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The water strategy in China based on mathematical model

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ABSTRACT

Combined with the distribution of the fresh water in China, we make the main rivers as the dividing basis, and then we get the five areas, including the three provinces of northeast China, Yellow River Basin, Yangtze River and Pearl River Basin, Tibet district and Sinkiang district, in the mainland China. The water will be moved to the provinces with water shortage. Considering the problems of human resource and piping cost and then comprehensively analyzing the water movement within the region and across the region, the optimal water movement scheme of the provinces with water shortage is as follows. The moving amount from Qinghai to Gansu is 6.415 billion m^3; the moving amount from Qinghai to Ningxia via Gansu is 6.685 billion m^3; the moving amount from Yunnan to Shanxi via Sichuan and Shaanxi is 31.636 billion m^3; the moving amount from Yunnan to Guangxi is 80 billion m^3; the moving amount from Guangxi to Jiangxi is 140 billion m^3; The moving amount from Jiangxi to Henan via Hubei is 71.739 billion m^3; the moving amount from Jiangxi to Hebei (including Tianjin and Beijing) via Hubei and Henan is 82.8 billion m^3; the moving amount from Jiangxi to Shandong via Anhui is 57.5348 billion m^3; the moving amount from Fujian to Jiangsu via Zhejiang is 62.858 billion m^3; the moving amount from Fujian to Jiangxi is 40 billion m^3.

Finally, on the basis of the water resource optimal movement, in order to use the water resource after being moved reasonably, the fuzzy AHP is adopted to obtain the needed amount of water for agriculture, industry and civilian use and the storage amount of water for emergency in the provinces.

KEYWORDS

Grey prediction model;
BP neural network;
Movement.

THE PROGRAM OF WATER RESOURCE MOVEMENT

(1) The regional division

In China, the main rivers could be divided into the Yellow River, Yangze River, Pearl River, Northeast Rivers, Northwest Rivers, and Southwest Rivers.

(2)The best water movement across areas

Four levels can be determined according to the movement difficulties[1]. The difficulty of movement across the neighboring provinces is 1; the difficulty of movement across the provinces at a distance of one province is 2; the difficulty of movement across the provinces at a distance of two provinces is 3; the difficulty of movement across the provinces at a distance of more than two provinces is 4. Then according to "short-path problem", the optimal movement path can be got. The movement results of the areas are shown in TABLE 7 and TABLE 9.

Figure 1 : The three provinces in Northeast China

Figure 2 : The yellow river basin area

Figure 3 : The yangze river and pearl river basin area

Figure 4 : Tibet area

Figure 5 : Sinkiang area

In Yellow River Basin, Qinghai Province is the only one with sufficient water; Shanxi is the province with water self-sufficiency; the other provinces are of water deficiency. In TABLE 1, we can find that it is easy to move the water from Gansu and Ningxia to Qinghai and to move the water from Shaanxi to other provinces can be easily realized. However Shaanxi is not a province of sufficient water. The surrounding areas[2,3] move the water from the Yellow River leading to the water deficiency in the Yellow River. It will damage the sustainable development of the water resources, so we should further consider moving the water from Yangtze River Basin.

From TABLE 2, we can find that it is easy to move the water from Yangtze River Basin to the Provinces with water shortage, such as Henan, Shandong and Hebei. So we stipulate them to move the water from Yangtze River Basin. Therefore, we can ease the tense of water supply of the Yellow River and decrease the move difficulties.

TABLE 3 shows that the provinces providing water to the north and the water movement difficulty. We can get that it is easy to move the water from Hubei, Anhui and Zhejiang to the north. But these three provinces don't have enough water, so we should consider moving water from the places with sufficient water. From the table, we can see that Jiangxi and Fujian are the best spots providing water. In order to avoid becoming a province with self-sufficiency[4] province because of moving too much water, other provinces can share the burden of moving water to the north.

