Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 19 | No. 3 | pp. 991-1000 | 2020

Original Research Paper

https://doi.org/10.46488/NEPT.2020.v19i03.009

Open Access Journal

An Improved InVEST Ecological Service Evaluation Model Based on BP Neural Network Optimization

Feng Wang†, Wenlong Chen and Lei Niu
School of Computer and Information Engineering, Fuyang Normal University, Fu Yang 236037, PR China
†Corresponding author: Feng Wang; wf111625@163.com

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 27-09-2019
Revised: 14-10-2019
Accepted: 11-12-2019

Key Words:
Ecological environment cost
Environmental degradation
Ecological assessment
InVEST model
BP neural network

ABSTRACT

The land is the material basis for human survival, and the contradiction between people and land has become increasingly prominent. The land ecological problem has gradually become a hot spot of concern. It is imperative to make a scientific evaluation of the land ecological quality and propose reasonable and feasible improvement measures and recommendations. At present, domestic research on environmental cost and environmental cost degradation mostly focuses on theoretical discussion, and there are few applications and practical research on enterprise environmental cost management. Based on the principle of protecting the ecological environment, this paper creates an ecological service assessment model to assess the real economic cost of land use development projects. From small community projects to large-scale national projects, because environmental costs are difficult to estimate, this paper uses the recovery cost method and the preventive expenditure method to quantify environmental costs. The cost of environmental degradation mainly comes from water pollution and air pollution. This paper uses the pollution function method to quantify the cost of environmental degradation. The InVEST model is used to evaluate the value of ecosystem services, and the BP neural network method is used to optimize the ecosystem service model, and the sensitivity analysis of the data is used to feedback the impact of the project on ecosystem services. The ecosystem service model based on neural network optimization makes the accuracy of data measurement results reaching 99.7%, which makes the model having a good generalization. Taking a paper mill as an example, this paper evaluates environmental costs by resource consumption cost, environmental degradation value and environmental governance cost, and estimates environmental degradation costs by major environmental governance costs. Finally, the environmental cost and environmental degradation cost are integrated, and the ecosystem service model is established. The neural network model was established in the Matlab environment based on the InVEST model, and the model simulation results of the ecosystem service system were obtained. Compared with the InVEST results, the results of this paper have better authenticity and market utilization value. Although a paper mill was used as an example, the system was evaluated and the evaluation results were analysed. Compared with the actual situation, there is a certain reliability. However, due to the limited data, the number of verifications is insufficient for the system. It is hoped that more data can be verified later to ensure its reliability.

INTRODUCTION

Ecosystem services are the biosphere that provides many natural processes to maintain a healthy and sustainable human living environment. Accelerate the reform of the ecological civilization system, adhere to the harmonious coexistence between man and nature, and coordinate the management of the landscape system. The improvement of people's living standards is inseparable from the construction of various engineering projects, but the construction of these projects will bring economic benefits and directly affect biodiversity and lead to environmental degradation. At this stage, most land development projects do not take into account the economic costs of changes in the ecosystem services: river pollution, air pollution, solid waste pollution. Therefore, the environmental cost of research projects is necessary for the development of enterprises. This paper takes a paper mill as an example to investigate the actual data of project development and construct an evaluation model for the environmental cost control of the project.

Traditionally, most land development projects only consider the project investment cost in the cost calculation and do not take into account the environmental costs caused by environmental degradation in production. Environmental degradation restricts ecosystem services. Therefore, the study of ecological service assessment models requires an assessment of environmental costs. Environmental costs include polluted rivers, poor air quality, hazardous waste sites, improperly treated wastewater, and climate change.

This paper presents the following four questions:

(1) Assess the environmental costs of development projects;

(2) Assessing the environmental degradation costs of development projects;
(3) Establish ecological service assessment model;
(4) Using a paper mill as an example to evaluate the effectiveness of the model.

HYPOTHESES AND SYMBOLIC DESCRIPTIONS

Assumptions

- Assume that exhaust gas pollution caused during mining and transportation is not considered.
- Assume that only the influencing factors mentioned in the text are considered.
- Assume that the data in the text are correct.
- Suppose the parameters used in the text are correct.

