Advances in Engineering Research, volume 118
2nd International Conference on Automation, Mechanical Control and Computational Engineering (AMCCE 2017)

A Macro Water Supply System Evaluation Model

Zhe Zhang[1, a *]

[1]North China Electric Power University, Baoding, China

[a]89678252@qq.com

Keywords: Water Supply System Evaluation ,Water Scarcity,Egypt

Abstract. In this paper, an evaluation and decision model for the water supply system in a region was built using the method of Grading Evaluation Method (GEM). Four indicators are defined, which are Probability of Water Supply (IS), Reliability of Water Supply (IR), Water Utilization Rate (IW) and Efficiency of Water Utilization (IE). The grades (+, =,–) of them respectively represent the indicator are high, middle and low. Then I set up a water supply indicator system and display in the evaluation and decision table. From the table, we can look to the problem and find corresponding solutions. On the basis of GEM, I creatively formulate the evaluation model. Meanwhile, a creative intervention plan is presented. At last, Egypt was chosen to verify the rationality of the model. The results are IS–、IR–、IW+、IE– , which shows Egypt's water will be over-exploited in the next few years.

Introduction

Are you afraid of a thirsty planet? With climate change and population increase, the water situation is faced with a great challenge. What's more, physical scarcity, economic scarcity and increasing pollution and consumption make the problem more exacerbated[1]. Nowadays, solving the water issue has become a common goal all over the world. We are eager to strive towards a blue planet. In order to provide access to water for all citizens of the world and make the planet better, I give out my creative solutions.

In this paper, I defind four indicators to desribe the water supply system in macro. Then I use Grading Evaluation Method (GEM) to establish an evluating tabel to give out the condition of the water supply system and give corresponding advice to improve the water supply system. Finally, I use Egypt as an exmple to verify the correctness of the model and give advice for Eygept.

Evaluation and decision-making model

Index design for measuring regional capacity.

I choose water supply guarantee rate, water guarantee reliability, utilization of water resources, water use efficiency as four indicators. Then I build assessment and decision-making model to measure the regional capacity to provide clean water. This method is easy to understand and evaluate, at the same time, it's also suitable for decision-making.

The four indicators can reflect the regional capacity to provide clean water and the ability to adapt to water scarcity. They can evaluate regional capacity to provide clean water and discover the characteristics of regional water shortages. Thus it's convenient for us to develop an intervention plan[2].

Index calculation.

1)Probability of water supply

Water supply guarantee rate is to describe the protection level under the multi-year average state. The formula is as follows:

$$IS = \frac{A}{D} \tag{1}$$

Where I_s is water supply guarantee rate. A means area with available water at normal levels. And D is total water demand.

2)Reliability of water supply

Water guarantee reliability describes whether the water demand can be met under certain guaranteed rate. We have the equation as follows:

$$IR = \frac{A_r}{D_r} \tag{2}$$

Where I_R means water guarantee reliability. A_r means area available water when water supply guarantee rate is $r\%$,and D_r is water demand in the condition.

3)Water utilization rate

Utilization of water resources represents the potential for water development and utilization. The formula is as follows:

$$IU = \frac{U}{W} \tag{3}$$

Where I_U presents utilization of water resources. U is actual water on average, and W is total water consumption including available water entry.

4)Efficiency of water utilization

Water use efficiency represents the potential for water conservation. Water consumption can be divided into the consumption of agriculture, industry, life and the environment consumption. Among them, agriculture and industry water consumption usually use most of the water. Meanwhile, taking the availability of the data into account, I choose agricultural and industrial water levels to represent the overall level. Then we have the equation as fellows:

$$IE = \frac{\alpha \cdot P_A + \beta \cdot P_I}{P_A + P_I} \tag{4}$$

Where I_E means water use efficiency. α is effective utilization coefficient of agricultural water, β is industrial water recycling rate, P_A is the ratio of agricultural water in total water use,and P_I is the ratio of industrial water in total water use.

Evaluation and decision making model.

According to the four indicators, I build the evaluation and decision making model.

Step 1: As we have calculated the value of the four indicators, then we can know the grade of each indicator according to Table.

Table1. Rating standards for the indicators

Grade	Is+/ Ir+	Is=/ Ir=	Is-/ Ir-	Iu+	Iu=	Iu-	Ie+	Ie+	Ie-
Interval	>1.2	0.7~1.2	<0.7	>0.8	0.6~0.8	<0.6	>0.8	0.6-0.8	<0.6

Step 2: After knowing the grade, we can find the corresponding area in the following table. Table 2 illustrates how to analyze the water problem, how to evaluate the region’s capacity to provide clean water and how to propose major policy according to the size of the four indicators.

