The changeable degree assessment of designed flood protection condition for designed unit of inter-basin water transfer project based on the entropy weight method and fuzzy comprehensive evaluation model

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Abstract: Since the 19th National Congress of the Communist Party of China, the high-quality development of China's economy has put forward higher requirements for scientific and technological support of water safety guarantee. The flood control conditions of the design unit of water transfer project have changed to a certain extent compared with the initial design stage, especially the underlying surface of rivers and engineering conditions in the northern region have changed greatly, which has seriously affected the conveyance safety of water transfer project and the supply guarantee of water receiving area. Therefore, it is necessary to evaluate the change degree of flood control conditions in the design unit of water transfer project, and point out the weak links of flood control, so as to guide the flood control safety construction of the left bank area. In this paper, from the aspects of the change of underlying surface conditions, the actual flood discharge conditions of upstream and downstream, and the actual discharge capacity of buildings, the change of actual flood discharge conditions of water transfer project design unit compared with the original flood control design conditions is comprehensively considered. According to the principle of relatively independent, quantifiable and easy to obtain between indexes, the evaluation index system of flood control design condition change is established, On the basis of determining the classification standard for the quantitative and qualitative indexes, the entropy weight and fuzzy mathematics comprehensive evaluation model are used to evaluate the change degree of the current flood discharge conditions and the original flood control design conditions of each design unit of the water transfer project. For the units with large changes in flood control design conditions in the evaluation results, corresponding measures to eliminate risk factors and risk control will be taken. Finally, taking the flood control risk evaluation of a management office in a large-scale water transfer project as an example, this paper evaluates the change degree of the current flood discharge conditions and the original flood control design conditions of 16 three-level units in the management office. The results show that there are 6 three-level units with changes in the original flood control design conditions, including 4 great changes and 2 significant changes. The application example shows that the entropy weight and fuzzy mathematics comprehensive evaluation model can accurately reflect the change degree of each three-level design unit in the management office, and play a certain technical support role in the study of the performance change law in the life cycle of water transfer project and the theory of water transfer project and service environment evaluation.

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1. Introduction
After the construction of the inter-basin water diversion project, some original overland flow has been changed to centralized outflows, some small rivers have been merged and diverted, the natural flood discharge channels on the left bank of the water diversion project have been cut off or changed, and the conditions of flood generation and concentration have been changed, which may lead to river closure and water level rising [1]. In the preliminary design of water diversion projects, the local flood impact assessment has been carried out, and corresponding measures have been taken for the flood impact of local and water diversion building itself. However, after the construction of water diversion projects, the social and economic development along the project is relatively fast, and some changes have taken place both the designed conditions of crossing rivers and local socio-economic conditions, especially the underlying surface in the project region has changed greatly. Therefore, under the primary designed standard of rainstorm, the change of underlying surface conditions in the flow concentration region, the drainage channel in the right bank is dissatisfied the designed demand, the flood discharge condition in the upper and lower reaches changes, and the actual flow capacity of the discharge structure is reduced compared with the designed conditions, all can cause risk event of the rising of designed flood level in the left bank and will cause local flood risk, and also cause corresponding economic losses and social impacts. Therefore, it is necessary to assess the changeable degree of designed flood protection condition for designed unit of inter-basin water diversion project.

Flood control capacity, flood risk and flood influence are mainly evaluated in flood control evaluation of water projects, For example, Xu Pingbo et al [2]. used MIKE11 to build one-dimensional hydrodynamic model of river channel, determined reasonable boundary conditions, and obtained water surface profile results of existing river channel through model calculation, so as to find out whether the safety super elevation of existing river embankment meets the specification requirements. Guan Xinjian et al [3]. constructed a comprehensive risk evaluation index system and a comprehensive evaluation model to comprehensively evaluate the risk of reservoir flood control operation under the influence of various risk factors; Based on the two-dimensional flow mathematical model of unstructured grid, Wang Lijie [4] analyzed the influence of river water level, velocity and local flow field changes on the river under different number of bridge schemes. At present, there are few evaluation studies on the current flood discharge capacity of water projects and the degree of change of the original design conditions. Water transfer project is a major measure to optimize the spatial and temporal allocation of water resources in China. It not only provides high-quality water resources for water shortage areas, but also alleviates the constraints of water resources on the urbanization development of water shortage areas, promotes the urbanization process, and has great social, economic and ecological benefits Therefore, it is necessary to focus on the evaluation of the degree of change of the water transfer project. Based on the entropy weight method and fuzzy comprehensive evaluation model, this paper assesses the changeable degree of designed flood protection condition for designed unit of inter-basin water diversion project, so as to take corresponding engineering and non-engineering measures to reduce or eliminate the risk factors. It can also play a certain technical support role in studying the law of performance changes in the life cycle of water transfer projects, and the theory of water transfer projects and service environment assessment.

