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Study on the Method of Calculating Damage Compensation for Natural Resource Assets Based on Value Assessment Models

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Abstract At present, ecological environmental protection and rational use of natural resources have become an important strategy for national development, and the establishment of a scientific system for calculating the damage compensation of natural resource assets is of great significance for promoting the construction of ecological civilization. In this paper, we constructed a natural resource asset damage compensation value assessment model based on IWOA-BP neural network, and established an accounting index system including land resources, biological resources and water and air regulation functions. The study adopts the improved whale optimization algorithm to optimize the weights and thresholds of the BP neural network, improves the uniformity of the initial population distribution through Sine chaotic mapping, and constructs a comprehensive accounting method for the value of land assets, the value of biological assets and the value of water and air regulation assets. The validity of the model was verified with Yulin City as the empirical research object. The results show that the IWOA-BP model is stabilized after 77 iterations, and has a faster convergence speed and higher prediction accuracy than the traditional BP, GWO-BP, and WOA-BP models. The average relative error of the model is controlled within 9.7452%, the average absolute error is 0.3013, and the root mean square error is 0.2241, and the assessment accuracy is significantly better than other algorithms. The total value of natural resource assets in Yulin City increased from 577,452.16 billion yuan to 577,934.63 billion yuan, and the value of land resources accounted for 64.94%. The model can effectively solve the problems of low accuracy and slow convergence of traditional methods in the calculation of natural resource asset damages, and provides a scientific and feasible calculation method for natural resource asset damages.

Index Terms Natural resource assets, damage compensation, value assessment model, IWOA-BP neural network, convergence speed, prediction accuracy

I. Introduction

In the United States, the ecological environment damages related relief means according to the relevant provisions of the public environmental law, under the leadership of the government, public participation, according to the relevant administrative procedures, is a kind of public law nature of the relief system [1]. China's natural resource asset damage compensation system, is based on China's unique national conditions of ecological and environmental elements of the means of relief [2]. With the development of practice, China's cognition of the value of natural resource assets, no longer limited to the field of ecological value, natural resource asset damage compensation system is in the overall promotion of natural resource asset property right system reform background, in order to fulfill the duties of the owner, safeguard the rights and interests of the owner and to explore the means of relief specifically for the damage of natural resource assets [3], [4].

At present, China's natural resource asset damage compensation value assessment method is not perfect enough, lagging behind the economic development and governance system, governance capacity modernization needs, economic growth of resource rights and interests have not been implemented, the property rights and interests of the pocket protection ability is not sufficient to support the sustainable development of resources, there is an urgent need for modernization, legalization and market-oriented reform [5]-[7]. In natural resource damage, natural resources belonging to the collective or individual ownership of natural resources can be based on natural resource management related laws to safeguard the rights and interests, but natural resource asset damage can only be based on natural resource management related administrative means, which can not reflect the asset nature of natural resources, affecting the fulfillment of the duties of the natural resource owners, and also easy to ignore the damage to the economic value of natural resource assets itself [8]-[11]. Therefore, to promote the research on the calculation method of compensation for damage to natural resource assets is the requirement of implementing the pilot task of the entrusted agent mechanism of natural resource asset ownership, and it is an inevitable way to implement the task of ecological civilization construction [12], [13].

As an important material basis for the development of human society, the assessment of the value of natural resources and the establishment of a mechanism for compensation for damages play an important role in promoting sustainable development. Against the background of increasingly prominent global environmental problems, how to scientifically and accurately assess the value of natural resource assets and establish a reasonable system for calculating damages has become a focus of attention for governments and academics. Natural resource assets are characterized by multifunctionality, complexity and dynamism, and their value composition involves multiple dimensions such as economic, ecological and social values, making it difficult for traditional single assessment methods to comprehensively reflect their true value. At the same time, natural resource damages are often characterized by lag, accumulation and irreversibility, and the calculation of damages needs to take into account multiple factors, such as changes in time series, differences in spatial distribution and ecosystem service functions. Existing assessment methods have limitations in dealing with these complex factors, and the accuracy and reliability of the assessment results need to be improved. In addition, the natural resource endowment of different regions varies greatly, requiring the establishment of an assessment framework that is both universally applicable and reflects regional characteristics. The rapid development of artificial intelligence technology provides new ideas for solving these problems, and machine learning methods such as neural networks have significant advantages in dealing with nonlinear, multidimensional, and big data problems, and are able to better explore the complex relationships and potential laws in natural resource value assessment.

