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Geo-Ref Information Services-USA, List B of Scientific Journals, Poland, Directory of Research Journals

International Journal of Earth Sciences and Engineering

ISSN 0974-5904, Volume 09, No. 06

December2016,P.P.2557-2562

Discussion on Establishment and Evaluation Method of Water Resource Management Performance Evaluation System

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Abstract: On the basis of comprehensive interpretation of the strictest water resource management system, water resource management performance evaluation index system has been constructed in this paper based on entropy theory model, the strictest water resource management performance evaluation safeguard measures system has been constructed, main safeguard measures have been proposed and finally application and inspection have been made for evaluation model through examples, which provides theoretical reference and guides to action.

Keywords: *evaluation method, water resource management, evaluation system, index establishment*

1. Introduction

Water resource management is to take administrative measures to promote the saving, protection and reasonable utilization of water resource for the sustainable utilization of water resource. It includes legal, administrative, economic, technical, educational and other means and manages allocation, exploitation, utilization, scheduling and protection of water resources to meet the demand of social economy development sustainably [1].

It is clearly stipulated in "Decision for Speeding up Water Conservancy Reform and Development" that water is the source of life, key of production and basis of ecology, which firstly brings water conservancy up to strategic height related to economic security, ecological security and national security and is another important leap of our party for water resource and water conservancy. "Decision" firstly points out that it needs to implement the strictest water resource management system and take strict water resource management as the strategic measure of speeding up economic development mode [2]. It puts forward the targets of water resource management clearly: till, try to control the total annual water consumption within, ten thousand Yuan of gross domestic product and ten thousand water consumption for industrial added value decrease obviously, effective utilization coefficient of farmland irrigation water increases to above, improve the water quality in water function area of rivers and lakes obviously, water quality of water source in urban water supply reaches standards comprehensively and groundwater overdraft is restricted basically.

Our country has promoted water saving society construction, experimental unit of real time monitoring system of urban water affairs as well as construction of water resources management system etc successively, improved the level of water resource management work with advanced scientific technology and management method, realized scientific, quantitative and modern objects of water resource management and allocated water resource reasonably to achieve eternal utilization [3].

This paper mainly makes evaluation for water resource management on the basis of improving water resource management evaluation system [4]. Water resource management evaluation system takes daily information management information as the main content, fully integrates water supply and water intake information as well as real time monitoring data, provides highly efficient management means for management personnel and provides support for modern management of water resource and then service the social public in a better way.

2. Index of Water Resource Asset Management Performance Evaluation

This paper constructs a set of scientific, reasonable and strictest water resource management performance evaluation and safeguard measure system suitable for national situation and water situation in China on the basis of analyzing the strictest resource management features and research. The main research significance lies in the following aspects:

(1) For the strictest water resource management performance, evaluate level by level, which is good for mastering the implementation effect of the strictest water resource management work timely, which is confirming the contribution of current water resource management to development target, finding out the weak process in management work, clarifying following work focuses and proposing reasonable suggestions[5], providing comprehensive and accurate information and evidence for decision making of water source management and promoting scientific and standard water resource management.

(2) Check whether current implementation process of water resource management meets the target and principle demand of the strictest water resource management and include evaluation

results into the content of government comprehensive evaluation of achievements, which is good for each governmental departments setting up and implementing scientific development view and achievements view and then establishing and improving long term water resource management mechanism [6].

(3) Make performance evaluation and horizontal comparison for the strictest water resource management level in different regions during one period of time, so that different regions can learn the strong points and close the gap mutually, which is good for improving the overall level of national water resource management work.

(4) Set up a set of the strictest water resource management performance evaluation safeguard measure system suitable for the need of water resource management work in new period and with strong targeted and relatively complete features, which can promote the implementation of performance evaluation work effectively and make the strictest water resource management work more standardized.

The evaluation of water resource asset operation management needs to reflect every aspect of water resource comprehensively. This paper plans to make evaluation from three aspects of asset operation situation, amount of assets and quality. The index system is as shown in Figure 1.

