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DELIVERING QUALITY SCIENCE TO THE WORLD

Evaluation of Sustainable Utilization of Water Resources in Hubei province

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Abstract: Considering the demand of social and economic development and the impact of ecological environment in the accelerating process of urbanization, a comprehensive evaluation system of water resources in Hubei province based on new-type urbanization was established. Based on the data to predict theory, using the rough set of evaluation index system of filtering, neural network forecasting method of urban comprehensive evaluation and prediction of water resources sustainable utilization, to establish the prediction model of urban water resources sustainable utilization evaluation and use the evaluation model of sustainable utilization of water resources in Hubei province data to carry on the empirical analysis, comprehensive evaluation of sustainable utilization of water resources for the city to provide decision-making basis.
Keywords: Water resources, sustainable utilization, evaluation.

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1. INTRODUCTION

Hubei Province is known as the “Thousand Lakes Province”. Water resource is one of its most advantageous resources and an important guarantee for the development of social economy and urbanization in Hubei Province. However, for a long time, due to management disorder, over-development, and weak protection, the current "famous name" has not been consistent with the actual situation. Therefore, it is necessary and urgent to combine the concept of sustainable development with the economy, the environment and the society to provide technical support and decision-making guidance for improving the sustainable use of urban water resources and promoting social and economic development.

2. EVALUATION INDEX SYSTEM CONSTRUCTION

At present, the academic research on the sustainable use index system of urban water resources has made some achievements, but any paper or research cannot cover the entire content of urban water resources sustainable use evaluation. Based on the literature related to the sustainable evaluation of water resources [1-2], this study takes the sustainable development theory as the starting point, combines the concept of sustainable development with the economy and the environment, and comprehensively considers the socio-economic-water-ecological environment. The urban water resources evaluation index system is shown in Figure 1.In the evaluation system, it is divided into three subsystems: social economy, water resources and ecological environment. Under each subsystem, there are detailed index criteria, and there are 18 index criteria.

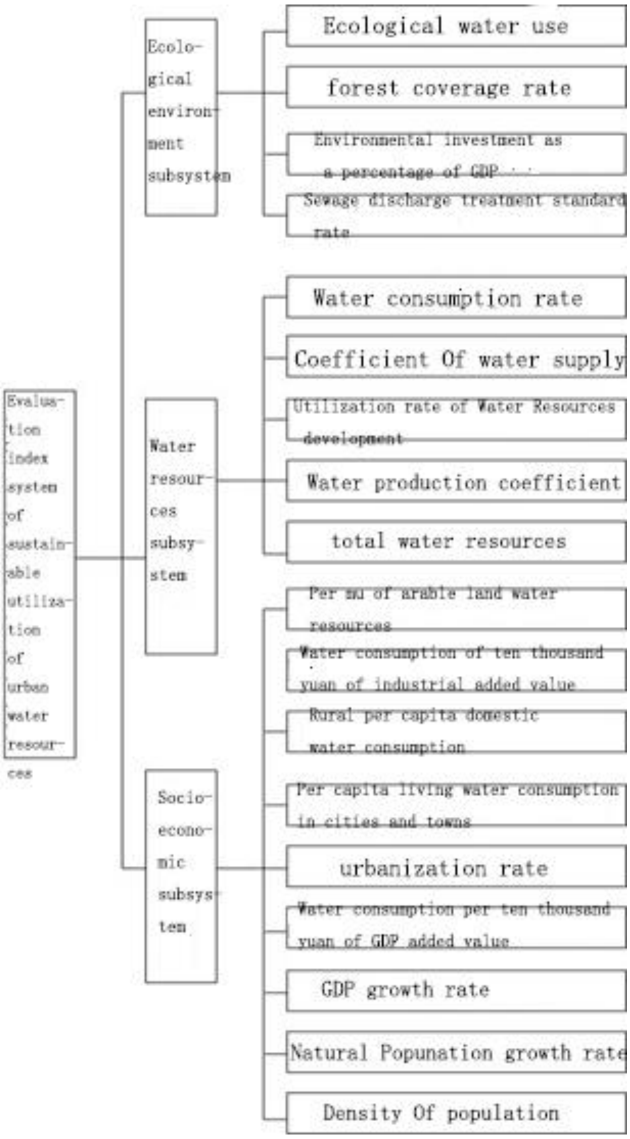

Fig. 1 Index system

3. EVALUATION MODEL CONSTRUCTION

In this study, the rough set reduction algorithm based on dependence and attribute importance is used to extract the key evaluation indicators, and then the BP pattern recognition network is used to learn the training data of urban water resources sustainable use evaluation, and the final evaluation result is obtained.