Based on the above analysis, this study proposes to construct a natural resource asset damage compensation calculation method based on the value assessment model. Firstly, a natural resource asset accounting index system is established, which includes the three aspects of land, biological and water and air regulation functions, to ensure the measurability, universality and data accessibility of the indexes. Then the BP neural network is optimized by the improved whale optimization algorithm, and the uniformity of the initial population distribution is improved by the Sine chaotic mapping, which improves the global optimization ability and convergence speed of the algorithm. Then the calculation models of land asset value, biological asset value and water and gas regulation asset value are constructed to form a complete value assessment system. Finally, Yulin City is used as an empirical research object to verify the validity and practicability of the model, and the comparative analysis with the traditional method proves the advantages of the proposed method in terms of assessment accuracy and computational efficiency.

II. Construction of a system of accounting for damage to natural resource assets

II. A. Establishment of a system of accounting for damage to natural resource assets

II. A. 1) Principles for the construction of the indicator system

This study makes a preliminary attempt to construct a natural resource asset accounting indicator system, and in the process clarifies three basic principles for selecting natural resource asset accounting indicators:

(1) The selected accounting indicators must be measurable and can be quantitatively accounted for, which is a prerequisite for comprehensive accounting of the value of natural resource assets and can be connected with the existing national economic accounting system;

(2) The selected indicators must be universal and suitable for the actual situation of different types of natural resources in different regions of China, which is a necessary condition for the indicator system to be widely used;

(3) Indicator data should be easily accessible, which is an important guarantee that the indicator system can be practicable in practical application.

II. A. 2) System of indicators for accounting for damage to natural resource assets

From the perspective of ecology, a natural resource asset accounting indicator system has been established, which mainly includes the three major aspects of land, biology and water and air regulation functions; ecological background information has been investigated and collected; the theory of landscape ecology has been applied; and changes in the spatial and temporal patterns of asset values have been analyzed and researched through the methodology of the large-scale identification system of ecological elements and spatial analysis, so as to reflect the gains and losses of the natural assets of the study area as well as the trends of change.

For the accounting of land resource assets, forest land type and forest land area are selected as specific indicators to reflect the area of different types of land resources, which can be used to directly reflect the changes in the physical quality of land resource assets.

For the accounting of biological resources assets, the object of accounting is mainly vegetation resources.

For the accounting of water and air regulating function resource assets, natural resources are specifically selected as indicators for carbon sequestration, oxygen release, air purification and water conservation. In the accounting, the ecological service function calculation model is utilized to carry out the physical quality accounting of the above indicators.

II. B.Accounting for damages to natural resource assets

II. B. 1) Methodology for accounting for the value of land assets

The value of the land asset is measured by the land acquisition compensation rate for grassland, and the value of grassland revenue is reflected through the value of grassland production per unit area. The value of the natural assets of land is calculated by discounting the equivalent annuity, as shown in formula (1).

$$V_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} \cdot U_{lij} \tag{1}$$

where V_1 is the value of natural resource land assets (yuan); l represents the land; i represents the region; j represents the type of grassland; A_{ij} is the area of grassland j of i-region class (hectare); and U_{lij} is the compensation standard for the expropriation of land per unit area of grassland of class j in the i-region class (yuan/hectare).

II. B. 2) Methods of accounting for the value of biological assets

Including the value of land production and the value of the remaining vegetation on the ground (to avoid double counting here the vegetation on the ground refers to the portion of vegetation on the ground after subtracting the amount of grass production), of which the value of land production is calculated as shown in equations (2) and (3).

$$V_g = \sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} \cdot U_{gij} \tag{2}$$

$$U_{gij} = Y_{ij} \cdot K_{ij} \cdot P_g \tag{3}$$

where V_g is the value of land production (yuan); i represents the region; j represents the type of grassland; and A_{ij} is the area of grassland (hectares) in the j category in the i region; U_{gij} is the value of land production per unit area of grassland in region i, category j (yuan/ha); Y_{ij} is the grass yield per unit area of grassland of class j in region i (kg/ha); K_{ij} is the land availability rate of grassland of class j in region i (%); and P_g is the unit market selling price of the land in region i (yuan/kg).