2. The changeable degree assessment method of designed flood protection condition for designed unit of inter-basin water diversion project based on the entropy weight method and fuzzy comprehensive evaluation model
2.1. Index system
In this study, the changes in the actual flood discharge conditions compared with the original designed flood protection conditions were comprehensively considered from three aspects: changes in the underlying surface conditions, the lower actual flow capacity compared with original designed conditions of buildings and upstream and downstream, Economic and social development changes.
According to the principle that indexes are relatively independent, quantifiable and easy to obtain, the indexes selected for each aspect under consideration are shown in Figure 1 to Figure 4 respectively.

**Figure 1.** Change analysis index of actual flood discharge condition compared with original designed flood protection condition

**Figure 2.** Assessment index of changes in the underlying surface conditions

**Figure 3.** Assessment index of changes in actual flow capacity compared with original designed conditions of buildings
For the corresponding third-level units of various types of buildings, the risk assessment indexes that need to be considered are slightly different: for example, channel inverted siphon, beam and culvert aqueducts do not involve the blockage of building itself.

Aimed at the selected index system, the indexes that can be quantified are: change of catchment area, change of catchment path, change of proportion of construction land in catchment. The quantitative method is based on 1:50000 DEM to extract basin characteristic parameters such as catchment area, river length and average gradient. The new results use topographic data with the same accuracy as the original results, as the original results are obtained by drawing watershed line, river path on paper topographic maps, and then approximately calculating the catchment area, river length, slope and other information, however, based on the ArcGIS10.1 platform, the new results are obtained by using the Hydrology module in Spatial Analyst Tools to gain the catchment parameter information through the combination of automatic extraction and manual correction. Therefore, the quality and precision of the new results are better than the original designed results.

Other indexes need qualitative and hierarchical analysis. The main sources of data are the survey forms filled in by the management offices and data collected from the field survey.

2.2. Classification criteria for assessment index changes
It is a fuzzy concept to which level the change of assessment index belongs, and there is no completely defined division boundary. Assuming that 10% is the dividing line between no change and minor change, and when the calculated changes are 9.9% and 10.1%, it is obviously unreasonable that the former is considered as no change while the latter is considered as minor change, and the line between the two and 10% can’t be divided in this way. In the study of this paper, membership function is mainly used to measure the degree of change of each assessment index. Supposing that X1, X2 and X3 are taken as three classification points, the fuzzy membership degree of the change value to the change level is calculated through equations (1) to (4), and the corresponding membership function [5] graph is given.

\[
U_{no} = \begin{cases} 
1, & X \leq 0 \\
1 - \frac{X}{X_1}, & 0 < X < X_1 
\end{cases}
\]

(1)

\[
U_{minor} = \begin{cases} 
\frac{X}{X_1}, & 0 < X < X_1 \\
\frac{X_2 - X}{X_2 - X_1}, & X_1 \leq X < X_2 
\end{cases}
\]

(2)

\[
U_{middle} = \begin{cases} 
\frac{X - X_1}{X_2 - X_1}, & X_1 \leq X < X_2 \\
\frac{X_3 - X}{X_3 - X_2}, & X_2 \leq X < X_3
\end{cases}
\]

(3)
Quantitative and qualitative methods are mainly adopted for the change degree of each assessment index. The quantitative method is to extract confidential 1:50000 DEM data, 1:50000 DLG data, land use and vegetation type data based on 2.5m resolution remote sensing image in the catchment above the cross section and within 10km of the right bank by the GIS technology, as well as the open 30m land use data and 2.5m resolution remote sensing image data in 2012. Thus, the change of catchment area, the change between the length of coverage path and corresponding designed results, the change in the area of urban, industrial, mining, and residential before and after the completion of the main canal project are compared and obtained. Specific content is in Table 1.

The qualitative classification method is mainly aimed at the assessment indexes that can’t be analyzed quantitatively, and adopts the method of combining questionnaire survey and technical means analysis. By investigating the corresponding third-level units of different types of water conveyance
buildings in each assessment unit of the research object, qualitative classification is carried out in terms of the flood discharge section of the upstream channel, the change of flood discharge capacity of the downstream river (the right bank drainage is unobstructed), the blockage of the building itself, and its vulnerability to blockage. Classification criteria are shown in Table 2 below.