TABLE 1 : The movement difficulties in yellow river basin

Provinces	Gansu	Ningxia	Shanxi	Shandong	Henan	Hebei
Qinghai	1	2	3	4	3	4
Shaanxi	1	1	1	2	1	2

TABLE 2 : The move difficulties across the areas

Provinces	Shanxi	Henan	Shandong	Hebei
Sichuan	1	2	3	4
Hubei	1	1	2	2
Anhui	2	1	1	2
Jiangsu	3	2	1	2

TABLE 3 : The move difficulty of pearl river basin and yangtze river basin

Provinces	Hunan	Zhejiang	Hubei	Anhui	Jiangsu
Sichuan	1	3	1	2	3
Jiangxi	1	1	1	1	2
Fujian	2	1	2	2	2
Guangxi	1	3	2	3	4
Yunnan	2	4	3	4	4

From TABLE 1, TABLE 2 and TABLE 3, the optimal movement path can be obtained. Because only Liaoning Province of the three provinces in the northeast China is short of water, we don't need to move the water from other areas outside northeast China. Finally the optimal water movement path of the provinces with water shortage in Yellow River Basin and Yangtze River Basin can be got which is shown in Figure 6.

Figure 6 : The optimal water resource movement figure

(3) The water amount needed to be moved in the provinces

For the inland areas, such as Gansu, Ningxia Shaanxi and etc, the moved water amount should satisfy the shortage amount Q_i.

And

$$Q_i = (1000 - N) \times \frac{S}{M}$$

For the coastal areas, such as Liaoning, Hebei, Jiangsu and etc, the moved water amount should be $Q_i \times w_1$;The moving amount from Qinghai to Gansu is 6.415 billion m^3;The moving amount from Qinghai to Ningxia via Gansu is 6.685 billion m^3;The moving amount from Yunnan to Shanxi via Sichuan and Shaanxi is 31.636 billion m^3; The moving amount from Yunnan to Guangxi is 80 billion m^3; The moving amount from Guangxi to Jiangxi is 140 billion m^3; The moving amount from Jiangxi to Henan via Hubei is 71.739 billion m^3; The moving amount from Jiangxi to Hebei (including Tianjin and Beijing) via Hubei and Henan is 82.8 billion m^3; The moving amount from Jiangxi to Shandong via Anhui is 57.5348 billion m^3; The moving amount from Fujian to Jiangsu via Zhejiang is 62.858 billion m^3; The moving amount from Fujian to Jiangxi is 40 billion m^3.

THE SPECIFIC ALLOCATION OF WATER RESOURCE IN WATER-DEFICIENT PROVINCES

For the sustainable development, we need to do some specific allocation of water resource[5] after the movement and to confirm the weight calculation steps of sustainable development index system of water resource in each province.