Symbol Description

Symbol	Definition
w_i	The weight of the input signal corresponding
x_i	The input signal
θ	The threshold
f	The activation function
net_i	The neurons
P_r	The cost of repairing natural resources
C_i	Repair and compensation for the unit cost of *i* resources
Q_i	The number of fixing *i* resources

ASSESSMENT OF ENVIRONMENTAL COSTS

The Significance of Studying Environmental Costs

The production and management activities of humans and enterprises will bring some negative impacts to the environment. Some industrial enterprises have high pollution characteristics and have a very bad impact on the ecological environment. The survival and development of an enterprise will affect the environment, but the survival and development of the enterprise depend to a large extent on the gift of the ecological environment. Starting from the micro-level, the environmental problems caused by the enterprise itself will not only generate expenditures other than production costs, but also affect itself, the surrounding environment and the social environment, damage its own social image, and cause the consequences of lowering the economic interests of the enterprise. From a macro perspective, if a country does not carry out environmental protection and prevention when building a business, it will violate the international environmental protection rules and affect the country's overall national strength and international influence. In summary, enterprises must pay attention to their environmental problems, so environmental cost accounting is a necessary measure. Through environmental cost accounting, we can find the environmental pollution problems generated by enterprises, to clarify the environmental costs of enterprises and to find environmental pollution problems of enterprises to curb environmental pollution and protect ecological environment resources (Li et al. 2011).

Concept and Classification of Environmental Costs

Since enterprises rarely calculate environmental costs into cost expenditures, there is currently no uniform standard for classification and calculation of environmental costs. Different enterprises have different footholds when accounting for environmental costs. For environmental costs, there is no precise definition for the time being. By analysing the cost of expenditure on environmental impacts, environmental costs can be divided into costs incurred in restoring a damaged environment, reducing the costs of pollution in the production process, and preventing the costs of environmental pollution.

Assessment of Environmental Costs

According to the cost source, it can be divided into recovery cost method, preventive expenditure method and pollution function method (Pan et al. 2019). The recovery cost method is generally difficult to accurately measure the cost of environmental damage directly, but it can be replaced with the idea that the expenditure required to restore the damaged natural resources to the previous state is used to measure the value of the damaged environmental resources. In general, natural resources are self-recovering, but if humans over-exploit and destroy natural resources, the natural world cannot be restored to the former state, and it is necessary to use human power to recover the environment. It is called "recovery compensation fee". For example, planting and maintaining the felled forest to restore it to its original state.

Its accounting model is: $P_r = \sum C_i Q_i$

Where, P_r is the cost of repairing natural resources, C_i is for repair and compensation, *i* is the unit cost of the resource, Q_i is the amount of resources for repair and pollution.

Preventive expenditure method refers to taking preventive measures to avoid or reduce environmental pollution. For example, in a polluted environment, people buy an air purifier to purify the air. The cost of purchasing an air purifier is to prevent expenditure. Pollution function method refers to the use of the correlation function method to measure the environmental costs of pollutants (wastewater, waste gas, solid waste) emitted by the enterprise during the production and operation process.

Environmental costs of certain liquid/gas pollutants: $Cl_i = V \times l \times t \times C_0$

Where, Cl_i is to prevent environmental costs of a liquid/gas pollutant; V is the volume of a liquid/gas contaminant; l is the concentration of a liquid/gas pollutant; t is the pollution equivalent value of a liquid/gas pollutant; C_0 is the environmental pollution cost per unit volume of a liquid/gas pollutant.

Total liquid/gas pollutant cost: $CL = \sum_{i=1}^{n} Cl_i$

Environmental costs of certain types of solid contaminants: $C = V \times f$

Among them, V is the volume of solid waste; f is the environmental cost per unit volume of solid contaminants.