Table 2. Evaluation and decision table

			IU-			IU=			IU+		
			IE+	IE=	IE-	IE+	IE=	IE-	IE+	IE=	IE-
IR+	IS+	problem							2	2	2-3
		solution							A-C2	A-C2	A-C2
IR=	IS+	problem	1A	1A	A1	1A	1A	1A-3	1A-2	1A-2	1A-2-3
		solution	B1	B1	A	B1	A	A	A-C2	A-C2	A-C2
	IS=	problem	1B	1B	1B	1B	1B	1B-3	1B-2	1B-2	1B-2-3
		solution	B1	B1	A-B1	B1	A	A	A-C2	A-C2	A-C2
IR-	IS+	problem	1B	1B	1B	1B	1B	1B-3	1B-2	1B-2	1B-2-3
		solution	B2	B2	A-B2	B2-C1	A-B2	A-B2	A-B2-C2	A-B2-C2	A-C2
	IS=	problem	1C	1C	1C	1C	1C	1C-3	IC-2	1C-2	1C-2-3
		solution	B2	B2	A-B2	B2-C1	A-B2-C1	A-B2-C1	A-B3-C2	A-B3-C2	A-B3-C2
	IS-	problem	1C	1C	1C	1C	1C	1C-3	1C-2	1C-2	1C-2-3
		solution	B2	B2	A-B2	B2-C1	A-B2-C1	A-B2-C1	A-B3-C2-D	A-B3-C2-D	A-B3-C3-D

Slightly exploited   Moderately exploited   Heavily exploited   over exploited

In table 2, The "problem" points the main causes of water scarcity in the region. 1 represents that reliability of water supply is below the acceptable level, which will easily lead to water shortages. 2 represents water utilization rate is too high, which will easily lead to environmental and ecological problems. 3 represents that the water is wasted and efficiency of water utilization is not matched with the water shortage situation.

The "solution" describes the main measures to solve the corresponding problem. A : Conserve water and control water demand. B: Strengthen construction of water resources. (Among them, B1: Construct water supply projects and increase water supply. B2: Develop groundwater resources, construct sewage treatment plants, protect environment and increase forest cover. B3: Develop rainwater, seawater, recycled water and other non-conventional water resources actively on the basis of B1, B2.) C: Strengthen water resources management and regional coordination. (Among them, C1: Strengthen intra-regional water management. C2: Strengthen water resource allocation among neighboring regions.) D: Change the economic structure to adapt to water resources, or construct inter-basin water transfer project.

Verify the Model with Eygpt as an example

From the UN water scarcity map, we select Egypt, a moderately overloaded country, as example.

After the collection of information, we then get the data needed. $A = 5.73\times10^{10}$ m^3/yr, $D = 7.12\times10^{10}$, $U = 6.83\times10^{10}$ m^3/yr, $W = 8.12\times10^{10}\ m^3/yr$, $A_r = 4.58\times10^{10}$, $P_A = 86\%$, $P_B = 6\%$, $\alpha = 0.53$, $\beta = 0.23$ [3].

We plug these data into the four index calculation formula, then calculate the corresponding value and assess their grades. The results show in Table 5.

Table 3. Calculation and classification of the indicators in Egypt

	IS		IR		IU		IE	
	IS	Grade	IR	Grade	IU	Grade	IE	Grade
Egypt	0.805	=	0.644	–	0.844	+	0.510	–

Conclusion

Based on these grades, we find the corresponding position in the assessment table (Table 2**).** The results are landed in 1C-2-3, which suggests that Egypt is a heavily exploited country. The results coincide with the facts, thus it proved the correctness of our model.

According to Table 2, we easily know the general questions in Egypt:

1)The reliability of water supply is significantly below the acceptable level,which will easily lead to severe water shortages[4].

2)The utilization of water resources is too high which will easily lead to environmental and ecological problems.

3)Lots of water is wasted. Water efficiency doesn't match with the water shortage degree.

On the basis of above analysis and combination with the actual situation in Egypt, we then analyze in detail why and how water is scarce in Egypt.

1. As water use efficiency IE is relatively low, we find the following problems in Egypt.

1)The economic structure is uncoordinated. A too large proportion of agriculture consume enormous irrigation water.

2)Agricultural water-saving irrigation technique is low, which wastes lots of water.

3)Repetitive utilization of industrial water is low, and a large number of renewable resources are wasted.

2. As we consider water supply guarantee rate IS , we find the following questions.

1)People do not have strong awareness of water conservation, which caused high water consumption in life.

2)Large population base and rapid growth result in an increase in water demand.

3. As water guarantee reliability IR is low, then we find:

1)Egypt is excessively dependent on Nile. The water in Nile accounts for 96.1% of total water resources. When Egypt takes place in Egypt, local precipitation and Nile river flow in Nile River reduces, resulting in the decrease of water supply.

2)The forest coverage rate is too low, resulting in huge loss of water resources

3)Part of water has been contaminated, thus it's hard for the government to provide clean water.

4. As the utilization of water resources IU is relatively high, then we find the questions.

1)Local groundwater resources are scarce.

2)Water resource has been excessively exploited, which resulted in little potential for further development of water resources.

3)Invest too little in desalination and sewage treatment.

Reference

[1] Hashimoto T, Stedinger J R, Loucks D P. Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation. Water Resources Research,1982, 18(1): 14-20.

[2] Xiaohong Cui, Di Wang, Degree of Water Multilevel Fuzzy Evaluation Model Based on Multiple Factors [J]. Mathematics in Practice and Theory. 2012.

[3] WHO. Water Sanitation and Health. http://www.who.int/water_sanitation_health/hygiene/en/. 2003.

[4] Conway,D.1993.The Development of a Grid-Based Hydrologic Model of the Blue Nile and the Sensitivity of Nile River Discharge to Climate Change.Unpublished PhD Thesis.UK.