The value of the remaining plants on the ground, calculated as shown in equations (4) to (6).

$$V_p = \sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} \cdot U_{pij} \tag{4}$$

$$U_{pij} = \left(G_{ij} - Y_{ij}\right) \cdot \frac{H_m}{H_p} \cdot P_m \tag{5}$$

$$G_{ij} = NPP_{ij} \cdot K_{pij} \tag{6}$$

where V_p is the value of the remaining plants on the land (yuan); i represents the region; j represents the land type; and A_{ij} is the area of land of the j class in the i region (ha).

II. B. 3) Methodology for accounting for the value of water and gas conditioning assets

It includes four aspects: carbon sequestration, oxygen release, air purification and water conservation.

(1) The formula for calculating the value of fixed CO_2 is shown in (7)-(8):

$$V_c = \sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} \cdot U_{cij} \tag{7}$$

$$U_{cij} = NPP_{ij} \cdot 1.19 \cdot P_c \tag{8}$$

(2) Release O_2 values are calculated as shown in equations (9) to (10):

$$V_o = \sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} \cdot U_{oij} \tag{9}$$

$$U_{oij} = NPP_{ij} \cdot 1.63 \cdot P_{oi} \tag{10}$$

(3) The air purification value (the value of SO_2 absorbed by vegetation) is calculated as shown in equations (11) to (12):

$$V_s = \sum_{i=1}^{n} \sum_{j=1}^{m} A_{ij} \cdot U_{sij} \tag{11}$$

$$U_{sij} = Y_{ij} \cdot K_s \cdot d \cdot C_s \tag{12}$$

(4) The value of culverted water is calculated as shown in equations (13) to (16):

$$V_w = \sum_{i=1}^{n} \sum_{j=1}^{m} A_{ij} \cdot U_{wij} \tag{13}$$

$$U_{wij} = W_{ij} \cdot C_{ia} \tag{14}$$

$$W_{ij} = \left(1 - \frac{AET_{ij}}{P_{ij}}\right) \cdot P_{ij} \tag{15}$$

$$C_{ia} = C_i \cdot \left[\frac{s \cdot (1+s)^t}{(1+s)^t - 1}\right] \tag{16}$$

III. Model for assessing the value of damages to natural resource assets

III. A. BP Neural Network

In this paper, we use BP neural network to establish a defect size parameter prediction model, BP neural network is a kind of multilayer feed-forward network trained in accordance with the error back propagation, which contains three kinds of layer structures, including the input layer, hidden layer, output layer, and each layer consists of a number of neurons [14]. When the forward propagation, the input layer information generates the output signal through the nonlinear transformation of the hidden layer; when the deviation of the output signal from the actual signal is larger than the pre-set training accuracy, it turns into the reverse propagation stage, and the deviation propagates step by step to the hidden layer of the network and the input layer, and adjusts the parameter of each neuron node, so that the error decreases along the direction of the maximum gradient; repeat the above process until the deviation reaches the training accuracy. Training stops.

BP neural network can realize this prediction demand in theoretical analysis, but there are still two deficiencies:

1) The selection of the number of nodes in the hidden layer is blind, which may lead to unsatisfactory prediction effect due to improper setting of the number of nodes in the hidden layer.

2) BP neural network built-in traingd, trainlm and other algorithms are easy to fall into the local optimal solution, so that the average prediction accuracy is still low after completing the preset number of training times.

For the above problems of BP neural network, the range of the number of nodes in the hidden layer is narrowed down by an empirical formula. Its expression is:

$$h = \sqrt{m+n} + a \tag{17}$$

where m is the number of nodes in the input layer; n is the number of nodes in the output layer; a is an integer from 1 to 10; h is the number of nodes in the hidden layer, which narrows down the selection range of the number of nodes in the hidden layer; and then the weights and thresholds of the IWOA optimized network are adopted to carry out a quantitative analysis of the weak magnetic detection inversion by using the optimized model of IWOA.

III. B. IWOA

In order to improve the non-uniformity of the initial population distribution of WOA, IWOA uses Sine chaotic mapping to generate the initial position of the population before starting the WOA iteration, which improves the uniformity of the initial distribution of the population and the global optimization seeking effect of the algorithm.The mathematical formula of Sine chaotic mapping is:

$$x_{i+1} = \mu \sin(\pi x_i) \tag{18}$$

where x_i is the iterative sequence value, i takes a non-negative integer, and $x_0 \in (0,1)$; μ is a system parameter, $\mu \in [0,1]$, and chaos occurs when $\mu \in (0.83, 0.93)$ and $\mu \in (0.95, 1)$.