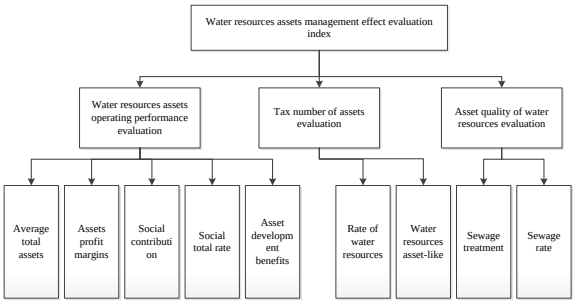

***Figure 1**: Water resources assets management effect evaluation index*

Specific meanings of related indexes are as following:

(1)Evaluation index of water resource asset operation situation, water resource asset operation situation is mainly evaluated from enterprise asset scale, profit level, contribution amount and level to society etc.

There are following several aspects:

① Average total asset, average total asset is the average value between total asset at initial stage and total asset at middle stage. It is an important index of confirming the operation scale of inspected unit.

Express in formula as the following:

Average total asset=(total asset at initial stage + total asset at end stage)/2

② Asset profit margin, asset profit margin is the ratio between gross profit within the period and average total asset within the period. Express in formula as the following:

Asset profit margin=total profit/average asset×100%

③ Social contribution rate, social contribution rate is the ratio between total social contribution within the period and average total operation asset within period.

Express in formula as the following:

Social contribution rate= (total social contribution within the period/average total operation asset within period) ×100%

In the above formula, total operation asset within period is the difference between average total asset and average total asset of non-operating asset. Express in formula as the following:

Average total operating asset within the period= average total asset-average total asset of non-operating asset.

④ Social accumulation rate, social accumulation rate relates to the ratio between total tax of operating and management unit handed over to the country within the evaluation period and total social contribution of water resource asset operation management unit within the period. While the total tax handed over to the country refers to value-added tax should be paid, product sales tax should be handed over and additional, income tax payable and other tax etc. Calculation formula of social accumulation rate is as following:

Social accumulation rate= (total tax handed over to the country within the period/ total social contribution of water resource asset operation management unit within the period) ×100%

⑤ Water resource asset development return rate, it refers to the ratio between water resource asset charge within evaluation period or net profit and corresponding operating cost within the period. Operation cost within the period is the sum between amortization amount of water resource asset development asset within period and expenditure of water resource asset operation management fee. Calculation formula is as following:

Water resource development return rate=(water resource asset development charge of this period or total return amount/ amortization amount of water resource asset development asset within period + expenditure of water resource asset management) ×100%

In the formula, water resource asset charge or return refers to the income attained from legal operation, sale or lease of asset of water resource asset.

(2) Water resource asset amount evaluation index. ① Water resource rate, it refers to the ratio between total water resource within evaluation period and average total water resource of multiple periods. Average water resource within the period and multiple periods is an index reflecting water resource level within evaluation period. Water resource rate can be expressed as following in formula:

Water resource rate= (water resource within the period/average total water resource of multiple periods) ×100%

② Asset ratio of water resource, it is ratio between total water resource asset within evaluation period and total water resource within period. It can be expressed with formula as following: Asset ratio of water resource=total water resource asset within period/total water resource within period ×100%. Asset ratio of water resource is an index reflecting development and construction degree of water resource, management level and water level. Asset ratio of water resource may be bigger than 1 or smaller than 1, the bigger value, the higher development construction and management level and utilization degree, vice versa.

(3) Evaluation index of resource asset quality, the evaluation of the difference of water resource asset quality is mainly presented in the relationship between quantity of sewage, waste water, treatment level, actual discharge of sewage and total water resource within management range.

① Sewage treatment rate, it is an important index of managing sewage treatment and reuse capacity within the basin of management range. Calculation formula is as following: sewage treatment rate=total sewage treatment within management range of the period/total discharge of waste water within management range of the period×100%

In the formula, total sewage treatment=total discharge of sewage and waste liquid within the management range of the period-actual discharge of sewage.

② Sewage rate, it refers to the sewage content in water and can be expressed as following formula:

((Total discharge of waste liquid within management range of period-total amount of sewage treatment within management range of the period)/total water resource within the period) ×100%

3. Water resource asset operation management performance evaluation model based on entropy theory

3.1 Standardized method of evaluation index

The dimensions of water resource asset operation management evaluation index are different and it needs to make standardized treatment. Set that there are n evaluation indexes and m evaluation objects, the index value of No. j index of No. i evaluation object; the types of index can be benefit type and cost type.