Table 2. Risk level assessment criteria of each qualitative factor

| Risk factor | Description of risk factors | Content of investigation | Change degree |
|-------------|----------------------------|--------------------------|---------------|
| **Upstream channel** | Flooding discharge section of upstream river: beam narrow degree | ① None, (no rural or urban buildings occupy the river; no engineering waste slag, soil occupy the river) | Basically unchanged |
| | | ② General, (rural or urban buildings occupy a small part of the river; engineering waste slag, soil occupy a small part of the river (visual less than 1/3 of the width of river)) | General change |
| | | ③ Serious, (rural or urban buildings occupy most of the river; engineering waste slag, soil occupy most of the river (visual greater than 1/3 and less than 2/3 of the width of river)) | Great change |
| | | ④ Very serious, (rural or urban buildings occupy almost the entire river channel; engineering waste slag, soil occupy almost the entire river channel (visual greater than 2/3 of the width of river)) | Significant change |
| **Downstream channel** | change of flood discharge capacity of the downstream | ① None, (no water-blocking buildings, engineering debris, new roads, etc. occupy the river) | Basically unchanged |
| | | ② Water-blocking buildings, engineering debris, new roads, etc. occupy less than 1/3 of the width of the river visually | General change |
| | | ③ Water-blocking buildings, engineering debris, new roads, etc. occupy greater than 1/3 and less than 2/3 of the width of the river visually | Great change |
| | | ④ Water-blocking buildings, engineering debris, new roads, etc. occupy greater than 2/3 of the width of the river visually | Significant change |
| **Blockage degree of building itself** | Sediment deposition, garbage blocking, visual proportion of the building’s height | ① None (the building itself is free of any blockage) | Basically unchanged |
| | | ② General (visually blocked below 10%) | General change |
| | | ③ Serious (visually blocked between 10% and 50%) | Great change |
| | | ④ Very serious (visually blocked over 50%) | Significant change |
| **Risk degree of building itself being easily blocked** | The situation of household garbage, wood and firewood and other floating objects near the entrance | ① There are no household garbage, firewood and other floating objects near the entrance | Basically unchanged |
| | | ② There are a small amount of household garbage, firewood and other floating objects near the entrance | General change |
| | | ③ There are a certain amount of household garbage, firewood and other floating objects near the entrance | Great change |
| Risk factor | Description of risk factors | Content of investigation | Change degree |
|-------------|-----------------------------|--------------------------|---------------|
| ④          | There are many household garbage, firewood and other floating objects near the entrance | Yes                      | Significant change |
| Building close to the mountain, poor watershed vegetation, geological fragmentation , prone to geological disasters | No                      | Basically unchanged |

2.3. Comprehensive Evaluation Method of Fuzzy Mathematics

The fuzzy mathematics comprehensive evaluation method[7] is used to determine the change degree of the actual flood conditions in the left bank compared with the original flood control design conditions. The main idea of comprehensive evaluation method of fuzzy mathematics is to use the concept of "membership function" to describe the intermediate transition of differences, which is a quantitative description of fuzziness, so that the mathematical method is no longer limited to the application field of classical mathematics. With the development of science and technology, the research and application of fuzzy mathematics have developed rapidly, especially when it is impossible to accurately describe the quantity of research objects, it is very convenient to deal with fuzzy mathematics theories and methods. The fuzzy theory was introduced in China around 1980, and has been widely used in weather forecasting, medical diagnosis, agricultural zoning, environmental resource evaluation, risk classification, etc., and has become one of the most widely used methods in multi-index comprehensive evaluation practice.

The comprehensive evaluation method of fuzzy mathematics is based on fuzzy set theory, which mainly aims at some fuzzy concepts. The boundaries of "yes and no" and "belonging to and not belonging to" are not so clear. LAZadeh defines fuzzy set as: the fuzzy set A on the domain U is a set characterized by real-valued function $\mu_A(x)$, which be called the membership function of A, $\mu_A(x)$ indicates the degree of membership $x$ to A, where $\mu_A(x)=1$ means that $x$ belongs to A completely, and $\mu_A(x)=0$ means that $x$ does not belong to A at all. Therefore, membership function in the fuzzy set is a generalization of characteristic function in classical mathematical set. Membership degree and membership function are the most basic concepts of fuzzy mathematics. Membership degree is used to represent the fuzziness of elements and is a mathematical index of the degree of membership of an element to a fuzzy set. Therefore, the key to solve fuzzy problems is to determine the membership degree. When dealing with practical problems involving fuzzy concepts, membership function should be determined first. Common methods for determining the membership function include fuzzy statistics method, typical function methods, incremental methods, multiple fuzzy statistics methods, optimal comparison methods, and absolute comparison method, etc. The weight coefficient is a mathematical expression of the importance degree of each factor in the domain. From the perspective of fuzzy sets, the weight coefficient can be regarded as the membership degree of evaluating each factor in the universe relative to "importance". There are many methods for determining weights in multi-factor evaluation problems, including expert experience estimation method, survey statistics method, analytic hierarchy process, and sequence synthesis method and so on.