(1) The establishment of the analytic hierarchy process figure

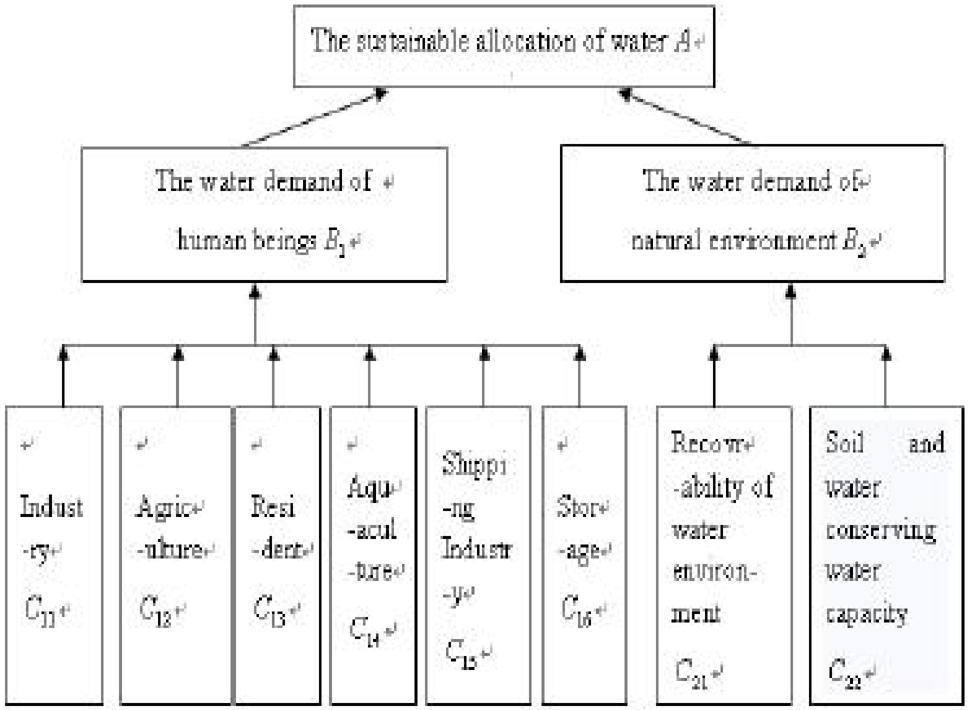

Figure 7 : The analytic hierarchy figure of sustainable development of water resource

(2) The establishment of fuzzy consistency judgment matrix

According to the dualistic contrast of the importance of index (criterion) theory, if we contrast the importance of index (criterion) C_i with the importance of index (criterion) C_j, we set calibration r_{ij} which represents the significance qualitative sequence is one figure among 0, 0.5 and 1.

If $C_i < C_j$, r_{ij}=1 and r_{ji}=0;If $C_j > C_i$, r_{ij}=0 and r_{ji}=1; If $C_i = C_j$, $r_{ij} = r_{ji}$=0.5.

With the help of references from [12] to [15], we can determine the relative significance of all the indexes. For Hebei Province

① For criterion B_1, the binary comparison qualitative permutation matrix of the six indexes in criterion B_1 to the significance is as below,

$$\mathbf{R_{10}} = \begin{bmatrix} 0.5 & 0 & 0.5 & 1 & 1 & 1 \\ 1 & 0.5 & 1 & 1 & 1 & 1 \\ 0.5 & 0 & 0.5 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0.5 & 0.5 & 1 \\ 0 & 0 & 0 & 0.5 & 0.5 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0.5 \end{bmatrix}$$

We implement the consistency test to matrix R_{10}. The first line should not be tested. And the test is started from the factors in the second line. $r_{12} = 0 < r_{13} = 0.5$, then in the matrix $r_{23} = 1$ which can correspond to the values in the table and satisfy the requirement. Similarly, we can verify the other values in the second line can meet the requirement. When testing the factors in the third line, $r_{13} = 0.5 < r_{14} = 1$ and therefore we can reckon $r_{34} = 1$, which is the same with the value in the matrix and meets the requirement. Similarly, the factors in the third line, and therefore we can reckon , which is the same with the value in the matrix and meets the requirement. Similarly, the factors in the third line can be satisfactory. In the same way we can test the other factors in the matrix till the consistency test is fulfilled. After the test, if the matrix can meet the requirement, the matrix needs no adjustment. According to the matrix, the weights of the indexes can be calculated.

$$\mathbf{R_1 = R_{10}} = \begin{bmatrix} 0.5 & 0 & 0.5 & 1 & 1 & 1 \\ 1 & 0.5 & 1 & 1 & 1 & 1 \\ 0.5 & 0 & 0.5 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0.5 & 0.5 & 1 \\ 0 & 0 & 0 & 0.5 & 0.5 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0.5 \end{bmatrix}$$

Combined with the relative affiliation of tone operator predetermined amount calibration[6], the relative affiliation vectors to criterion B_1 is as below,

$\boldsymbol{\omega_{10}}$ **=(0.7 1, 0.7, 0.36, 0.36, 0.09)**

After the normalization, we can get

$\boldsymbol{\omega_1}$ **=(0.22, 0.31, 0.22, 0.11, 0.11, 0.03)**

② For criterion B_2,

$$\mathbf{R_{20}} = \begin{bmatrix} 0.5 & 1 \\ 0 & 0.5 \end{bmatrix}$$

After the consistency test, the values in the matrix can meet the requirement and we can get $R_2 = R_{20}$. Therefore,