(1) Benefit index, the bigger benefit index, the better, adopt range conversion formula as:

$$r_{ij} = \frac{\left(X_{ij} - \min\limits_{i} X_{ij}\right)}{\min\limits_{i} X_{ij} - \min\limits_{j} X_{ij}} \qquad (1)$$

(2) Cost index, the smaller cost index, the better, conversion formula as:

$$r_{ij} = \frac{\left(\max\limits_{i} X_{ij} - X_{ij}\right)}{\max\limits_{i} X_{ij} - \min\limits_{j} X_{ij}} \qquad (2)$$

3.2 Water resource asset operation management performance evaluation based on entropy theory

(1) Entropy of evaluation index

Entropy is to use the entropy theory in information theory to confirm the relative importance degree of decision index. The entropy of each index reflects the information amount provided by different evaluation objects [7]. It is determined by the internal contradictions, positions and mechanisms among indexes and represent the fixed information of evaluation object.

Assume there are m evaluation objects, n evaluation indexes, the property value of No. j index of No.i evaluation object is x_{ij} and make standardized processing for xij to attain r_{ij}. Make normalization processing for r_{ij} to attain one set of discrete distribution value:

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad (i = 1,2,\cdots,m,\ j = 1,2,\cdots,n) \qquad (3)$$

Based on the concept of entropy, the uncertainty of relative importance of evaluation index j to decision program i can be measured by entropy.

$$E_j = -\sum_{i=1}^{m} p_{ij} \ln p_{ij} \quad (j = 1,2,\ldots,m) \qquad (4)$$

It can be learnt from entropy weight that, when pij (i=1,2,…,m) is equal, entropy is the biggest, which is Emax=lnm.

Define the relative entropy of No. j index as following:

$$H_j = \frac{E_{\max} - E_j}{E_{\max}} \qquad (5)$$

It can be learnt from the property of entropy that Hj∈[0,1], the smaller relative entropy Hj, the closer to each index. So choose relative entropy to quantify the amount of information provided by each index.

Make normalization processing for entropy and attain the entropy of each index:

$$W_j = \frac{H_j}{\sum_{j=1}^{n} H_j} = \frac{1 - \overline{E_j}}{n - \sum_{j=1}^{n} \overline{E_j}} \qquad (6)$$

$$\overline{E_j} = -\frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \qquad (7)$$

It can be learnt from above definition and property of entropy function that entropy is with following properties:

① When the value of each decision object on index j is completely the same, entropy achieves the biggest value; when the entropy is zero, it means that this

index does not provide any user information to decision maker and this index can be considered to cancel [8].

② when there is big difference between the values of each decision object on index j, the smaller entropy value, the bigger entropy and it indicates that this index provides useful information to decision maker.

③ The bigger entropy of index j, the smaller entropy weight, the less important of this index, and the entropy weight of index j meets the following conditions:

④ As the entropy of weight, it has the special significance. It indicates the coefficient of relative motivation after given decision object and under the situation that each decision is confirmed. Considering from the perspective of information, entropy g_j represents how much degree of this index j providing useful information on decision making problem and the entropy is in direct relationship with decision object.

(2) Water resource asset operation management performance evaluation model based on entropy theory.

Set up water resource asset operation management effect evaluation model of entropy theory based on the entropy of evaluation index.

$$G = R \cdot W = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_m 2 & \cdots & r_{mn} \end{bmatrix} \cdot \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_n \end{bmatrix} \quad (8)$$

Attain gi value of different evaluation objects based on above formula, the bigger gi value, the better effect of water source asset operation management of evaluation object, take this as evaluation basis.

4. Empirical research-Water resource asset management performance evaluation in Shenzhen city

As the water resource asset management in Shenzhen city is at preliminary stage and a lot of indexes are still in statistics [10-12]. Here only take one Reservoir Administration Bureau in Shenzhen city as example and calculate the effect of water resource asset operation management in this unit. Based on the meaning of water resource asset operation management effect evaluation index, related index data statistics are as shown in table 1.

Because the dimensions of each index are different, carry out standardized treatment, in which sewage rate belongs to index that the smaller the better, all the others belong to the type that the bigger the better. Standardized results are as following in the following: based on the basic principle of entropy theory, calculate the entropy of each index, as shown in table 2 and table 3.