3.1 Rough set algorithm based on dependency degree and attribute importance to extract key indicators

The attribute reduction algorithm based on dependency degree and attribute importance can quickly extract key attribute indicators to reduce the number of input neurons in bp neural network and accelerate the training process of bp network.

Algorithm Description: Set $x \in C$ For an attribute, $X \subseteq C$ a subset of attributes; a subset of any object $X \subseteq U$, $\underline{R}(X) = \{X \in U \mid [X]_{ind(B)} \subseteq X\}$ for X on B The next approximation. $POS_R(X) = \underline{R}(X)$ for X The positive domain. definition D Correct c Dependency is $r_c(D) = |POS_c(D)| / |U|$ Available by dependency x for X The importance of the attribute is $sig_x(x) = r_c(D) - r_{c-\{x\}}(D)$ 。 When attribute x for X When it is not important, $sig_x(x)$=0, solve each attribute $sig_x(x)$,will $sig_x(x) \neq 0$ The attributes are added to the result set and eventually form a reduction[3-4].

3.2 BP network training simulation model

The most commonly used in practice is the three-layer BP neural network. Given a *Sigmoid* type network with M samples $(x_k, y_k)(k = 1,2,3,...,M)$, for a certain input x_k , the network output is y_k , the output of the i node is O_{ik} , the input of the j node is $net_{jk} = \sum_i w_{ij} O_{ik}$, and the error function is defined as $E = \frac{1}{2}\sum_{k=1}^{m}(y_k - o_k)^2$.

If j is the output node, then

$$O_j = f(net_j)$$

$$w_{ij} = w_{ij} + \alpha\delta_j o_i = w_{ij} + \alpha f'(net_j)(y_j - o_j)o_i$$

$$= w_{ij} + \alpha \cdot O_j \cdot (1 - O_j) \cdot (y_j - O_j) \cdot O_i$$

$$\begin{aligned} \delta_j &= -\frac{\partial E}{\partial net_j} = -\frac{\partial E}{\partial o_j} \cdot \frac{\partial o_j}{\partial net_j} \\ &= -\frac{\partial E}{\partial o_j} \cdot f'(net_j) \\ &= \text{-}(\mathrm{y}_j - O_j) f'(net_j) \end{aligned} \tag{1}$$

If j is a hidden layer node (non-output node), then

$$w_{ij} = w_{ij} + \alpha\left(\sum_{k=1}^{H_k}\delta_k w_{jk}\right) \cdot f'(net_j) \cdot o_i$$

$$= w_{ij} + \alpha \cdot \left(\sum_{k=1}^{H_k}\delta_k w_{jk}\right) \cdot O_j \cdot (1 - O_j) \cdot O_i$$

$$\delta_j = -\frac{\partial E}{\partial net_j} = -\frac{\partial E}{\partial o_j} \cdot \frac{\partial o_j}{\partial net_j}$$

$$\frac{\partial E}{\partial o_j}=\sum_{k=1}^{H_k}\left(\frac{\partial E}{\partial net_k}\cdot\frac{\partial net_k}{\partial o_j}\right)$$

$$\frac{\partial net_k}{\partial o_j}=\frac{\partial\left(\sum_{j=1}^{H_h}w_{jk}o_j\right)}{\partial o_j}=w_{jk}$$

As a result,

$$\delta_j=-\frac{\partial E}{\partial o_j}\cdot f'(net_j)=-\left(-\sum_{k=1}^{H_k}\delta_k w_{jk}\right)\cdot f'(net_j) \tag{2}$$

Assuming that there are N layers, and the NTH layer only contains output nodes, the BP algorithm design is as follows:

Step1: input the initial weight W

Step2: repeat the following process until convergence:

(1) From the first layer to the N layer

Calculation, and (signal positive transmission process);

Reverse calculation from N to 2 for each layer (error back propagation process);

(2) For the same node, it is calculated by equations (1) and (2)

Step3: modify the weight;

Through the above process, the established neural network model can be used for the evaluation and prediction of the later sample data.