The actual flood conditions in the left bank are divided into 4 levels compared with the original designed flood protection conditions, namely level 1 (basically unchanged), level 2 (general change), level 3 (great change), level 4 (significant change)). The calculation steps[8] for carrying out fuzzy comprehensive evaluation are as follows:
Establish the factor domain of the evaluation object $U = \{u_1, u_2, \cdots, u_n\}$, where $u_1, u_2, \cdots, u_n$ are the $n$ factors of the evaluated objects.

2. Construct the comment domain of evaluation factors $V = \{v_1, v_2, \cdots, v_m\}$, where $v_1, v_2, \cdots, v_m$ are the $m$ comment levels for each evaluation factor.

3. A single factor $u_i$ evaluation was conducted between factor theory domain $U$ and comment theory domain $V$, and the fuzzy set $(r_{1i}, r_{2i}, \cdots, r_{mi})$ on $V$ is obtained, so as to determine the fuzzy relation matrix $R$ [9]:

$$R = \begin{bmatrix}
  r_{11} & r_{12} & \cdots & r_{1m} \\
  r_{21} & r_{22} & \cdots & r_{2m} \\
  \vdots & \vdots & \ddots & \vdots \\
  r_{ni} & r_{n2} & \cdots & r_{nm}
\end{bmatrix} = (r_{ij})_{n \times m}$$

Where: $r_{ij}$ represents the relative membership of the $i$th factor $u_i$ in the factor domain $U$ corresponding to the $j$th rank $v_j$ in the comment domain.

4. Determine the weighted fuzzy vector of evaluation factors $A = (a_1, a_2, \cdots, a_n)$, where $\sum_{i=1}^{n} a_i = 1$.

5. Through the fuzzy synthesis operation, the weight vector $A$ and the fuzzy relation matrix $R$ are integrated, and the fuzzy comprehensive evaluation result $B$ is obtained:

$$B = (b_j)_{m \times 1} = A \circ R$$

Where: "\(\circ\)" is a fuzzy synthetic operator. There are four common operators: $M(\land, \lor)$ operator, $M(\lor, \land)$ operator, $M(\lor, \lor)$ operator, and $M(\land, \land)$ operator. Different types of operators are different in weight function, comprehensive degree, and membership degree information. Since only part of the information is selected in the algorithm of taking large and small size, it is easy to cause the loss of some important information. In comprehensive consideration, weighted average calculation $M(\land, \lor)$ is used for synthesis, then:

$$b_j = \sum_{i=1}^{n} a_i r_{ij} (j = 1, 2, \cdots, m)$$

Carry out a comprehensive evaluation. Generally, according to the principle of maximum membership degree, the comment corresponding to the maximum value $\max b_j$ of each component of $B$ is taken as the final comprehensive evaluation result.

2.4. Entropy weight method to determine index weight

Entropy was first introduced into information theory by Shen Nong, and has been widely used in engineering technology, social economy and other fields [10].

The basic idea of entropy weight method is to determine the objective weight according to the
variation of index. Generally speaking, if the information entropy $E_j$ of an index is smaller, the greater the variation degree of the index value is, the more information it provides, the greater the role it can play in the comprehensive evaluation, and the greater its weight. On the contrary, the larger the information entropy $E_j$ of an index is, the smaller variation degree of the index value is worth, the less information provided, the smaller role it plays in the comprehensive evaluation, and the smaller its weight.

The weight calculation steps of entropy weight method [11-12] are as follows:

① Data standardization
Standardize the data of each index.
Suppose K indexes are given $X_1, X_2, ..., X_K$, among $X_i = \{x_{i1}, x_{i2}, ..., x_{in}\}$. Assume that the standardized value of each index data is $Y_i = Y_{ij} = \frac{x_{ij} - \min(x_i)}{\max(x_i) - \min(x_i)}$, the information entropy of each index

② Find the information entropy of each index
According to the definition of information entropy in information theory, the information entropy $E_i$ of a group of data is $E_i = -\ln(n)^{-1} \sum_{i=1}^{n} p_{ij} \ln p_{ij}$. Among $p_{ij} = Y_{ij}/\sum_{i=1}^{n} Y_{ij}$, If $p_{ij} = 0$, then defines $\lim_{p_{ij} \to 0} p_{ij} \ln p_{ij} = 0$.