III. C. IWOA-BP quantitative process

In response to the underperformance of BP neural network tuning, IWOA-BP neural network searches for the optimal weights and thresholds by IWOA and assigns them directly to BP neural network, and only fine-tunes them during the subsequent training of BP neural network, and the core of the whole process is that IWOA makes the BP neural network equipped with more optimal initial parameters.

The specific process of IWOA optimizing the BP neural network prediction model is as follows:

1) Data normalization. The variability of the sample data size and order of magnitude affects the effectiveness of the neural network in analyzing the data, which can be avoided by normalizing the data before training by calling the mapminmax function to normalize the input and output values of the samples to $\left[0,1\right]$.

2) Divide the training set and test set. There are several sets of sample data in the sample consisting of defective feature values and corresponding defective size parameters, which are divided into training set and test set according to a certain ratio.

3) Determine the optimal number of hidden layer nodes.

4) Initialize the whale population. The number of population individuals N, the maximum number of iterations T, the upper limit of the position vector - c, the lower limit $+c$, the dimension d, the dimension d is calculated as shown in Eq. (19), and the Sine chaotic mapping generates the initial population position.

$$d = h\left(m+n+1\right)+n \tag{19}$$

where h is the number of nodes in the hidden layer; m is the number of nodes in the input layer; n is the number of nodes in the output layer.

5) Calculate the individual fitness value, i.e., the training set prediction mean square error. The position vector of the individual with the smallest fitness value is the local optimal solution, and other individuals approach to it, the local optimal position vector is denoted as X^*, the current position vector of other individuals is denoted as X, and the distance vector between X and X^* is denoted as R, i.e.:

$$R = \left|C \cdot X^*(t) - X(t)\right| \tag{20}$$

$$X(t+1) = X^*(t) - A \cdot R \tag{21}$$

$$A = 2a \cdot r - a \tag{22}$$

where R is the distance vector; $\mathbf{X}^*(t)$ is the local optimal position vector; $X(t)$ is the current position vector; A is the distance coefficients; C is the coefficient vector; and a is the vector of linear decrements from 2 to 0; r is the random vector, $r \in [0,1]$.

6) When the distance coefficient $|A| \geq 1$ and the distribution of fish is concentrated, the whales feed by shrinking the encirclement, and the position is updated as shown in equation (23).

$$X(t+1) = X^*(t) - A \cdot R \tag{23}$$

When the distance coefficient is $|A| < 1$ and the fish are dispersed, the whales feed by spiraling upwards and the position is updated as shown in equation (24).

$$X(t+1) = \left|X^*(t) - X(t)\right| e^{bl} \cos(2\pi l) + X^*(t) \tag{24}$$

The above two position updating methods improve the local optimization seeking ability of IWOA.

When the distance coefficient is $|A| \geq 1$, the individual whale will search the fish school in a wide range, which improves the global optimization seeking ability of IWOA.

7) Repeat step 5) ~ step 6) to complete the number of iterations and output the optimal position vector.

8) BP neural network parameter assignment. Assign the elements in the optimal position vector to the BP neural network, and build the neural network inversion quantitative model.

9) Prediction of defect size parameters using BP neural network optimized by IWOA.

III. D. Assessment of the value of damages to natural resource assets

In order to verify the effect of IWOA-BP neural network for natural resource asset damage compensation assessment, traditional BP model, GWO-BP, WOA-BP, and IWOA-BP model are used to assess the resource data. Setting the BP neural network input nodes as 2, the hidden layer nodes as 5, the output layer nodes as 1, and the population size as 20, the experimental iteration is 350 times, and the algorithm performance comparison is shown in Figure 1. As can be seen from the figure, IWOA-BP is gradually stabilized after 77 iterations, and compared with the other two algorithms, the convergence speed is significantly faster and the error is smaller.

