Evaluation on Ecological Security of Hangzhou Urban Land based on BP Neural Network

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Keywords: Land ecology, Security evaluation, BP neural network

Abstract. Take Hangzhou as an example, ecological safety evaluation of urban land provides the basis for promoting urban ecological security.21 indicators were chose to set up the evaluation system. By using BP neural network method, the study followed is trying to evaluate ecological security of urban land. The 2001 to 2007 data for all indicators as input nodes of neurons, the neural network training. Then enter the 2008-2010 data of the indicators, and finally get the sub-level of security evaluation results. And the result shows that the security level of Hangzhou's in 2008 and 2009 are bothⅢ, and its Ⅳin 2010. Finally, BP neural network is able to achieve the purpose no evaluating the ecological security of urban land. And it takes an important part in exploring a new way for security of urban land as well.

Introduction

Land ecological security means that land resource is used and managed rationally to make land resource ecological condition meet social and economic development needs, the utilization of land resource can keep coordinated relationship with social and economic development, and land resource is in the healthy and balanced safe state without the restriction and threat of ecological environment [1]. Urban land ecology is a system with limited bearing capacity. When the pressure of nature, economy and society is too high, the urban land ecological system is broken, which damages the life and property security of the people. In recent years, with the development of social economy, the local urban land ecological security is broken, and urban land ecological security becomes the focus in the society. Scientific evaluation on urban land ecological security not only helps to explore the road to protect the urban land ecological security, but also has great significance to promote sustainable development of nature, economy and society.

Urban Land Ecological Security Evaluation Model and Method

Evaluating land ecological security is in the exploration state in China [2]. The common evaluation methods include factor comprehensive evaluation method, gray correlation method, matter element analysis method and ecological footprint method. The methods generally use the regression statistic for evaluation such as linear or index model [3]. The relationship of influencing factors of land ecological security is very complicated, which is generally nonlinear relationship. Therefore, it is difficult to make correct description by a certain mathematical model. BP neural network algorithm has the advantages of great nonlinearity, good fault-tolerance and accurate computation. Using nonlinear evaluation methods can reduce the subjectivity of determining weight artificially. And using BP network can realize the approximation of any function, and the

evaluation result is more accurate. The paper uses BP artificial neural network to evaluate the urban land ecological security in Hangzhou from 2008 to 2010.

Establishing evaluation index system. Land ecological security system consists of land nature ecological security system, land economy ecological security system and land society ecological security system, which reflects the stability and sustainable development of land ecological security system. The paper makes comprehensive evaluation on urban land ecological system based on evaluating the subsystems of nature, economy and society. By referring to the literature relating to land ecological security at home and abroad, combined with the availability and typical representative rule of index data, 7 indexes were selected from land nature ecological system, land economy ecological system and land society ecological system. There are 21 indexes establishing land ecological security evaluation system in Hangzhou, as shown in Table 1.

Tab.1 Ecological security evaluation system of urban land

Objective layer	System layer	Index layer
		X1per capita cultivated land /hm2
		X2proportion of cultivated land /%
		X3coordination degree of water and soil /%
	Land nature ecological security	X4 forest coverage rate /%
		X5 green coverage rate in built-up area/%
		X6 water and soil erosion rate /%
		X7acid rain frequency /%
		X8 per capita GDP/yuan /people
		X9per capita net income of rural residents /yuan
		X10proportion of the tertiary industry in GDP /%
Urban land ecological security	Land economy ecological security	X11 proportion of social fixed asset investment in GDP/%
		X12 fertilizer use /kg/hm2
		X13pestcide use /kg/hm2
		X14PHGO /t/hm2
		X15 population density /people/km2
		X16natural population growth rate /‰
		X17employment rate /%
	Land society ecological security	X18urbanization level /%
		X19water resource per capita /L
		X20agricultural mechanization /kW/hm2
		X21number of utility cars per 10 000 person /tai

Standards of determining land ecological security level. According to the standards and literature at home and abroad [4-6], the paper divides the standards of evaluating land ecological security into five security levels.

BP neural network evaluation method. BP neural network is a multi-layer feedforward network which is trained according to error back propagation algorithm, which means that the learning process of error back propagation algorithm consists of forward propagation of information and back propagation of error. Learning rule means that the steepest descent method is used to adjust the weight and threshold of network by back propagation, which makes the error sum of squares of network minimal. The topological structure of BP neural network model includes input layer, hidden layer and output layer [7].

Each node of neural network is called neuron. The main function of each neuron of input layer is to receive the input information from the external, and pass it to the neuron of the middle layer. The

hidden-layer structure of the middle layer can be single layer or multi-layer structure, which processes the internal information. The determination of nodes of hidden layer decides the network performance, which is the most important part. The hidden layer completes self-learning process by a series of algorithms. The last hidden layer transfers the information to the output layer. The output layer outputs the final results and digital information to the external. When there is forward propagation, the input sample is introduced from the input layer. After being processed by each hidden layer, it is passed to the output layer. If the actual output of output layer is not consistent with the expected output, it turns to the back propagation of error. The back propagation of error passes the output error to the input layer, and delivers the error to all units of each layer. And the error signals of units of each layer are received. The error signal is the basis of remedying each unit weight. And the forward propagation of the signal and the back propagation of error is repeated, which is the learning process of network. The repeated modification of network parameters makes the final self-learning process. The weights of each layer are adjusted and remedied in self-learning process until the expected error accuracy is achieved.

