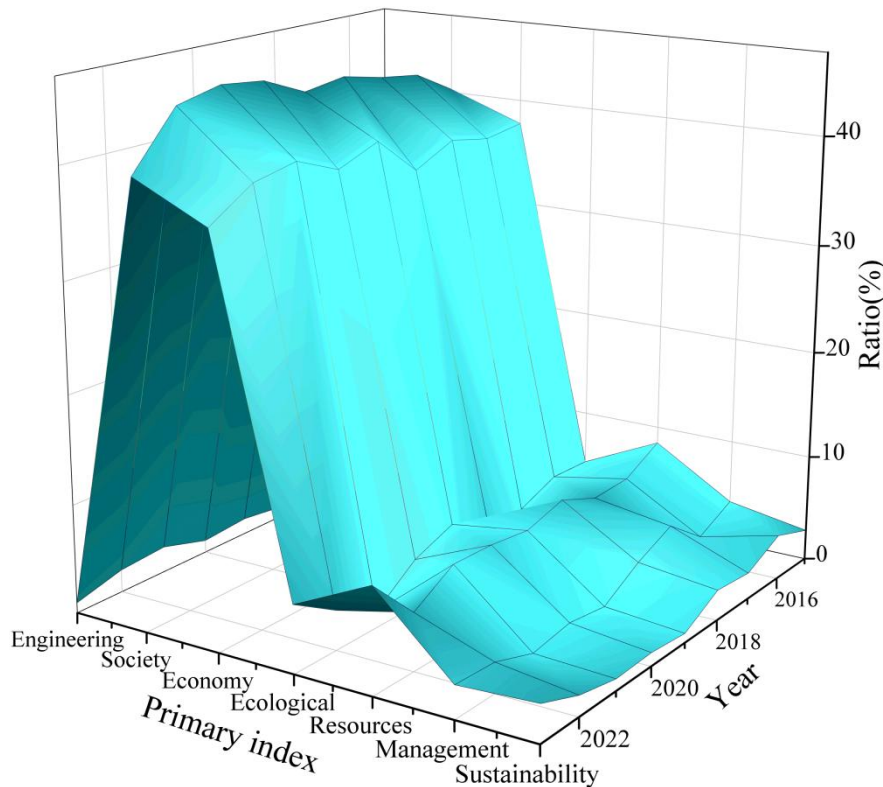


Figure 6 Primary index obstacle factor

4.2.2 Secondary indicator barrier factors

The obstacle degree model is used to calculate the obstacle degree of 29 evaluation indexes, and for different years, the evaluation indexes ranked according to the size of the obstacle degree are sorted, and the evaluation indexes ranked in the top five are extracted to analyze the main obstacle factors affecting the structural water-saving efficiency of urban irrigation buildings, and the detailed obstacle factors are shown in Table 4.

As can be seen from the table, during the period from 2015 to 2023, the degree of promoting local economic development (T7) and urban per capita net income (T12) ranked the first or the second in the degree of influence on the structural water-saving benefits of urban irrigation buildings, and their obstacle degrees mainly fluctuated within the range of 10.65% to 17.83%. The above two obstacle factors mainly originate from the first-level indicators of social and economic benefits, which again verifies that the comprehensive benefits of water saving of urban irrigation building structures are the result of the mutual and coordinated development of water resources and social and economic systems. This fully demonstrates that the optimization of urban irrigation building structures and the integration of water-



saving facilities depends on the level of local economic development in order to achieve sustainable development, and the higher the per capita net income of the city, the more diversified the design of the corresponding irrigation building structures, which can better ensure that the urban irrigation buildings to achieve the intensive use of water resources. The results of the obstacle analysis also reflect that urban irrigation buildings do not have a high degree of ecological green coverage, and there is still much room for improvement in terms of sustainability, and in terms of economic and social aspects, there is a waste of water, water saving efficiency is not high.

Table 4 Secondary index barrier factor

Year	1	2	3	4	5
2015	T7	T12	T15	T13	T6
2016	T12	T7	T19	T24	T13
2017	T12	T12	T24	T15	T19
2018	T7	T12	T6	T24	T15
2019	T12	T7	T29	T19	T6
2020	T7	T12	T15	T6	T29
2021	T12	T7	T14	T15	T6
2022	T12	T7	T15	T14	T19
2023	T12	T7	T15	T13	T6

4.3 Optimization Strategies for Water Saving in Urban Irrigation Buildings

Based on the evaluation results of the comprehensive benefits of water saving under the structural design of urban irrigation buildings in the previous paper, this paper realizes the in-depth integration of the structural design of urban irrigation buildings and water saving technology from adhering to high standards of construction, evaluating long-term sustainable impacts, and increasing inputs to better realize the sustainable development of urban water resources utilization.