$\boldsymbol{\omega_{20}}$ **=(1, 0.33)**

After the normalization,

$\boldsymbol{\omega_2}$ **=(0.75, 0.25)**

③ The binary comparison qualitative permutation consistency judgment matrix of criterion layer B to the target layer A is as follows,

$$\mathbf{R_0} = \begin{bmatrix} 0.5 & 1 \\ 0 & 0.5 \end{bmatrix}$$

After the consistency test, the values in the matrix can meet the requirement and we can get $R = R_0$. Therefore,

$\boldsymbol{\omega}$ **=(1, 0.33)**

After the normalization,

$\boldsymbol{\omega}$ **=(0.75, 0.25)**

④ Considering (1), (2) and (3), we can calculate the weight q_{ij} of index to the target layer.

$$\mathbf{q_{ij} = \omega_i * \omega_{ij}}$$

(When $i = 1$, $j = 1,2,3,4,5,6$; when $i = 2$, $j = 1,2$)

The calculation results can be shown in the following table.

TABLE 4 : Table of hierarchy sort

Layer B	Weights	Layer C	Weights	Combination Weights
B_1	0.75	C_{11}	0.22	0.17
		C_{12}	0.31	0.23
		C_{13}	0.22	0.17
		C_{14}	0.11	0.08
		C_{15}	0.11	0.08
		C_{16}	0.03	0.02
B_2	0.25	C_{21}	0.75	0.19
		C_{22}	0.25	0.06

Conclusion

According to the combination weight proportion, we allocate the usable water resources after the movement. From the aspects of the sustainable development, the water resources mainly are used in agriculture and then used in the recoverability of water environment.

Similarly, the allocation of the water resources in the areas where the water is moved to other places can be got. The results are shown in TABLE 5

After the analysis of TABLE 5, Tianjin, Shanxi, Liaoning, Gansu, Ningxia, Jiangsu, Shandong and Henan are the districts of agriculture development. Shanghai is an industrial developed city, which is poor in agriculture. The water resource in Beijing is mainly for the citizen daily use. In the provinces with different degrees

TABLE 5 : The combination weights of the indexes of the provinces with water shortage

Provinces	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{21}	C_{22}
Tianjin	0.17	0.23	0.17	0.08	0.08	0.02	0.19	0.06
Shanxi	0.17	0.23	0.17	0.10	0.06	0.02	0.19	0.06
Liaoning	0.17	0.23	0.17	0.10	0.06	0.02	0.19	0.06
Gansu	0.17	0.23	0.17	0.10	0.06	0.02	0.19	0.06
Beijing	0.11	0.16	0.24	0.07	0.16	0.02	0.12	0.12
Ningxia	0.19	0.23	0.15	0.08	0.08	0.02	0.06	0.19
Shanghai	0.23	0.06	0.19	0.13	0.13	0.02	0.12	0.12
Jiangsu	0.19	0.22	0.15	0.11	0.06	0.02	0.19	0.06
Shandong	0.15	0.22	0.19	0.11	0.06	0.02	0.06	0.19
Henan	0.19	0.22	0.15	0.06	0.11	0.02	0.19	0.06

of pollution[7,8], we implement different degrees of allocation to the recoverability degree of water environment and the soil and water conserving water capacity, so as to make the sustainable development of the water resources have the optimal treatment.

CONCLUSION

In this article, In the process of establishing the approach model of obtaining the water resources for the provinces with water shortage, in order to select the most effective and economic approach of obtaining water resource, we choose a combination mode of movement and desalinization. In the research of the water movement in the provinces with water deficiency, in order to ensure the stable moveable water resources in the provinces with water shortage, we should store the water which is moved from other areas. In the modeling, we should think about the storage, movement and desalinization and protection of the water resource. Having the main line of cost control, we also consider the feasibility and effectiveness, which can solve the water problems in China reasonably and effectively.

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