ASSESSMENT OF ENVIRONMENTAL DEGRADATION COSTS

The Significance of Assessing the Cost of Environmental Degradation

The development and utilization of land projects will bring environmental pollution. In particular, some highly polluting projects can exacerbate environmental degradation (Zhao 2016). Environmental degradation affects the image of the company and inhibits its efficiency. Therefore, the survival and development of an enterprise cannot be separated from a good ecological environment.

Concept of Environmental Degradation Costs

Environmental degradation refers to the unreasonable development and utilization of natural resources by human beings, causing changes in the structure of ecosystems, leading to a decline in the self-regulation of ecosystems and a decline in function, which is not conducive to the survival and development of humans and living beings. The cost of environmental degradation is also called environmental pollution loss, including the degradation of natural degradation caused by environmental degradation, and the loss of human health.

Assessment of Environmental Costs

The cost of environmental degradation is difficult to estimate and is generally translated into other losses due to environmental degradation (Yang 2017). For example, the cost of environmental degradation of air pollution is studied, and human health loss and crop yield loss, which account for a large proportion of pollution losses, are evaluated (State Forestry Administration 2014). The main cause of environmental degradation costs is water pollution and air pollution. Therefore, environmental costs are assessed by the cost of water and air pollution (Wang 2014). According to the pollution function method mentioned above:

Environmental costs of certain liquid/gas pollutants: $Cl_i = V \times l \times t \times C_0$

Total liquid/gas pollutant cost: $CL = \sum_{i=1}^{n} Cl_i$

Therefore, the estimated environmental degradation costs are: $CL = \sum_{i=1}^{n} Cl_i$

ECO-SERVICE ASSESSMENT MODEL

InVEST Model

The InVEST model (Yang et al. 2012) consists of three modules: Freshwater ecosystem assessment, marine ecosystem assessment and terrestrial ecosystem assessment, each of which contains specific assessment projects. Freshwater ecosystem assessments include water production, flood regulation, water quality and soil erosion; marine ecosystem assessments include shoreline formation, coastal protection, aesthetic assessment, aquaculture, habitat risk assessment, overlay analysis, wave energy assessment. terrestrial ecosystem assessments include biodiversity, carbon stocks, pollination and wood production. The InVEST model is hierarchically designed as shown in Table 1.

The level 0 model assesses the relative level of ecosystem services or significant areas of special service demand. For example, coastline mapping in InVEST draws only coastlines that are particularly prone to erosion and flooding, without assessing ecosystem functioning, Grab the simplest model of the nature of the problem.

The Level 1 model is suitable for obtaining more data than level 0, but still meets relatively few data requirements. The first level model can be used to determine the differential biodiversity of the ecosystem service function area, and the ecosystem function under current or future conditions. Regional differences and biodiversity, all primary models can output absolute value and provide users with an economic valuation option.

The Level 2 model can more accurately describe the service value and function of the ecosystem. The results of the assessment are important for environmental protection measures and environmental compensation. The level 3 model is suitable for special areas such as fisheries.

Our model will use a 2-level model to more accurately describe the ecological environment. The BP neural network will also be used to optimize the 2-level model. The results of the evaluation will be adjusted by project planners and managers to reach to expected indicator.

Table 1: Grading design of InVEST model.

Level 0 model	Level 1 model	Level 2 model	Level 0 model
Relative value	Absolute value	Absolute value	Absolute value
No evaluation	Evaluate through a range of methods	Evaluate through a range of methods	Evaluate through a range of methods
Generally no strict time, No annual average	Average time step, no time series	Time step from day to month, have a wide time series	Time series are associated with feedback and value domains
From the basin to the appropriate spatial range of the world	From the basin to the appropriate spatial range of the world	From a small area to the world	From a small area to the world
Suitable for determining important areas(high risk or specialized ecological service area)	Suitable for strategic decision (make a strategic decision based on criteria)	Suitable for the tactical decision, making with absolute value	More accurate assessment of ecosystem services
No interaction between ecosystem services	Interaction between individual ecosystem services	Interaction between individual ecosystem services	Complex ecosystem interactions with feedback and thresholds

InVest Model Applied to Ecological Service Assessment

Ecosystem services mean that the biosphere provides many natural processes to maintain a healthy and sustainable human living environment.