4. ACCESS TO RAW DATA

The water resources evaluation data used in this paper are derived from the China Statistical Yearbook, the China Water Resources Bulletin, the Hubei Provincial Statistical Yearbook, the Hubei Provincial Water Resources Bulletin, the Hubei Provincial Environmental Status Bulletin and related departments. Considering the difficulty and consistency of data acquisition, the data of Hubei Province from 2008 to 2016 were collected and verified as evaluation data. It is shown in Table 1.These data will be used as data to improve BP neural network validation.

Table 1: data set of water resource utilization in hubei province from 2008 to 2016

The sample sequence		2008	2009	2010	2013	2014	2015	2016
condition attribute	C1	1033.95	825.28	1268.72	790.15	914.3	1015.63	1498
	C2	55.6	44.4	68.2	42.5	49.2	54.6	80.6
	C3	26.2	34.1	23	36.93	31.54	29.66	18.82
	C4	14.6	15.1	15.7	15.7	16.1	16.3	16.5
	C5	46.9	46.3	44.2	44.2	44.3	43.3	42.5
	C6	328.7	330.4	332.2	311.9	322.1	322.1	316.6
	C7	2.7	3.5	4.3	4.93	4.9	4.5	5.07
	C8	13.4	13.5	14.8	10.1	9.7	8.9	8.1
	C9	241	218	186	111	100	102	87

	C10	45.2	46	49.7	54.51	55.67	56.85	58.1
	C11	163	163	169	165	165	164	163
	C12	47	57	62	71	72	72	94
	C13	231	196	185	77	70	81	75
	C14	409	460	428	419	431	430	320
	C15	26.77	31.14	38.4	38.5	38.5	39.1	38.9
	C16	93.7	95.9	96.8	96.7	97.1	97.2	97.2
	C17	1.58	1.62	1.7	1.81	1.88	1.88	1.92
	C18	0.032	0.078	0.071	0.078	0.079	0.082	0.084
decision attributes D		good	general	general	general	good	good	good

The data in Table 1 is standardized and shown in Table 2.

Table 2: Standardized data sample set

The sample sequence		2008	2009	2010	2013	2014	2015	2016
condition attribute	C1	0.344423254	0.049629159	0.676089567	0	0.175390266	0.318542064	1
	C2	0.343832021	0.049868766	0.674540682	0	0.175853018	0.317585302	1
	C3	0.407509663	0.843732744	0.230811706	1	0.702374379	0.598564329	0
	C4	0	0.263157895	0.578947368	0.578947368	0.789473684	0.894736842	1
	C5	0	0.136363636	0.613636364	0.613636364	0.590909091	0.818181818	1
	C6	0.172413793	0.088669951	0	1	0.497536946	0.497536946	0.768472906
	C7	0	0.337552743	0.675105485	0.94092827	0.928270042	0.759493671	1
	C8	0.791044776	0.805970149	1	0.298507463	0.23880597	0.119402985	0
	C9	0	0.149350649	0.357142857	0.844155844	0.915584416	0.902597403	1
	C10	0	0.062015504	0.348837209	0.721705426	0.811627907	0.903100775	1
	C11	1	1	0	0.666666667	0.666666667	0.833333333	1
	C12	1	0.787234043	0.680851064	0.489361702	0.468085106	0.468085106	0
	C13	0	0.217391304	0.285714286	0.956521739	1	0.931677019	0.968944099
	C14	0.364285714	0	0.228571429	0.292857143	0.207142857	0.214285714	1
	C15	0	0.354420114	0.943227899	0.9513382	0.9513382	1	0.9837794
	C16	0	0.628571429	0.885714286	0.857142857	0.971428571	1	1
	C17	0	0.117647059	0.352941176	0.676470588	0.882352941	0.882352941	1
	C18	1	0.115384615	0.25	0.115384615	0.096153846	0.038461538	0
decision attributes D		3	2	2	2	3	3	3

5. MODEL APPLICATION AND IMPLEMENTATION

Discretize the data normalized in Table 2, and then use the rough set attribute reduction algorithm above to reduce the table data to obtain the reduction set {c1, c3, c4, c5, c7, c8, c9, c11, C14, c15, c16, c18}, which is used as the input layer of the BP neural network, the number is 12.Since the final evaluation result can only be one of “good”, “general”, “poor”, and “unsustainable use”, the number of output layer nodes of the BP neural network is set to 1.A three-layer BP neural network is established with Matlab7. The network structure is 12-7-1, that is, there are 12 input layer neurons, one output layer neuron is 1, and the number of hidden layer nodes is 7, calculated by the formula. n, m are the number of input and output neurons, respectively.