***Table 1**: Performance evaluation of water resources assets management data*

The project name	indicators	Points indicator	2002 index values	2003 index values	2004 index values
Performance evaluation of water resources assets management data	Water resources assets management status indicators	Average total assets	2854	3252	4125
		Assets ratio profit rate	14%	15%	14%
		Social contribution	10%	12%	16%
		The social accumulation rate	5%	5%	9%
	Quantitative index of water resources assets	Asset development yields	9%	4%	6%
		Rate of water resources	98%	96%	96%
		Green water is produced	0.2	1.1	1.3
		Sewage rate	30%	36%	52%
		Sewage treatment	30%	35%	41%

***Table 2:** Index standardization results*

The project name	indicators	Points indicator	2002 index values	2003 index values	2004 index values
Performance evaluation of water resources assets management data	Water resources assets management status indicators	Average total assets	0	0.25	1
		Assets ratio profit rate	0.69	0	1
		Social contribution	0	0.36	1
		The social	0.64	0	1

	accumulation rate			
Quantitative index of water resources assets	Asset development yields	0.62	1	0
	Rate of water resources	0.5	0.52	0
	Green water is produced	1	0.68	1
	Sewage rate	0	1	0.62
	Sewage treatment	0	0.63	1

Table 3: *The index of entropy*

The project name	indicators	Points indicator	entropy index
Performance evaluation of water resources assets management data	Water resources assets management status indicators	Average total assets	0.125
		Assets ratio profit rate	0.124
		Social contribution	0.104
		The social accumulation rate	0.174
	Quantitative index of water resources assets	Asset development yields	0.136
		Rate of water resources	0.116
		Green water is produced	0.108
		Sewage rate	0.108
		Sewage treatment	0.107

Water resource asset operation situation evaluation result is:

$$G_1 = R_1 \cdot W_1 = [0.214 \quad 0.145 \quad 0.174 \quad 0.195 \quad 0.123] \cdot \begin{bmatrix} 0 & 0.201 & 1 \\ 0.362 & 0 & 1 \\ 0 & 0.352 & 1 \\ 0.625 & 0 & 1 \\ 0.541 & 1 & 0 \end{bmatrix} \quad (9)$$
$$= (0.232 \quad 0.362 \quad 0.851)$$

It can be learnt that for the water resource asset operation situation, the asset operation situation in 2004 is the best between 2002 and 2004, followed by 2002.

Similarly, calculate evaluation result of water resource asset number situation is:

$$G2 = R2 \cdot W2 = (0.523 \quad 0.452) \cdot \begin{bmatrix} 1 & 0.251 & 0 \\ 0 & 0.625 & 1 \end{bmatrix} \quad (10)$$
$$= (0.521, 0.415, 0.478)$$

In view of the number of water resource asset, the water resource is being polluted continuously, capital number situation decreases continuously. The evaluation result of water resource asset quality index is:

$$G_3 = R_3 \cdot W_3 = \begin{bmatrix} 0 & 1 & 0.623 \\ 0 & 0.521 & 1 \end{bmatrix} \quad (11)$$
$$= (0, 0.585, 0.858)$$

It can be learnt from the calculation results that the water resource asset quality increases continuously from 2002 to 2004. The evaluation result of total water resource asset operation management effect is:

$$G = R \cdot W = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_m 2 & \cdots & r_{mn} \end{bmatrix} \cdot \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_n \end{bmatrix} \quad (12)$$
$$= (0.302 \quad 0.412 \quad 0.541)$$

It can be learnt that in the evaluation years of the water resource asset operation effect in this unit, 2004 is the best, followed by 2003, from 2003 to 2004; the increase range is the biggest.

5. Conclusions

This paper has constructed water resource management performance evaluation index system based on entropy theory model and on the basis of interpreting the strictest water resource management system comprehensively, constructed the strictest water resource management performance evaluation safeguard measure system, proposed key safeguard measures and finally made application and inspection for evaluation model, which provides theoretical reference and guide of action for implementing water resource management idea. Main research conclusions are as following:

(1) Learn from the concept of environment performance evaluation, clarify the concept of water resource management performance evaluation, elaborates the necessity and important significance of implementing water resource management performance evaluation work and propose countermeasure suggestions for constructing water resource management performance evaluation system reasonably as well as the idea of water resource management performance evaluation; analyze the idea of evaluation index system construction and concept framework of index selection, point out the principle and idea of index screening and construct water resource management performance evaluation system based on pressure-state-response model [13-15]; introduce water resource management performance index, select entropy theory method as performance evaluation method and provide simple, convenient and operable method for the specific

implementation of water resource management performance evaluation work [16-17].