4.3.1 Structural design of high-standard irrigation buildings

Practice shows that scientific planning and high standard construction and put into use after the urban irrigation buildings, is to realize the irrigation project can be stable and long play a fundamental



role in the benefits. At this stage, the level of urban economic development and farmland irrigation is different from the basis, in the introduction of new technology of farmland irrigation, must be scientifically planned, rational arrangements, combined with the specific reality of the city, planned, step by step optimization of the design of the structure of the irrigation building. Strengthen the introduction of information technology, relying on intelligent technology to assist the structure of urban irrigation buildings more in line with the actual irrigation, so as to realize the efficient use of water resources. Really play a good role in the construction of high-standard urban irrigation buildings, improve the comprehensive management of water resources application efficiency.

4.3.2 Long-term sustainability and impact

(1) An environmental impact assessment should be conducted during the structural design process of urban irrigation buildings, including the long-term impact of optimized irrigation patterns on soil salinization, groundwater levels and other environmental factors. For this purpose, an interdisciplinary team including experts, scholars and local government officials should be established to collect and analyze environmental data on a regular basis using modern monitoring techniques and data analysis tools. If it is found that a certain irrigation building structure design leads to soil salt accumulation after irrigation, the irrigation building structure design can be adjusted or soil improvement measures can be used to counteract this.

(2) In-depth analysis of the potential impact of water-saving technologies in terms of economic benefits. Water-saving technologies such as precision irrigation and intelligent water management systems not only reduce water consumption, but also help to improve crop yields and quality, thus directly affecting economic income. Regular cost-benefit analyses need to be conducted in collaboration with agricultural economists to assess the economic benefits of water-saving technologies on different crop cultivation. At the same time, the government should provide appropriate financial support and market orientation to innovate efficient structural design of irrigation buildings so as to increase the market competitiveness of the output.

(3) Sustainable development path planning should be developed. The government can set up a special fund to support the research, development and promotion of irrigation building structure design and water-saving technologies, while increasing support for sustainable irrigation building design practices in local policies.

4.3.3 Increase investment in the rehabilitation of irrigation structures

The design and renovation of urban irrigation building structures is important for improving water



use efficiency and promoting sustainable development. As a public service provider, the relevant departments should play a leading role in this area and increase their investment in the structural upgrading of urban irrigation buildings. This will not only help to enhance overall competitiveness, but is also a reflection of the relevant departments' fulfillment of their social management and public service functions. While increasing investment, it is also necessary to actively guide the participation of social capital in the structural transformation of urban irrigation buildings.

Through the combination of policy guidance and market mechanism, a diversified input mechanism is formed. This can not only ease the financial pressure, but also introduce more market forces and innovative resources to promote the rapid development of the structural transformation of urban irrigation buildings. In order to attract the participation of social capital, the relevant departments can adopt a series of policy measures. In addition, farmers and enterprises can be encouraged to actively participate in the upgrading of water-saving irrigation building structures through policy support and financial subsidies. This will not only improve the technical level of farmers and enterprises, but also promote the popularization and application of water-saving irrigation technology. At the same time, the relevant departments can also set up demonstration projects and promotion mechanisms for the structural upgrading of water-saving irrigation buildings, so as to guide more farmers and enterprises to participate in the structural upgrading of irrigation buildings by means of typical demonstrations and publicity and promotion.

5. Conclusion

The article establishes an irrigation building structure design system by combining intelligent water-saving technology and the concept of sustainable development, and analyzes the comprehensive water-saving benefits of urban irrigation under this system by means of water-saving comprehensive benefit evaluation model and obstacle degree model. The weights of each evaluation index of water saving benefits of urban irrigation building structures vary greatly, among which the weights of social benefits and economic benefits are relatively large, with their weights accounting for 20.49% and 18.36%, respectively, while the weight of engineering benefits accounts for only 8.26%. For City H, the water saving benefit in the optimal year is about 4.13 times that of the worst year of the comprehensive benefit of water saving of urban irrigation building structures, and the overall trend of the comprehensive benefit of water saving of urban irrigation building structures shows an upward trend from 2015 to 2023. In the integration of urban irrigation building structure design and water-saving technology, the social and economic two have the greatest influence on it, and the engineering, resource, management and other indexes have a smaller degree of influence. Therefore, under the guidance of the concept of sustainability,



the integration of urban irrigation building structural design and water-saving technology needs to be based on the optimization of high-standard irrigation building structures, combined with long-term sustainability and impact evaluation, and sufficiently enhance the investment in the structural transformation of irrigation buildings, in order to realize the sustainable development of urban irrigation buildings.

