Application of set pair analysis method and analytic hierarchy process in risk analysis of resettlement in the south to North Water Transfer Project

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Abstract. There is a great complexity and connection between the risk indicators of the resettlement of the south to North Water Transfer project. The traditional analytic hierarchy process can not solve the uncertainty of the resettlement work. The paper introduces the set pair analysis method, and establishes the risk index evaluation system for the characteristics of the resettlement. Through the hierarchical analysis method to get the index weight, using single index set calculation connection number, contact number and relative membership degree of elements of the analysis, finally to evaluate the South-to-North Water Diversion Project Resettlement risk level combined with the theory of confidence. Combine with the engineering practical examples. The results show that the evaluation model calculation are consistent results with the actual construction, the set of analysis method can be applied in land requisition and resettlement risk assessment.

1. Introduction

The south to North Water Diversion Project aims to improve the uneven distribution of water resources in our country. Water diversion resettlement work is an important part of South to North Water Diversion Project, also is the difficulty of the construction of the project. Relocation and resettlement include land requisition and resettlement of residents. The size of the risk in the process of implementation of the project will not only effect the construction period and cost, and will influence the takeover of the quality of life of the people and social stability, so south to North Water Diversion Project sign moved to the resettlement of the risk assessment research for resettlement work has very important significance.

In the process of risk assessment, the risk level of the project of the south to North Water Transfer Project is a fuzzy concept with uncertainty. The existing risk assessment index system usually adopts 1-10 or 0-100 as the classification standard, and does not consider the uncertainty relation between the evaluation level. Set pair analysis as a method to deal with the problem of uncertain system has been widely used in the field of risk analysis, water quality evaluation, ecological evaluation and so on. In this paper, the risk analysis model of the south to North Water Transfer relocation and Resettlement Based on set pair analysis is set up based on the uncertain factors in the process of the transfer of the south to North Water Diversion Project.

2. Set pair analysis theory

2.1 Set pair analysis method

Set Pair Analysis called SPA, the basic principle will be research object to establish two sets up a set of, and the two set of factors related to the characteristics of identity, difference and opposition of the analysis to between the relevant factors to determine and uncertainty information for effective analysis. In order to show the correlation between two or more sets of pairs, the concept of the degree of connection μ is introduced, which is used to describe the A and B in a comprehensive and systematic description. In the same case, the value of μ is 1, in the case of complete opposition, the

value of μ is -1, uncertainty between the two cases, the value of μ range of [-1, 1]. Set pair analysis theory:

In a certain context, two combinations of *A*, *B*, and a set of *H*= (*A*, *B*), at the same time, it is assumed that the set pair of *H* has research object number is *N*. These research objects in the combination of *A*, *B* have three characteristics-between the identity, the difference and the difference between the opposites. S, P, F, respectively, representative the numbers of similarities, differences and differences in the number of features, then *F=N-S-P*. Among them, the characteristic of *F* is the number of different characters which can not be identified. Thus, the expression of the link between *B* and *A* is obtained:

$$\mu = \frac{S}{N} + \frac{F}{N} i + \frac{P}{N} j \quad (1)$$

$a=\frac{S}{N}$, $b=\frac{F}{N}$, $c=\frac{P}{N}$. They indicate that the research set pair in the same background, the same degree of difference and opposition. *a*, *b*, *c*, are real, and *a*+*b*+*c*=1, *a*, *b*, *c*, range is 0 to 1. As the same degree and the degree of opposition, *a* and *c* are relatively determined, *B* with uncertainty. The connection degree formula can be simplified as:

$$\mu = a + bi + cj \quad (2)$$

In the formula: *i* is the difference coefficient, the value range is [-1,1]; *j* is the opposition coefficient, the general provisions of its value is -1.

2.2 Set pair model and connection degree

Set the evaluation object space is *A*, which indicates the risk evaluation index, and the attribute space is *B*, which indicates the risk grade. Applied to the theoretical analysis and the object of evaluation sample space *i* monolayer indicator, the risk index value of x_{ij} (*j* in the range 1 to 8) and risk grade *g* (*g* value ranges from 1 to 5) between the single index contact a few μ_{ijg}. The value at risk x_{ij} range for pairwise adjacent to the evaluation index of the critical value of *S*. The range of the number of links is $\mu \in (-1,1)$.The calculation procedure for the expression of the number of links μ_{ig} is expressed in literature [3].

V_{ig} represents the sum of the number of links, whose value is the sum of the number of links and the product of the corresponding weight:

$$v_{ig} = \sum_{j=1}^{n} w_j \mu_{ijg} \quad (3)$$

The calculation method of the relative membership degree of the sample is a formula 4, and it is normalized by the formula 5:

$$\mu_{ig} = 0.5 + 0.5 v_{ig} \quad (4)$$

$$\overline{\mu_{ig}} = \mu_{ig} / \sum_{g=1}^{5} \mu_{ig} \quad (5)$$

2.3 Determination of evaluation level

$$k_0 = \min\left\{ k \left| \sum_{i=1}^{g} \overline{\mu_{ig}} > \lambda \right. \right\} \quad (6)$$

Type: λ is the confidence, the value is generally [0.6, 0.7].