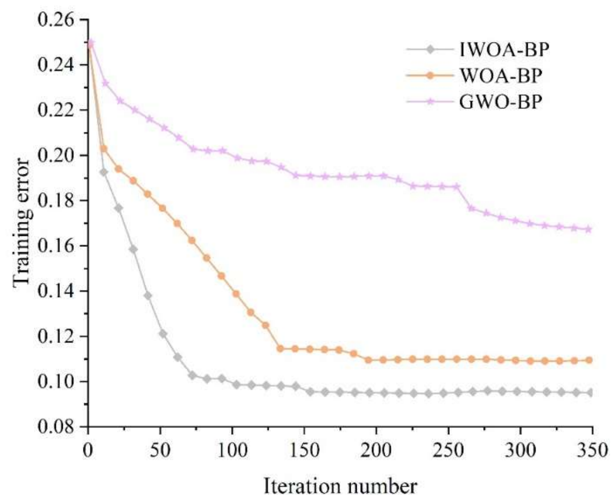

Figure 1: Comparison chart of algorithm optimization effect

The input sample set is used to verify the validity and accuracy of the IWOA-BP model by using the GWO-BP, WOA-BP model and the BP neural network model as a comparison. The evaluation data comparison is shown in Table 1. As can be seen from the table, comparing the damage level sample data, the evaluation results of the IWOA-BP algorithm are closest to the actual sample data.

Table 1: Comparison of evaluation data

Degree of damage	Actual	BP	GWO-BP	WOA-BP	IWOA-BP
Unimpaired	8	7	7	7	8
Mild damage	12	12	13	17	11
Moderate damage	18	21	16	12	17
Severe damage	21	17	22	23	21

In order to reflect the accuracy and validity of the prediction results, three evaluation indexes are selected to evaluate the prediction results. The three evaluation indexes are: the mean relative error (MAPE), the mean absolute error (MAD), and the root mean square error (RMSE), and the expressions are as follows:

$$P_{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \tilde{y}_i}{y_i}\times 100\%\right| \tag{25}$$

$$P_{MAD} = \frac{1}{n}\sum_{i=1}^{n}\left|y_i - \tilde{y}_i\right| \tag{26}$$

$$P_{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \tilde{y}_i\right)^2} \tag{27}$$

where y_i is the i th actual value; $\tilde{y}_i$ is the i th predicted value; and n is the total number of data.

The comparison of evaluation results is shown in Table 2. As can be seen from Table 2, the IWOA-BP model has the smallest error and the highest precision compared to the BP, GWO-BP and WOA-BP models, and the IWOA-BP model has an average relative error control of less than 10% for the evaluation results, and the average absolute error and the root-mean-square error are lower than the two models, which meets the requirements of the assessment of damages to natural resource assets. This is because the convergence speed of the IWOA algorithm is faster than other algorithms, the global convergence ability is better, and it is not easy to fall into the local optimal situation, and the convergence accuracy of the IWOA algorithm is higher, and the optimization effect obtained by optimizing the BP neural network through the IWOA algorithm is better than other algorithms. Therefore, the IWOA-BP model is feasible for use as a natural resource asset damage assessment.

Table 2: Evaluation results of each algorithm

Algorithm	$P_{RMSE} / (10^{-13} S / m)$	$P_{MAPE} / \%$	$P_{MAD} / (10^{-13} S / m)$
BP	1.5783	53.2155	1.1153
GWO-BP	0.6722	20.7943	0.4722
WOA-BP	0.5741	15.5719	0.3709
IWOA-BP	0.3013	9.7452	0.2241

By diagnosing the extent of damage and analyzing its relationship with natural resource assets, further research can be conducted on methods of predicting compensation for damage to natural resource assets, and thus assessing the value of compensation for damage to natural resource assets.

IV. Analysis of examples

IV. A. Analysis of the current situation in the study area

IV. A. 1) Status of the economy and natural resources

Located in the northernmost part of Shaanxi Province, Yulin is a key circulation node city with rapid socio-economic development and abundant natural resources, which has a good location advantage. At the same time of rapid development, some resource problems have been exposed, how to effectively protect and utilize these valuable natural resources has become an urgent problem to be solved at present. Based on summarizing the research results of previous researchers, this paper establishes a set of natural resources balance sheet applicable to Yulin City as an example. The IWOA-BP model is used to calculate the asset value volume and liabilities of natural resources in Yulin City.

IV. A. 2) Data sources

In practical application, the first-hand data collected by the local natural resources bureaus and the actual monitoring data can be used, and the combination of the two can give full play to their respective advantages and improve the accuracy of the accounting results. In the data preprocessing process, the data from the statistical yearbook of each prefecture-level city are compared with the data provided by the local natural resources bureaus, and if the data from both are consistent, they can be used directly; if the data in the statistical yearbook of the prefecture-level city are missing or the data from the statistical yearbook of the prefecture-level city are inconsistent with the data provided by the natural resources bureaus, the data from the local natural resources bureaus will be used.