③ Determine the weight of each index
According to the formula of information entropy, the information entropy of each index is calculated as $E_1, E_2, ..., E_K$. Calculate the weight of each index through information entropy:

$$W_i = \frac{1 - E_i}{k - \sum_{i=1}^{k} E_i} (i = 1, 2, ..., k)$$

3. Case application-changeable degree assessment of designed flood protection condition for each designed unit in a management office of inter-basin water diversion project.
This paper investigates and sorts out the basic information of each third-level assessment unit of a management office, analyzes and summarizes the classification of each assessment index, as shown in Table 3 and Table 4.

| Number | Name of assessment units | Change degree of area | Change degree of river length | Change degree of construction land area proportion in the river basin |
|--------|--------------------------|-----------------------|-------------------------------|---------------------------------------------------------------|
| 1      | Jialu River              | -1.87%                | -7.31%                        | -2.35%                                                        |
| 2      | Jiayu River              | 0.50%                 | 0.00%                         | 2.34%                                                         |
| 3      | Xushui River             | -1.97%                | 20.64%                        | 3.63%                                                         |
| 4      | Chao River               | 12.43%                | 0.00%                         | -2.93%                                                        |
| 5      | Wei River                | -3.42%                | 0.00%                         | 9.20%                                                         |
| 6      | Shibali River            | -0.20%                | 0.00%                         | 2.90%                                                         |
| 7      | Jinshui River            | 3.66%                 | 0.00%                         | -0.85%                                                        |
| 8      | Zhanma Village           | 3.38%                 | -1.94%                        | 31.10%                                                        |
| 9      | Jiazhai Ditch            | 6.29%                 | 19.34%                        | 29.42%                                                        |
| 10     | Liucun Ditch             | 4.72%                 | 7.00%                         | 1.79%                                                         |
| 11     | Jinhu Ditch              | -1.93%                | 22.34%                        | 82.41%                                                        |
| 12     | Xingyuan Northwest Ditch | -3.26%                | -22.39%                       | 55.52%                                                        |
| Number | Name of assessment units  | Change degree of area   | Change degree of river length | Change degree of construction land area proportion in the river basin |
|--------|---------------------------|-------------------------|-------------------------------|---------------------------------------------------------------------|
| 13     | Shuiquan Ditch            | -1.05%                  | 8.63%                         | 8.16%                                                               |
| 14     | Dalizhuang Ditch          | 7.75%                   | -1.52%                        | 22.87%                                                              |
| 15     | Hexitai Ditch             | -0.12%                  | -5.82%                        | 31.67%                                                              |
| 16     | Fuzhuang Ditch            | -25.09%                 | 2.96%                         | 38.27%                                                              |

Table 4. Qualitative classification of assessment indexes of third-level units in a management office

| Number | Name of assessment unit  | Upstream channel | Downstream channel | Self-blocking | Easy to block                                                                 |
|--------|--------------------------|------------------|--------------------|--------------|--------------------------------------------------------------------------------|
| 1      | Jialu River              | No narrow beam   | Water-blocking     | Blocked below 10% | A certain amount of household garbage and other floating objects               |
|        |                          | at flood         | buildings occupy   |              |                                                                               |
|        |                          | discharge section| less than 1/3 of   |              |                                                                               |
|        |                          |                   | the channel       |              |                                                                               |
| 2      | Jiayu River              | No narrow beam   | No blocking building|              |                                                                               |
|        |                          | at flood         | occupy the river   |              |                                                                               |
|        |                          | discharge section| channel            |              |                                                                               |
| 3      | Xushui River             | Occupy a few     | No blocking building|              |                                                                               |
|        |                          | river channels,  | occupy the river   |              |                                                                               |
|        |                          | less than 1/3    | channel            |              |                                                                               |
| 4      | Chao River               | No narrow beam   | No blocking building|              |                                                                               |
|        |                          | at flood         | occupy the river   |              |                                                                               |
|        |                          | discharge section| channel            |              |                                                                               |
| 5      | Wei River                | Occupy a few     | No blocking building|              |                                                                               |
|        |                          | river channels,  | occupy the river   |              |                                                                               |
|        |                          | less than 1/3    | channel            |              |                                                                               |
| 6      | Shibali River            | No narrow beam   | No blocking building|              |                                                                               |
|        |                          | at flood         | occupy the river   |              |                                                                               |
|        |                          | discharge section| channel            |              |                                                                               |
| 7      | Jinshui River            | No narrow beam   | No blocking building|              |                                                                               |
|        |                          | at flood         | occupy the river   |              |                                                                               |
|        |                          | discharge section| channel            |              |                                                                               |
| 8      | Zhanma Village           | Occupy part of   | Water-blocking     | Blocked below 10% | many household garbage, firewood and other floating objects                 |
|        |                          | the river,       | buildings occupy   |              |                                                                               |
|        |                          | greater than 1/3 | more than 1/3 and   |              |                                                                               |
|        |                          | and less than 2/3| less than 2/3 of    |              |                                                                               |
|        |                          |                   | the channel        |              |                                                                               |
| 9      | Jiazhai Ditch            | Occupy part of   | Water-blocking     | the building itself is free of any blockage | many household garbage, firewood and other floating objects |
|        |                          | the river,       | buildings occupy   |              |                                                                               |
|        |                          | greater than 1/3 | more than 1/3 and   |              |                                                                               |
|        |                          | and less than 2/3| less than 2/3 of    |              |                                                                               |
|        |                          |                   | the channel        |              |                                                                               |
| 10     | Liucun Ditch             | Occupy a few     | Water-blocking     | A certain amount of household garbage and other floating objects     |
|        |                          | river channels,  | buildings occupy   |              |                                                                               |
|        |                          | less than 1/3    | more than 1/3 and   |              |                                                                               |
|        |                          |                   | less than 2/3 of    |              |                                                                               |
|        |                          |                   | the channel        |              |                                                                               |
### 3.1. Single-factor fuzzy evaluation of third-level unit