An ecological service evaluation model that the InVest model applies to ecological services is shown in Table 2.

Model Optimization

We used the BP neural network to optimize the ecological environment assessment method of a paper mill. After obtaining the environmental data of a paper mill, data cleaning and fitting methods are used to obtain more reliable data, and the data can meet the requirements of training neural networks. And using a part of the actual data as the test data reached a good expectation, making the accuracy of the BP neural network model reach 99.7%. The use of our trained BP neural network in the national area has also yielded good results.

EXAMPLE APPLICATION

Assessment of Environmental Costs of A Papermaking Enterprise

According to the life cycle idea, the environmental cost that a paper mill may cause during the production and operation process is divided into four parts: raw material mining, product production, product sales and disposal according to the whole process of paper products from raw materials to production to waste stage [Yu 2018.]. Considering that paper products are a kind of material that can be degraded by nature, the environmental impact in the circulation and disposal stages is relatively small. Therefore, this paper mainly accounts for the environmental costs of the two stages of mining raw materials and product production.

Stage of mining raw materials: The cost of the raw material extraction phase includes the following two parts: Part of it is the loss of forest resources caused by the mining of wood and coal; the other part is the cost of the exhaust gas emitted by the vehicles that transport the raw materials (Zheng 2013], but this part of the cost cannot be calculated because the relevant data cannot be obtained.

In 2018, from Table 3, we can get the following conclusion: The pulp consumption of the paper-making enterprise was 10,999.75 tons. The raw materials of pulp were mainly wood pulp and waste paper pulp, of which wood pulp accounted for 34.5%, and waste paper pulp accounted for

Table 2: InVEST Model Module Evaluation Project.

Freshwater ecosystem module	Marine ecosystem module	Terrestrial ecosystem module
Hydroelectric power	Expand check, create GS	Biodiversity
The water quality	Coastal protection	Carbon storage
Water rate	The Marine water quality	Crop pollination
Soil and water conservation	Ecological risk assessment	Wood production
	The aesthetic evaluation	
	Aquaculture	
	Superimposed analysis	

65.5%. The wood converted from paper pulp can be used to calculate the wood consumed.

Wood pulp consumption of wood: 10999.75 × 34.5% × 4.75 = 18025.84m^3

Waste wood pulp consumption: 10999.75 × 65.5% × 3 = 21614.51m^3

Total amount of wood consumed:18025.84 + 21614.51 = 39640.35m^3

The amount of wood per hectare in the forest is 89.79 m3; forest cost per hectare is about 3,700$. (7 in the following formula refers to the exchange rate of RMB against the US dollar.)

The resulting forest loss costs: P_1 = (39640.35/89.79) × 2.49/7 = 169 ($)

In 2018, it consumed 183,100 tons of coal, and the cost of forest loss was calculated according to the recovery cost method.

Mining one ton of coal will disturb 1.1 tons of topsoil, with an average bulk density of 1.7 tons per cubic meter of soil; a soil thickness of 0.3 meters; and a forest value of 24,900 per hectare.

The resulting forest loss costs: P_2 = [183100 × 1.1 /(1.7 0.3)] × 2.49 / 104 × 10000 / 7 140486 ($)

Total forest loss costs:

P = (1099.28 + 98.34) × 10000 / 7 = 1710886 ($)

Production product stage: The environmental costs incurred during the production phase were calculated based on the pollution generated by the production process of the product. The production process of the product includes pulping section, papermaking section, coating section and processing section. The pollutants produced during the production process mainly include wastewater, waste gas, waste residue and noise. The environmental cost at this stage is mainly reflected in the environmental damage cost caused by pollutant discharge and the environmental governance, prevention and management costs invested by the enterprise.

Environmental Damage Costs

Calculation of wastewater discharge fee: After the wastewater discharged from a paper mill is treated by the company's wastewater treatment system, most of the wastewater is recycled and reused. From Table 4, we can get the following conclusion: The reuse rate of wastewater is 88.79%, and the amount of wastewater to be treated is 88.3 m^3/a.