The neuron network has n input neurons, m output neurons and p hidden-layer neurons, the output of neurons is [8],

$$x_i^{\ 1} = \sigma\left(\sum_{j=1}^{n} w_{ij}^0 x_j + w_{i0}^0\right), i = 1,2,\cdots, p \qquad (1)$$

The output of neurons of output layer is

$$y_i = \sum_{j=1}^{p} w_{ij}^0 x_j^1 + w_{i0}^0, i = 1,2,\cdots, m \qquad (2)$$

The action function (excitation function) of nodes generally selects logarithm S (sigmoid) type function.

$$f(x) = \frac{1}{1+e^{-x}} \qquad (3)$$

In the formula, w_{ij}^0 means the weight of the neurons of two layers.

Land Ecological Security Evaluation in Wuhan

Data source. The research data is from statistical yearbook in Hangzhou(2001~2010), environment condition report in Hangzhou(2001~2010), national economy and social development statistical report in Hangzhou(2001~2010), urban statistical yearbook in Hangzhou(2001~2010) and Hangzhou statistical information network, and some data is organized by the writer.

The value of sigmoid function and the output range of the last node of the network is [0,1], the samples must receive unitization processing firslty, which remits the influence of unit and order of magnitudes on evaluation results. In order to keep rationality, the influence of 0 and 1 is remitted, which makes the results close to the fact. Based on the general formalization formula (formula 4), 0.1 and(0.9－0.1)are added, and the formula (5) is used to make data distribute from 0.1 to 0.9 [9].

$$x_{ij} = \frac{x_{ij} - \min}{\max - \min} \qquad (4)$$

$$x_{ij}^{'} = 0.1 + \frac{(x_{ij} - \min)(0.9 - 0.1)}{\max - \min} \qquad (5)$$

The data of each year is a sample, and the total number of samples is 10, and the index is 21. Therefore, i＝1, 2,…,21; j＝1,2,…,10.

BP neural network evaluation results and analysis. Evaluation results, The data of indicators from 2001 to 2007 is used as the neuron node input, and the neural network is trained. The network receives learning, and the relationship between the evaluation results and each indicator is achieved. The index data from 2008 t0 2010 is input again, which finally gets the evaluation results of each subsystem security level (Table 4).

According to actual condition, we can get that there is a complicated nonlinear function relationship between each indicator and security degree of land ecological security in Hangzhou f（X_1, X_2, X_3, …, X_{21}）. Trough self-learning, BP neural network achieves the relationship between index and land ecological security degree, which can get the evaluation results from 2008 to 2010. The setting of training parameters of BP neural network is that the error is 0.0001, the number of hidden-layer neurons is 21, the learning rate is 0.1, sigmoid parameter is 0.9, and the maximal iteration times is 50 times. After the results operate for 10 times, the results are output. And the fitting error of sample is 6.26E- 5.

Tab.4 Level of ecological security of land evaluation results in Hangzhou from 2006 to 2008

Year	Land ecological security evaluation results of each subsystem			Comprehensive result
	nature	economy	society	
2008	0.768(Ⅲ)	0.865(Ⅳ)	0.723(Ⅲ)	0.787(Ⅲ)
2009	0.789(Ⅲ)	0.892(Ⅳ)	0.695(Ⅲ)	0.791(Ⅲ)
2010	0.813(Ⅳ)	0.910(Ⅴ)	0.678(Ⅲ)	0.801(Ⅳ)

Result analysis, From the relationship between each subsystem, the security evaluation result of each subsystem in Hangzhou from 2008 to 2010 from good to bad is land economy ecological security system, land nature ecological security system and land society ecological security system. On the other hand, the difference of security between land economy ecological system and land society ecological system is great. The reason is that the rapid development of economy in Hangzhou makes GDP increase and the proportion of the tertiary industry increase, which improves the land economy ecological security degree in Hangzhou. The security degree of land nature ecological security system benefits from higher water and soil coordination degree and less water and soil erosion in Hangzhou. However, the per capita cultivate land is less than the standard level in Hangzhou, so the nature ecological security system is not optimistic. The reason why the land society ecological system security degree is low is that high population density in Hangzhou has great influence on land society ecological system. In addition, the great difference between subsystems indicates that the land ecological subsystem in Hangzhou has the tendency of imbalanced development.

From the perspective of comprehensive evaluation results, the security degree of land ecological security system in 2008 is close to that in 2009, but that in 2010 is high. The reason is that Hangzhou is authorized as the comprehensive coordinated reform pilot region of national resource conservation and environmental friendly society, which has achievement in 2008.

Conclusions

The paper evaluates the ecological security of urban land in Hangzhou, and the aim is to explore the application of BP neural network model to urban land ecological security evaluation. The research indicates that BP neural network model overcomes the defect of great subjectivity of analytic hierarchy process and Delphi method. It can objectively evaluate urban land ecological security, and is an objective evaluation method. The evaluation results are consistent with the actual

condition in Hangzhou. By learning historical data, BP neural network can realize urban land ecological safety evaluation, which has great significance to explore urban land ecological security evaluation method, which proves that the method has great actual application value. There are problems when the method is applied, as follows. (1) network convergence speed is slow, which needs long training time. (2) the number of hidden layer of network and the selection of units has no theoretical guidance, which is determined based on experience and repeated experiments. (3) how to combine artificial neural network evaluation model and traditional evaluation method.

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