The change degree of designed flood protection conditions and actual flood discharge conditions in the left bank of the main canal was evaluated according to level 4, that is, basically unchanged, general change, great change and significant change. For each flood risk assessment unit of the management office, the single-factor evaluation matrix of each third-level unit is listed according to the type of building.

According to various practical analysis materials and research data of the research objects risk evaluation, fuzzy mathematics and precise mathematical methods were used to quantitatively estimate each evaluation index, and then the evaluation expert team evaluated each index in turn according to the determined evaluation level criteria. On this basis, the evaluation decision matrix $a_i(i = 1, 2, \ldots, n)$ of single factor in each subset is obtained, as shown in Table 3-3. Firstly, according to the type of buildings in a management office of water diversion project, it was divided into four categories, the evaluation matrix of each category was defined as $A_1$-$A_4$, which are respectively river inverted siphon and drainage culvert $A_1$; Channel inverted siphon, culvert aqueduct, beam aqueduct, culvert $A_2$; Left bank inverted siphon, left bank culvert $A_3$; Left bank aqueduct $A_4$. Secondly, according to the three-level evaluation unit included in each category, the evaluation matrix is defined respectively for a total of 16 cross sections, which are: Jialu River $A_{11}$, Jiayu River $A_{12}$, Xushui River $A_{21}$, Chao River $A_{22}$, Wei River $A_{23}$, Shibali River $A_{24}$, Jinshuihe $A_{25}$, Zhanma Village $A_{31}$, Jiazhai Ditch $A_{32}$, Liucun Ditch $A_{41}$, Jinghu Ditch $A_{42}$, Xingyuan Northwest Ditch $A_{43}$, Shuiquan Ditch $A_{44}$, Dalizhuang Ditch $A_{45}$, Hexitai Ditch $A_{46}$, Fuzhuang Ditch $A_{47}$.

For the corresponding third-level units of various types of buildings, the evaluation indexes that need to be considered are slightly different: for example, the channel inverted siphon, beam and culvert-type aqueducts do not involve the evaluation index of the building's blocking, and the flood discharge...
aqueduct does not involve the evaluation index of building’s easy to block. In the light of the various types of buildings in the management office, the corresponding evaluation factors were listed. 6 evaluation indexes \( U = (u_1, u_2, u_3, u_4, u_5, u_6, \ldots) \) are used for channel inverted siphon, culvert aqueduct, beam aqueduct, and culvert in large river crossing buildings, where \( u_1 \) is the change degree between the catchment area and the designed condition of the corresponding flood risk assessment unit of the extracted left bank buildings, \( u_2 \) is the change degree between the length of the confluence path and the corresponding designed results; \( u_3 \) is the change degree of the ratio between the urban, industrial, mining and residential land area of the basin before and after the completion of the main canal project; \( u_4 \) is the change of the upstream section narrow; \( u_5 \) is the change of the flood discharge capacity of the downstream channel or the degree of drainage unobstructed at the right bank outlet; \( u_6 \) is the economic and social change of the evaluation unit. 8 evaluation indexes were used for the left inverted siphon and left culvert in the left bank building, in addition to the above 6 indexes, the risk of blockage degree of building itself and the building being easily block need to be considered; 7 evaluation factors were adopted for the left bank drainage building, which need to consider the risk of the building itself being prone to blockage, see Table 5 and Table 6 for the specific classification.