According to the environmental cost measurement method mentioned above,

Processing CODcr costs: Q_1 = 191680 ÷ 1 × 0.7 / 7 = 134176 ($)

Handling nh3-n costs: Q_2 = 250 ÷ 0.8 × 0.7 / 7 = 31.25 ($)

Total cost of wastewater treatment: Q = (134176 + 218.75)/ 7 = 1919.25 ($)

Calculation of exhaust gas discharge fee: In 2018, the total amount of exhaust gas produced by a paper mill was 1,446,600 standard cubic meters. The content of the exhaust gas components is shown in Table 5.

Dealing with sulfur dioxide costs: R_1 = 564160 ÷ 0.95 × 0.6 / 7 = 50901.65 ($)

Dealing with nitrogen oxides costs: R_2 = 324760 ÷ 0.95 × 0.6 / 7 = 29301.65 ($)

Dealing with soot costs: R_3 = 62780 ÷ 2.18 × 0.6 / 7 = 2468.41 ($)

Dealing with the total cost of atmospheric pollutants: R = (356311.58 + 205111.58 + 17278.90)/ 7 = 87671.71 ($)

Calculation of carbon emission costs: In 2018, a paper-making enterprise emitted 338,100 tons of carbon dioxide. Although carbon dioxide is not an air pollutant, carbon

Table 3: Wood conversion amount of paper pulp in the paper industry.

Product	Direct consumption of raw materials	Wood folding amount/m^3×t
Wood pulp	Logs, logs, residues	4.75
Waste pulp	Waste paper	3

Table 4: Disposal of wastewater from the Paper Mill in 2015 (Li & Ren 2011).

Amount of wastewater (Ten thousandm^3/a)	Contaminant		Average missions
88.3	CODcr	Concentration (mg/L)	217
		Production amount (t/a)	161.68
	NH3-N	Concentration (mg/L)	0.28
		Production amount (t/a)	0.25

Table 5: Disposal of atmospheric pollutants by a paper mill in 2018 (Li & Ren 2011).

Exhaust gas volume (Ten thousandm3/a)	Contaminant		Average emissions
144.66	SO_2	Concentration (mg/Nm^3)	390.50
		Production amount (t/a)	564.16
	NOx	Concentration (mg/Nm^3)	224.5
		Production amount (t/a)	324.76
	Smoke	Concentration (mg/Nm^3)	43.4
		Production amount (t/a)	62.78

dioxide is the most important greenhouse gas, causing global warming and the melting of glaciers. Therefore, carbon dioxide emissions should be treated. The average price of carbon dioxide in 2018 is 6$ per ton.

Carbon emission costs: 338100 × 6 = 2028600 ($)

Calculation of sewage charges for solid waste: In 2018, the total amount of solid waste generated by a papermaking enterprise was 72,885.49 tons. The company's solid waste safe disposal rate reached 100%, and the comprehensive utilization rate reached 99.2%. Since the solid waste generated by a paper mill can be safely disposed of 100%, the comprehensive utilization rate reaches 99.2%, and the zero discharge to the external environment is basically realized. The damage caused to the environment can be neglected.

Calculation of noise discharge fee: To reduce the harm of production noise to the personnel in the plant and surrounding neighbourhoods, the company makes reasonable arrangements for the noise-generating equipment in the factory, installs noise-proof walls around the plant, installs silencers at the noise source of the equipment, and constructs green belts for the plant area. As well as avoiding night time transportation and other means, noise reduction will reduce the noise pollution below the national environmental standards, and will not adversely affect the environment and surrounding people. Therefore, it can be determined that the noise emission fee of the plant is zero.

In summary, the environmental costs of pollutant emissions: W = Q + R = 89590.6 ($)

Corporate Environmental Governance Costs

Table 6 shows the cost of a paper mill's environmental governance costs divided into seven projects.