References

- [1] Fan, Z., Liu, J., Fan, Y., & Pan, J. (2024). Design and water-saving capacity of planting roof with compound irrigation and stab-resistant function. *Journal of Environmental Engineering and Landscape Management*, 32(3), 222-230.
- [2] Qiong, D., & Hao, P. (2021, March). Design and implementation of irrigation water saving control system based on WSN. In *2021 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)* (pp. 75-78). IEEE.
- [3] Yin, Q., Shi, X., Xiong, S., Qu, Y., Zhou, Y., Liu, J., ... & Ma, L. (2021). Selection of Water-Saving Plants and Annual Water Consumption Estimation for Garden Green Spaces in Beijing. *Forests*, 12(11), 1572.
- [4] Farrar, M., Gill, S., Shahid, S. A., & Babiker, K. (2018). Water saving innovation in urban landscaping and irrigated agriculture by using AustraBlend multimineral root zone conditioner. *Asian J Sci Technol*, 9(12), 9092-9100.
- [5] Bauer, S., Linke, H. J., & Wagner, M. (2020). Optimizing water-reuse and increasing water-saving potentials by linking treated industrial and municipal wastewater for a sustainable urban development. *Water Science and Technology*, 81(9), 1927-1940.
- [6] Belkayali, N., & Ayan, E. (2017). Effective use of water in the landscape architecture curriculum. *New Trends and Issues Proceedings on Humanities and Social Sciences*, 4(6), 98-104.
- [7] Allen, L. (2017). *Greywater, Green Landscape: How to Install Simple Water-saving Irrigation Systems in Your Yard*. Storey Publishing, LLC.
- [8] Hajani, E., & Rahman, A. (2014). Rainwater utilization from roof catchments in arid regions: A case study for Australia. *Journal of Arid Environments*, 111, 35-41.
- [9] Zhong, Q., Tong, D., Crosson, C., & Zhang, Y. (2022). A GIS-based approach to assessing the capacity of rainwater harvesting for addressing outdoor irrigation. *Landscape and Urban Planning*, 223, 104416.
- [10] Jacque, H., Knox, J. W., Gush, M., & Holman, I. P. (2023). Modelling the potential of rainwater harvesting to improve the sustainability of landscape and public garden irrigation. *Journal of Environmental Management*, 348, 119167.



- [11] Van Dijk, S., Lounsbury, A. W., Hoekstra, A. Y., & Wang, R. (2020). Strategic design and finance of rainwater harvesting to cost-effectively meet large-scale urban water infrastructure needs. *Water research*, 184, 116063.
- [12] Rybicki, S. M., Schneider-Skalska, G., & Stochel-Cyunel, J. (2022). Bio-Morpheme as innovative design concept for “Bio City” urban structure in the context of water-saving and human health. *Journal of Cleaner Production*, 369, 133266.
- [13] Masnavi, M. R., Rezaei Hariri, M. T., & Mirmoghtadaee, M. (2020). Integrated Urban Water Management (IUWM) Framework Codification in Architectural and Urban Design: The Case of Hashtgerd Young City Project. *Space Ontology International Journal*, 5(4), 29.
- [14] Myers, T., Mohring, K., & Andersen, T. (2017, November). Semantic IoT: Intelligent water management for efficient urban outdoor water conservation. In *Joint International Semantic Technology Conference* (pp. 304-317). Cham: Springer International Publishing.
- [15] Yue, C., Cui, M., Kong, X., Watkins, E., & Barnes, M. (2022). Landscape irrigation and water conservation in urban areas: an analysis of information-based strategies. *HortTechnology*, 32(2), 213-225.
- [16] Warner, L. A., Lamm, A. J., & Silvert, C. (2020). Diffusion of water-saving irrigation innovations in Florida’s urban residential landscapes. *Urban Forestry & Urban Greening*, 47, 126540.
- [17] Yao, L., Zhao, M., & Xu, T. (2017). China’s water-saving irrigation management system: Policy, implementation, and challenge. *Sustainability*, 9(12), 2339.
- [18] Pralhad Jaybhaye & Asis Mukherjee. (2024). Enhancing Broccoli (*Brassica oleracea* L. var. *italica* Plenck) Yield with Efficient Water Use: A Marginal Analysis of Irrigation and Water Saving Techniques. *International Journal of Environment and Climate Change*(10),207-224.
- [19] Guohui Li,Haonan Deng & Hong Yang. (2024). A multi-factor combined traffic flow prediction model with secondary decomposition and improved entropy weight method. *Expert Systems With Applications*(PA),124424-124424.
- [20] Liang Kai,Liu Yu,He Huan,Du Liang,Ning Liaoyi,Jiao Zhen & Sun Xinyu. (2021). Demand-side response Resource Value Evaluation Method based on Entropy-weighted Close Value Method. *Journal of Physics: Conference Series*(1),012046-.