| Evaluation index | Change degree | Lever 1 | Lever 2 | Lever 3 | Lever 4 |
|------------------|---------------|---------|---------|---------|---------|
| Area change      | \( a_{11} \)   | \( a_{12} \) | \( a_{13} \) | \( a_{14} \) |
| River length change | \( a_{21} \)   | \( a_{22} \) | \( a_{23} \) | \( a_{24} \) |
| Construction land change | \( a_{31} \) | \( a_{32} \) | \( a_{33} \) | \( a_{34} \) |
| Beam narrow change in upstream river section | \( a_{41} \) | \( a_{42} \) | \( a_{43} \) | \( a_{44} \) |
| Flood discharge capacity change of downstream | \( a_{51} \) | \( a_{52} \) | \( a_{53} \) | \( a_{54} \) |
| Blockage degree of building itself | \( a_{61} \) | \( a_{62} \) | \( a_{63} \) | \( a_{64} \) |
| Risk degree of building itself being easily blocked | \( a_{71} \) | \( a_{72} \) | \( a_{73} \) | \( a_{74} \) |
| Economic and social change | \( a_{81} \) | \( a_{82} \) | \( a_{83} \) | \( a_{84} \) |

Table 6. Corresponding third-level unit evaluation indexes of each type of building

| Building type | Channel inverted siphon, drainage culvert | Channel inverted siphon, culvert aqueduct, beam aqueduct, culvert | Left bank inverted siphon, left bank culvert | Left bank aqueduct |
|---------------|------------------------------------------|-----------------------------------------------------------|-----------------------------------------------|-------------------|
| Number of evaluation indexes | Eight | Six | Eight | Seven |
| Evaluation indexes | Area change | Area change | Area change | Area change |
In accordance with the analysis of evaluation factors, the judgment matrix of single factor of each evaluation unit can be obtained as follows:

Such as: Jialu River, the river inverted siphon, \( A_{11} \):

\[
A_{11} = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 0.539 & 0.461 & 0 \\
1 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
1 & 0 & 0 & 0
\end{bmatrix}
\]  \hspace{1cm} (5)

3.2. Entropy weight method to determine index weight

In this comprehensive evaluation model, for different building types, according to the corresponding evaluation index content is summarized and sorted, the evaluation index data of various types of buildings are standardized, and the information entropy of each index is calculated, and the weight of each index is determined through the information entropy, respectively:

1. Weight of each evaluation index \( W_1 \) of the river inverted siphon and drainage culvert:

\[
W_1 = [\text{Area change}, \text{River length change}, \text{Construction land change}, \text{Beam narrow of upstream section}, \text{Change of flood discharge capacity of downstream, Blockage degree of building itself}, \text{Degree of building itself being easily blocked, economic and social change}]
= [0.000, 0.030, 0.000, 0.203, 0.182, 0.149, 0.182, 0.253] \hspace{1cm} (6)
\]

2. Weight \( W_2 \) of the drainage aqueduct:

\[
W_2 = [\text{Area change}, \text{River length change}, \text{Construction land change}, \text{Beam narrow of upstream section}, \text{Change of flood discharge capacity of downstream, Degree of building itself being easily blocked, economic and social change}]
= [0.000, 0.092, 0.276, 0.169, 0.141, 0.106, 0.217] \hspace{1cm} (7)
\]

3. Weight \( W_3 \) of the channel inverted siphon, culvert aqueduct, beam aqueduct and culvert:
W3 = [Area change, River length change, Construction land change, Beam narrow of upstream section, Change of flood discharge capacity of downstream, economic and social change]  
= [0.042 0.076 0.089 0.297 0.370 0.125]  (8)

④ Weight W4 of the left bank inverted siphon and the left bank culvert:
W4 = [Area change, River length change, Construction land change, Beam narrow of upstream section, Change of flood discharge capacity of downstream, Blockage degree of building itself, Degree of building itself being easily blocked, economic and social change]  
= [0.050 0.132 0.137 0.129 0.170 0.088 0.135 0.159]  (9)

⑤ Weight W5 of the drainage aqueduct:
W5 = [Area change, River length change, Construction land change, Beam narrow of upstream section, Change of flood discharge capacity of downstream, Degree of building itself being easily blocked, economic and social change]  
= [0.000 0.092 0.276 0.169 0.141 0.106 0.217]  (10)

3.3. Fuzzy comprehensive evaluation
According to the above fuzzy comprehensive evaluation principle, the comprehensive evaluation matrix of the current flood discharge conditions of the management office compared with the original designed flood protection conditions can be expressed as follows:

\[
B = W_i \ast A_j = (w_1, w_2, w_3, ..., w_n) \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} 
\]  (11)

Where, W is the weight matrix of various buildings obtained by entropy weight method, A is the judgment matrix of each evaluation unit according to single factor evaluation method, and n is the number of evaluation factors of different building types.