Depreciation costs for environmental protection facilities: 720.92 (ten thousand dollars)

Environmental Prevention Costs

Environmental prevention cost refers to the environmental protection costs invested by enterprises to avoid environmental pollution, such as pollution source discharge monitoring systems installed by enterprises, testing fees, and environmental education training for relevant personnel. In 2018, the depreciation expense of the pollution source discharge monitoring system was about 9429$, and the entrusted inspection department commissioned the inspection fee of 1572$, and the environmental protection education and training fee for the relevant personnel was about 5714$.

Through the above calculations, the environmental costs of a paper mill are shown in Table 7.

Assessment of Environmental Costs of A Papermaking Enterprise

The main cause of environmental degradation costs is water pollution and air pollution. Therefore, environmental costs are assessed by the cost of water and air pollution (Zhao 2016).

The environmental degradation cost of a papermaking

Table 6: Environmental protection facilities costs and annual depreciation.

Project	Total/ten thousand	Annual depreciation/ten thousand
Eastern district wastewater recovery facility	297.55	14.13
Western district wastewater recovery facility	28.3	1.35
Incoming wastewater treatment facility	18.88	0.9
Paper machine white water recycling facility	119	5.65
Flue gas treatment facility	203.16	9.65
Noise control	1.48	0.07
Pollution source online monitoring	19.86	0.94

Table 7: Environmental cost report of a paper mill in 2018.

Stage	Cost type	Accounting object	Result/ten thousand
Production phase	Damage cost	Sewage charges	13.44
		Disposal cost	57.87
		Carbon cost	1174.90
		Solid waste cost	0
		Noise cost	0
	Governance cost	Governance	243617
	Prevention cost	Prevention	11.7

enterprise is the sum of the cost of treating water pollution and air pollution.

The environmental degradation costs of paper companies: 101.87 (ten thousand dollars)

Assessment of Ecological Services in The Paper Mill

Using BP neural network to optimize the evaluation method in InVEST, because there is less data disclosure for a paper mill, we will use the fitting method to generate more data and then adjust the data reasonably, including data cleaning and normalization. In the process of fitting, we mainly use the NumPy library in Python to fit (Fig. 1), and get the fitted equation:

$$f = 1.009x^2 - 37.64x + 3.78e + 04$$

To get the final cost of a paper mill in treating wastewater, treating waste gas, treating solid waste, and treating noise, we input the known data as input neurons into our BP neural network model and then train through the NEWFF function in MATLAB. For neural network objects, we have 10 neurons in the hidden layer, 3 neurons in the output layer, and 500 steps in the maximum number of training steps. The training data has 75 different data in the factory over the years. Set the learning rate to 0.05 and the minimum error of the training target to 0.001 (Fig. 2).

Finally, our BP neural network model converges after 495 iterations (Fig. 3).

The gradient size is 0.042 (Fig. 4):

Then carry out regression analysis (Fig. 5):

The final accuracy rate reached 97.33%.

ADVANTAGES AND DISADVANTAGES OF THE MODEL

Model Advantage

(1) In the process of establishing the InVEST model, the second-level model was used, which enabled the eco-environment administrator to have a certain impact on

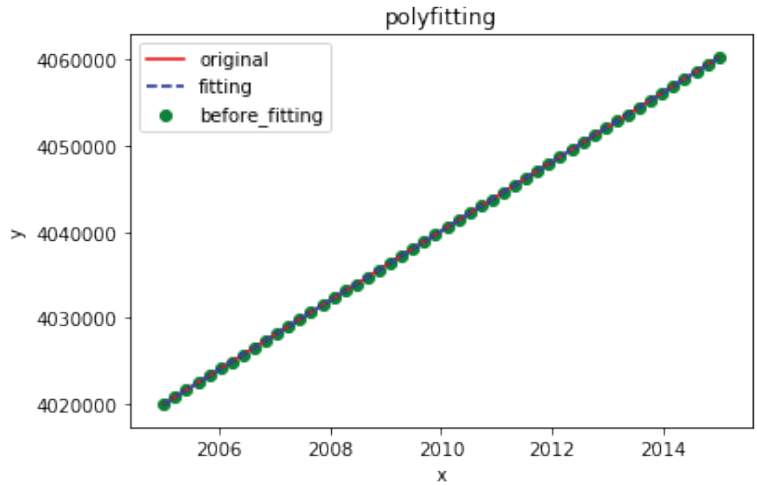

Fig. 1: Fitted function image.