The network training used 20 actual samples from 2010 to 2015 in Hunan Province and Henan Province. The original data were from the Hunan and Henan Statistical Yearbooks and the Hunan and Henan Water Resources Bulletin. The 12 evaluation indicators will be reduced {c1, The sample data corresponding to c3, c4, c5, c7, c8, c9, c11, c14, c15, c16, c18} trains the BP neural network, and the target value is returned to the mapping range of the logarithmic sigmoid function. The process is processed into a number between [0, 1].After 320 steps of training, the network mean square error has reached the standard of 0.0001.So far, the urban water resources sustainable utilization evaluation model based on the rough set-BP neural network has been established. Only the normalized sample data can be input to the model in the later stage, and the evaluation sample can be evaluated.

Next, the data of Hubei Province 2008-2016 in Table 2 is taken as a test sample, and the simulation model is used to perform the simulation operation to verify the accuracy of the model. It can be seen from Fig.2 that the fitting effect is good and has good promotion ability. The above results show that the error between the output value and the real value of the model is relatively small, and the performance can meet the requirements of practical applications.

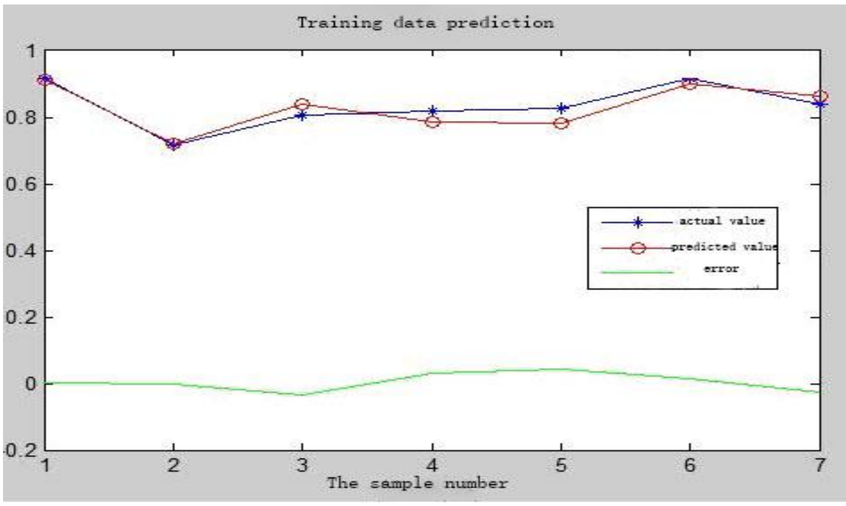

Fig.2 Training data prediction

6. CONCLUSIONS AND RECOMMENDATIONS

An improved BPNN model using the constructed urban water resources sustainable use assessment. Through the simulation evaluation of the longitudinal evaluation of water resources sustainable utilization data from 2008 to 2016 in Hubei Province, the results show that it is reasonable and feasible to evaluate the sustainable use of urban water resources by using the improved BPNN evaluation model designed by this study. Sexuality provides support for the implementation of urban water resources sustainable use evaluation management.

The sustainable development and utilization of urban water resources in our province should take the following measures:

(1) It must be adhered to the principle of “open source and throttling”. Open source focuses on strengthening the construction of water supply projects, adopting various measures of water storage, water conservation and water transfer, and tries every means to open up water sources. The throttling

is to focus on the whole society's water conservation, vigorously carry out water-saving society construction, increase pollution control in water-deficient areas, and strengthen the protection of drinking water sources; actively promote cross-basin in resource-deficient areas, The construction of regional water transfer projects; the addition of water storage facilities, citing the resources of abundant water resources during the dry season, and solving the “structural” water shortage caused by the differences in time and space of water resources in Hubei Province.

(2) Enhance residents' awareness of water saving. Under the premise of urbanization development in Hubei Province, it is particularly urgent to improve the efficiency of urban domestic water use.

(3) Implement water ecological management projects to achieve rain and sewage diversion. The industrial wastewater and domestic sewage in the urban area are all treated by the urban sewage treatment plant, and the sewage from the villages around the lake enters the sewage pipeline. At the same time, it is recommended to divert the kitchen sewage and the toilet sewage pipe from the architectural design, build the septic tank in the community, and regularly dry and clean the supply. Implement wetland protection and restoration projects to improve the self-repairing capacity of lake wetlands.

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