After calculation, the comprehensive evaluation matrix of each evaluation unit of a water transfer project management office is obtained. Take the river inverted siphon Jialu River as an example:

① Jialu River, the channel inverted siphon B_{11}:

\[
B_{11} = [0.456 \ 0.3472 \ 0.1958 \ 0] 
\]  (12)

Among them, the maximum membership degree is 0.456, the degree of change is level 1, basically unchanged.

According to the comprehensive evaluation matrix, the maximum membership can be obtained, so as to evaluate the change level and degree of flood discharge conditions of each unit compared with the original flood control design conditions

| No. | Unit name      | Type of buildings         | Maximum membership degree | Level | Degree of change            |
|-----|----------------|---------------------------|---------------------------|-------|-----------------------------|
| 1   | Jialu River    | river inverted siphon    | 0.456                     | 1     | basically unchanged         |
| 2   | Jiayu River    | river inverted siphon    | 0.635                     | 1     | basically unchanged         |
| 3   | Xushui River   | channel inverted siphon  | 0.528                     | 1     | basically unchanged         |
| 4   | Chao River     | channel inverted siphon  | 0.875                     | 1     | basically unchanged         |
| 5   | Wei River      | channel inverted siphon  | 0.528                     | 1     | basically unchanged         |
| 6   | Shibali River  | channel inverted siphon  | 0.8185                    | 1     | basically unchanged         |
| 7   | Jinshui River  | channel inverted siphon  | 0.9029                    | 1     | basically unchanged         |
According to the comprehensive evaluation, the current flood discharge conditions of the drainage aqueducts of Xingyuan northwest Ditch and Dalizhuang Ditch of the management office are significantly change from those of the original designed flood protection conditions, and the drainage inverted siphon of Zhanma Village, the drainage aqueduct of Liucun Ditch, Jinghu Ditch and Shuiquan Ditch are greatly changed, while the other ten units are basically unchanged.

Due to the increase of the proportion of construction land area in the watershed above the cross section, the narrow flood discharge section of the upstream river, the poor drainage at the outlet, and the risk of building blockage (domestic waste, firewood floating objects), the current flood discharge conditions of the drainage aqueducts in Xingyuan northwest ditch and Dalizhuang ditch have changed significantly compared with the original design conditions, Corresponding engineering measures and non engineering measures[13-15] can be taken to eliminate or reduce the safety risk of project operation.

The engineering measures are as follows: (1) clean up the engineering wastes, domestic garbage and floating materials of firewood near the entrance; (2) In order to prevent flood passage from silting up, sand retaining sill and grit chamber should be built at the entrance of drainage structure; (3) If the drainage is not smooth, dredge the downstream drainage channel, strengthen the river regulation, improve the flow capacity of the downstream river, and avoid the adverse impact of human activities on flood discharge.

Non-engineering measures: (1) Preparation of a highly operable left bank flood emergency plan; (2) Do a good job in the daily inspection and maintenance of drainage buildings through the canal, and try to eliminate possible risk factors; (3) Use the extracted small watershed and its characteristic parameters to strengthen the sharing of real-time rainwater conditions in water conservancy, and carry out the main canal Forecast and early warning of heavy rain and flood at cross-sections along the line; (4) Strengthen the construction of laws and regulations for upstream and downstream rivers, clarify the scope of protection and specific requirements, establish a monitoring mechanism for behaviors such as river building and piling muck, and conduct dynamic monitoring and supervision.

4. Conclusion
This article comprehensively considers the changes in current actual flooding conditions compared to the original designed flood protection conditions form changes in the underlying conditions of the river basin, actual upstream and downstream flooding conditions, and actual current capacity of the building. According to the principle of relatively independent, quantifiable and easy to obtain between indexes, the overall assessment index system of regional flood control risk on the left bank is established. On the basis of determining the classification criteria of quantitative and qualitative indexes, the fuzzy mathematics comprehensive evaluation method was used to evaluate the change degree of current flood
discharge conditions and original designed flood protection conditions of third-level units. In this paper, the overall evaluation of 16 third-level units of a management office shows that there are 6 third-level units with changes in the original designed flood protection conditions, including 4 great changes and 2 significant changes. For the third-level designed unit that has changed in the evaluation results, analyze its changing factors, and takes corresponding flood control engineering and non-engineering measures to eliminate and control risk factors, so as to reduce the above adverse effects and effectively guarantee the flood control safety of the left bank area. At the same time, it provides technical support for improving flood control emergency plan, strengthening project operation and maintenance, and reasonably allocating corresponding resources.

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