(2) Consider about expert comments and suggesting on the basis of the constructed general index system and by combining the specific situation in one city, attain suitable index system suitable for Zhengzhou city through screening and further adopt principal component analysis and independent analysis method to establish water resource management performance evaluation index system of one city; evaluate water resource management performance in one city, evaluation result and reality are with good consistency, which can provide reference for one city to implement water resource management evaluation work.

References

[1] J. R. Goode, C. H. Luce, J. M. Buffington, Enhanced sediment delivery in a changing climate in semi-arid mountain basins: Implications for water resource management and aquatic habitat in the northern Rocky Mountains, Geomorphology, Volume 139-140, Issue 4, PP 70-84, 2012.

[2] Y. P. Li, G. H. Huang, S. L. Nie, An interval-parameter multi-stage stochastic programming model for water resources management under uncertainty, Advances in Water Resources, Volume 29, Issue 5, PP 776-789, 2006.

[3] R. A. Gibboney, J. M. Gould, SEBAL Model with Remotely Sensed Data to Improve Water-Resources Management under Actual Field Conditions, Journal of Irrigation & Drainage Engineering, Volume 131, Issue 1, PP 85-93, 2005.

[4] S. Dessai, M. Hulme, Assessing the robustness of adaptation decisions to climate change uncertainties: A case study on water resources management in the East of England, Global Environmental Change, Volume 17, Issue 1, PP 59-72, 2007.

[5] E. Birol, K. Karousakis, P. Koundouri, Using economic valuation techniques to inform water resources management: a survey and critical appraisal of available techniques and an application, Science of the Total Environment, Volume 365, Issue 1-3, PP 105-122, 2006.

[6] T. H. Snelder, B. J. F. Biggs, Multiscale River Environment Classification For Water Resources Management, Jawra Journal of the American Water Resources Association, Volume 38, Issue 5, PP 1225-1239, 2007.

[7] R. Ragab, C. Prudhomme, Climate change and water resources management in arid and semi-arid regions: prospective and challenges for the 21st century, Biosystems Engineering, Volume 81, Issue 1, PP 33-34, 2002.

[8] I. Winz, G. Brierley, S. Trowsdale, The Use of System Dynamics Simulation in Water Resources Management, Water Resources Management, Volume 23, Issue 7, PP 1301-1323, 2009.

[9] S. Hajkowicz, A. Higgins, A comparison of multiple criteria analysis techniques for water resource management, European Journal of Operational Research, 2008, 184(1):255-265. Volume 12, Issue 22, PP 70-84, 2005.

[10] A. Castelletti, R. Soncini-Sessa, Bayesian Networks and participatory modelling in water resource management, Environmental Modelling & Software, Volume 22, Issue 8, PP 1075-1088, 2007.

[11] C. Pahl-Wostl, E. Mostert, D. Tàbara, The Growing Importance of Social Learning in Water Resources Management and Sustainability Science, Ecology & Society, Volume 13, Issue 2008, PP 439-461, 2008.

[12] B. Mitchell, Integrated water resource management, institutional arrangements, and land-use planning, Environment & Planning A, Volume 37, Issue 8, PP 1335-1352, 2005.

[13] E. Friedler, Water reuse — an integral part of water resources management: : Israel as a case study, Water Policy, Volume 3, Issue 1, PP 29-39, 2001.

[14] P. Jeffrey, M. Gearey, Integrated water resources management: lost on the road from ambition to realisation?, Water Science & Technology A Journal of the International Association on Water Pollution Research, Volume 53, Issue 1, PP 1-8, 2006.

[15] J. Tjell, A DSS for water resources management under uncertainty by scenario analysis, Environmental Modelling & Software, Volume 20, Issue 8, PP 1031-1042, 2005.

[16] M. B. Charlton, N. W. Arnell, Adapting to climate change impacts on water resources in England—An assessment of draft Water Resources Management Plans, Global Environmental Change, Volume 21, Issue 1, PP238-248, 2011..

[17] D G. Lorenzini, O Saro. Analysis of Water Droplet Evaporation through a Theoretical-Numerical Model, International Journal of Heat and Technology, Volume 34, Issue S2., S189-S198, 2016.