IV. B. Accounting for Elmwood's Natural Resource Financing Damage Debt

IV. B. 1) Accounting for natural resource assets in Yulin City

(1) Accounting for the land value of forest land

In this paper, the average annual net income of the annual net income of the forest land is 657-918 yuan/mu, and its average value of 789 yuan/mu is taken here. Then use the annuity capitalization method to calculate the economic value of forest land, and substitute the formula to calculate the results as shown in Table 3.

Table 3: The economic value of woodland land

Land use type	Prematurity		Final term	
	Physical quantity	Value	Physical quantity	Value
Land use type (ten thousand yuan, hectares)	1214278	1462814	1215842	1471573

The economic value is accounted for to the secondary land category, as shown in table 4. On the surface, it can be seen that the value of land resources is in line with the trend of changes in land area, but its changes are a comprehensive reflection of society, economy, resources and environment. The total value of land resources in Yulin City is dominated by forest land, which is about 39%, followed by cultivated land, and there is not much difference in economic value among the remaining types. The continuous development of the city has also led to a growing demand for urban construction land. Overall, the value of total land resources has increased during the survey period, which shows that the government's efforts in ecological environment and resource protection have been effective in recent years.

Table 4: The economic value of land resources in yulin

Land use type (ten thousand yuan, hectares)	Prematurity		Final term	
	Physical quantity	Value	Physical quantity	Value
Ploughing	1020831	3.00374E7	1013024	2.97836E7
Water field	2783.19	102821.84	2988.05	84439.23
Waterpouring	147303.02	4377466.61	146363.78	4325476.3
Arid land	868152.79	2.55524E7	861546.16	2.5334E7
Planter	189826	5626579.25	194431	5737450.75
Woodland	1241880	5.93956E7	1246541	5.95896E7
Grass	2576562.54	6336147.73	3690004.93	9055231.49
Commercial services	2187.64	4971402.55	2759.31	5518409.44
Industrial land	20150.57	1.30208E7	23230.67	1.46927E7
Industrial land	7992.57	5806223.17	9336.67	6447989.87
Mining land	10362	7212240.2	13331	8224826.6
Residential land	79949.89	1.02868E7	79503.68	1.14372E7
Urban residential land	5258.89	1.02867E7	6292.68	1.14371E7
Rural homestead	7317.2	95.83	71252	91.33
Public administration and public service	2517.42	1607825.83	1458.42	1773035.85
Special land	2182	1942848.2	2911	2041598.6
Transport land	17661.96	1.1544E7	19304	1.23626E7
Railway land	1513.71	1961667.05	1986.43	2086357.1
Highway land	13468.27	9055502	14806.54	9693814.41
Airport land	225.67	140292.69	715.35	133018.17
Pipeline land	621.35	379623.72	618.7	389748.65
Water and water facilities	37471.04	4053595.74	38179.08	4329796.47
River surface	25795	-	25761	-
Lake surface	3471	-	3468	-
Reservoir water	4086.92	3488610.58	4745.85	3723798.35
Water builder	879.88	562668.16	1541.77	586125.12
Other land	423423.21	753833.74	422580.43	734135.52
Idly	278379.21	686447.07	277788.43	666865.93
Facility agricultural land	2498.01	65069.67	2727.03	47396.59
Tian kan	47302.21	-	46892.74	-
Saline land	11328.47	-	11278.22	-
Sand	68328.28	-	68217.33	-
Bare land	5423.74	-	5411.38	-
Total	7127134.65	2.19255E8	8310996.63	2.30236E8

(2) Accounting for water resources assets

The physical volume of the water resource asset table of Yulin City (in billion cubic meters) is filled in by using the data from the Yulin City Water Resources Bulletin for 2019-2023, as shown in Table 5.

Table 5: The physical measure of water resources in yulin city(Unit: 100 million cubic meters)

	2019	2020	2021	2022	2023
Surface water	17.57	17.57	21.76	21.44	19.74
groundwater	17.32	17.32	16.48	17.51	16.29
Repeated calculation	11.4	11.4	12.26	12.57	10.28
Total water resources	20.09	20.09	25.42	25.83	25439

Based on the neural network model of water resource asset value, in MATLAB 2017, the collected data of water resources in Yulin City is input by calling the IWOA-BP evaluation value model that has been saved and successfully trained, and the SIM function simulation is used to obtain the value of water resources in Yulin City to be evaluated in a normalized way, and the water resource asset value of Yulin City can be derived by back-normalization. The output value of water resources value in Yulin City for 2019-2023 calculated by MATLAB simulation is shown in Table 6, which is 114.73 and 109.85 at the beginning and end of the period, respectively.