3. Risk assessment system for resettlement of the diversion project of the south to North Water Diversion Project

South to North Water Diversion Project sign moved to the resettlement of the application of the risk assessment set of theoretical analysis, each evaluation between levels of identity, difference, connection of objective facts considered, is the resettlement placement in the specified index and established the risk assessment standards constitute a set, through the appraisal standard between compared to the same and the opposition of contact.

3.1 Establishment of index system

Consider the characteristics of the project of the south to North Water Diversion Project, the actual needs of the resettlement work and the analysis of the calculation. List of risk indicators for resettlement and relocation are Engineering land acquisition compensation price difference; Housing Units compensation price differences; Crop production value; Survey data change; Be removed by the masses can not be placed in a timely manner; The special effects caused by the relocation of facilities; Temporary land can not be reclaimed; Influence of construction, which are expressed by R_1 to R_8.

With 0,1,2,3,4 the probability of occurrence of the risk and the severity of the consequences were divided into five quantitative levels, the specific level of description as shown in Table 1 and table 2.

Table 1 the grade table of risk occurrence probability

Probability	Related description	Grade
Almost impossible	impossible to appear	0
Very small	not likely but still appear	1
Occasionally	occasionally occur during the period of the resettlement	2
It is quite possible	several times during the period of resettlement	3
Frequently	in the period of resettlement for many times	4

Table 2 the grade table of risk consequence

Level situation	Related description	Grade
Can be ignored	the basic social and engineering has no effect	0
Relatively light	overall smooth, slightly affected	1
More serious	affect social or engineering construction	2
Serious	serious impact on the local, engineering blocked	3
Very serious	large-scale impact on the local social order, the project can not be built	4

The risk level of the transfer of the south to North Water Diversion Project is classified as table 3.

Table 3 risk grade and standard score

The level of risk	description	The mark of risk	Risk acceptability	Risk Importance	Risk countermeasures
One	Low risk	0-3	Negligible	Basically not important	Pay attention to
Two	lower risk	3-6	Can accept	more important	attention
Three	moderate risk	6-9	Accept and controllable	important	importance
Four	higher risk	9-13	Don't want	Very important	Focus
five	high-risk	13-16	Can not accept	The most important	Immediate disposal

3.2 Determination of the weight of index

The weight of each risk index in risk assessment is determined by many methods, among which the analytic hierarchy process (AHP) is proposed by Professor SATTY, which can be used to

determine the weight of risk assessment index. Using analytic hierarchy process to determine the index weight of the risk assessment of the transfer of the south to North Water Diversion Project, the calculation steps are as follows:

(1) To calculate the evaluation index of the judgment matrix; (2) The ranking of each factor of evaluation index and its consistency check; (3) The judgment matrix needs to meet the consistency.

4. Example applications

The data from the literature [11], according to table 2 and table 3 combined with local resettlement actual situation, respectively to indicators of risk occurrence probability and consequence grade Fu, and the two score list judgment matrix, according to the third part of the calculation method for the weight of each risk index. The calculation results are shown in table 4.

Table 4 the score of risk index evaluation

index	risk factors	Occurrence	Risk Consequence	Evaluation score	weight
R1	Engineering land acquisition compensation price difference	3	4	12	0.397
R2	Housing Units compensation price differences	3	3	9	0.230
R3	Crop production value	3	2	6	0.117
R4	Survey data change	3	1	3	0.056
R5	Be removed by the masses can not be placed in a timely manner	2	2	4	0.067
R6	The special effects caused by the relocation of facilities	2	2	4	0.071
R7	Temporary land can not be reclaimed	2	1	2	0.038
R8	Influence of construction	1	1	1	0.028

According to the formulas in paper [3] which are used to express μ calculate the number of risk indicators, in which the value of S_{0j} to S_{5j} is 0, 3, 6, 9, 13, 16 respectively. Formula 3 calculates the comprehensive relationship between the sample and the risk level, and the relative membership degree of the risk index V_{ig} is calculated, and the calculation results are shown in table 5.

Table 5 calculation results of risk level

Membership grade k	The level of risk	Integrated connection number v_{ig}	The relative membership degree μ_{ig}
1	One	-0.526	0.109
2	Two	-0.189	0.186
3	Three	-0.0145	0.226
4	Four	0.489	0.342
5	five	-0.4035	0.317

The formula 6 shows that, the values of μ_{ig} is 0.342, take corresponding to membership grade k_0 is 4, namely the engineering example in resettlement risk level for four, is not willing the risk level and need to pay attention to, must take reasonable actions in a timely manner to control risk. Compared with the results of evaluation in the [11] literature by given consistent results on the whole.

5. Conclusions

The study on risk assessment of the transfer of the south to North Water Diversion Project is relatively small at home and abroad, especially in the research of uncertainty. This paper based on the risk assessment standard of resettlement and resettlement, according to the characteristics of the resettlement of the risk characteristics of the project, determine the evaluation index system and the corresponding standard of resettlement risk. With hierarchical analysis method to calculate the weights of indicators of risk, the application set of analysis method, risk index between determined and uncertainty to establish contact, establish the membership of each risk index and calculate the comprehensive degree of membership, considering the uncertainty relation between the different risk indicators, finally according to the confidence criterion that resettlement risk level. Finally, the risk grade of the project is four, which shows that the set pair analysis method is effective and feasible to evaluate the risk of the project of the south to North Water Diversion Project. It also provides reference for other engineering risk assessment.

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