Table 6: The value of water resources in yulin(Unit: 100 million yuan)

	2019	2020	2021	2022	2023
Total water resources	114.73	115.64	113.41	112.75	109.85

IV. B. 2) Accounting for damage to natural resource assets in Elmwood City

Based on the physical volume of natural resource liabilities in Yulin City of Shaanxi Province Statistical Yearbook as shown in Table 7, the accounting of natural resource damages in Yulin City is shown in Table 8. The natural resource damage liabilities during the accounting period totaled 49.315 billion yuan, with land remediation accounting for the most, as high as 72%, followed by soil and water conservation management, accounting for 17% of the total, and biological resources accounting for the least, only 11% of the total.

Table 7: The amount of land resources and liabilities in yulin city (Unit: ha, wan ha, 10,000 yuan)

Index name		Physical quantity	
		Prematurity	Final term
Soil pollution	Industrial solid waste (10,000 tons)	21.56	1612.3
	Life waste (10,000 tons)	-	-
Soil and water conservation governance	Comprehensive control surface product(Wan hectare)	12.55	12.42
Agricultural soil fertility change	Fertilizer input (10,000 tons)	15.76	17.44
Disaster improvement	Total hazard points (places)	-	-
	Disaster hazard point exclusion (location)	-	-
Land improvement	Clean area (wan hectare)	11.34	23.58
Mine management	Area(hectare)	0.11	0.19

Table 8: The land resources of yulin city damage the value (Unit: ha, wan ha, 10,000 yuan)

Land resource environmental impairment type		Prematurity	Final term
Soil pollution	Total soil pollution	21.56	1592.22
	Soil pollution waste	-	-
	Total input	0.16	12.03
Soil and water conservation governance	Comprehensive control surface product	12.55	12.42
	Total input	23.14	23.03
Agricultural soil fertility improvement	Total fertilizer input	13.58	16.44
	Total input	4.52	5.05
Disaster improvement	Total hazards	-	-
	Hazard point exclusion	-	-
	Total input	-	-
Land improvement	Improvement area	11.42	22.79
	Total input	49.15	95.33
Biological resources	area	0.11	0.19
	Total input	0.63	1.57
The value of the value of the land resource environment			

IV. B. 3) Liability Statement for Damage to Natural Resource Assets in the City of Elmwood

The natural resource assets damage liabilities of Yulin City are shown in Table 9. By analyzing the table, the main composition of land resources in Yulin City in 2023 is agricultural land, and the value structure of land resources is also dominated by agricultural land, with the total value of assets amounting to 9,711,244.41 billion yuan, accounting for 64.94% of the total assets of land, which is mainly forest land and cultivated land, which amount to 614,354 billion yuan and 301,815 billion yuan, respectively, and account for 41.57% of the total value of land resources and 23.37%.From 2019-2023, the total value of land resources increases from 14424.3 billion yuan to 14911.2 billion yuan, with a value added of 48.69 billion yuan. The total value of assets at the end of the period of biological resources in Yulin reached 562,912.4 billion yuan, of which biological resources assets accounted for the largest proportion, accounting for the bulk of the total biological resources assets. Overall, biological resources changed smoothly within the accounting.

Table 9: The balance sheet of natural resources in yulin

Aassets	Prematurity		Final term		In debt	Prematurity	Final term
	Quantity	Amount	Quantity	Amount		Amount	Amount
Column	1	2	3	4	Column	1	2
Land resources	427	14424.3	425	14911.2	Land resources	75.46	136.51
Biological resources	13041.1	562912.4	12976.3	562912.4	Biological resources	81.24	85.64
Water resources	24.19	115.46	26.74	111.03	Water resources	2.14	2.63
					Total liability	158.84	224.78
					Balance of assets	577293.32	577709.85
Total assets	-	577452.16	-	577934.63	Total	577452.16	577934.63

V. Conclusion

This study has successfully established a scientific calculation method for natural resource asset damage compensation by constructing the IWOA-BP neural network value assessment model. The empirical application of the model in Yulin City shows that the method has good assessment effect and practical value. The average relative error of the IWOA-BP model is only 9.7452%, which is significantly lower than that of the traditional BP model (53.2155%), and it exhibits higher prediction accuracy. At the same time, the model only needs 77 iterations to reach the convergence state, which has faster computational speed and stronger global search capability than other optimization algorithms, and effectively avoids the problem of falling into local optimal solutions.

The results of natural resource asset accounting in Yulin City show that the total value of assets increased by 48.69 billion yuan during the period 2019-2023, of which land resources accounted for 64.94%, reflecting the dominant position of land resources in the structure of natural resource assets. The total value of biological resources assets reaches 562,912.4 billion yuan, and the value of water resources changes from 11.546 billion yuan to 11.103 billion yuan, reflecting the value change characteristics of different types of natural resources. In terms of damage liability accounting, land remediation accounted for 72% of the total damage liabilities, soil and water conservation management accounted for 17%, and biological resources accounted for 11%, providing data support for the development of targeted protection and restoration measures.

The assessment model not only improves the science and accuracy of the calculation of damage compensation for natural resource assets, but also provides a practical technical tool for natural resource management. The successful application of the model verifies the effectiveness of artificial intelligence technology in the field of natural resource value assessment, and provides important theoretical support and methodological guidance for promoting the construction of ecological civilization and sustainable development.

References

[1] Reid, J., Bruner, A., Chow, J., Malky, A., Rubio, J. C., & Vallejos, C. (2015). Ecological compensation to address environmental externalities: lessons from South American case studies. Journal of sustainable Forestry, 34(6-7), 605-622.

[2] Wu, W. (2020). The reform of the compensation system for ecological and environmental damage in China. Natural Resources Journal, 60(1), 63-102.

[3] Libin, N. I. E., & Bo, P. E. N. G. (2024). On damages compensation system of the state ownership of natural resources. CHINA MINING MAGAZINE, 33(11), 139-145.

[4] Zhou, Y., Luo, H., Tang, J., Zhang, L., Zhu, H., & Sun, S. (2023). Study on ecological environment damage compensation in China. Journal for Nature Conservation, 76, 126503.

[5] Tortsev, A. M., Studenov, I. I., & Belousov, A. N. (2017). Comparative analysis of domestic approaches to compensation for damage caused to water bioresources. Economic and Social Changes: Facts, Trends, Forecast, 10(5), 184-196.

[6] Faure, M., & Liu, J. (2011). New models for the compensation of natural resources damage. Ky. J. Equine Agric. & Nat. Resources L., 4, 261.

[7] Savinykh, V. A. (2014). Peculiarities of the Legal Framework for Compensation of Environmental Damages by Natural Resource Users. Vestnik Saint Petersburg UL, 148.

[8] Wu, J., Chang, I. S., Wu, J., & Chang, I. S. (2020). Compensation for Environmental Damage. Environmental Management in China: Policies and Institutions, 161-166.

[9] Tao, W., Lu, Y., Lijing, D., Yue, Y., Bing, X., & Rui, Z. (2023). An empirical study of the design of an ecological damage compensation assessment framework for land reclamation from the sea. Journal of Coastal Conservation, 27(3), 21.

[10] Shi, J., Wang, T., Xu, L., Gao, Z., Cao, C., Luo, Y., ... & Zhang, Y. (2024). Study on the Ecological Compensation Standard in the Xinjiang Uygur Autonomous Region of China under the Perspective of Natural Capital Supply and Demand. Sustainability, 16(7), 3078.

[11] Ma, L., Pang, D., Gao, J., Wang, W., & Sun, R. (2023). Ecological asset assessment and ecological compensation standards for desert nature reserves: evidence from three different climate zones in China. Sustainability, 15(13), 10679.
[12] Yang, X., Yan, Y., Li, S., & Hu, H. (2021). Calculation of compensation for forest ecosystem damage by engineering projects in Guangdong Province, China. Environmental Challenges, 5, 100316.
[13] Zeng, H., Cheng, C., Jin, Y., & Zhou, Q. (2022). Regional environmental supervision and corporate environmental investment: from the perspective of ecological damage compensation. Environmental Science and Pollution Research, 29(19), 28896-28912.
[14] Yingjie Zhong. (2025). Identification of Robot Dynamic Parameters Based on BP Neural Network. Frontiers in Computing and Intelligent Systems,12(1),144-149.