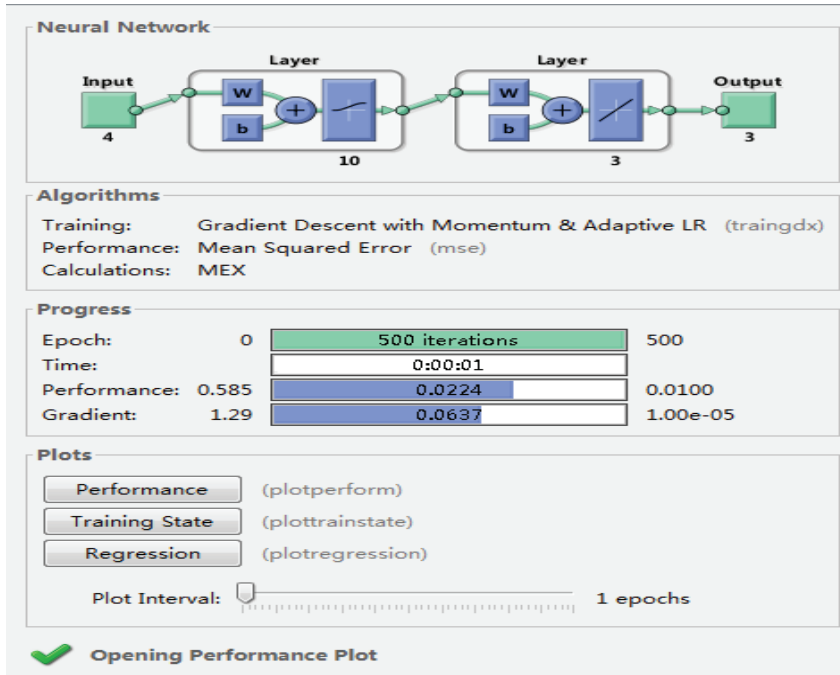

Fig. 2: Results of BP neuron training.

the environmental change, enabling the environmental administrator to participate in the prediction model. We use BP neural network to optimize the weight of each factor in the ecological environment in the InVEST model, and we get better results by example.

(2) Using the specific data to verify the InVEST model, so that the robustness of the model is improved.

Model Defect

The system establishes a system model of natural environment assessment, but the model is not perfect at the regional criteria level. I hope to consider adding more regional indicator factors in future work to meet the natural environment assessment model.

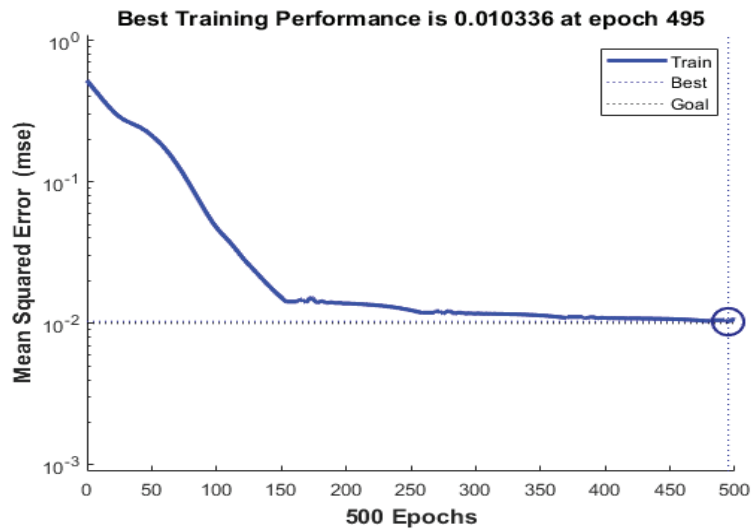

Fig. 3: Image of gradual convergence of neurons.

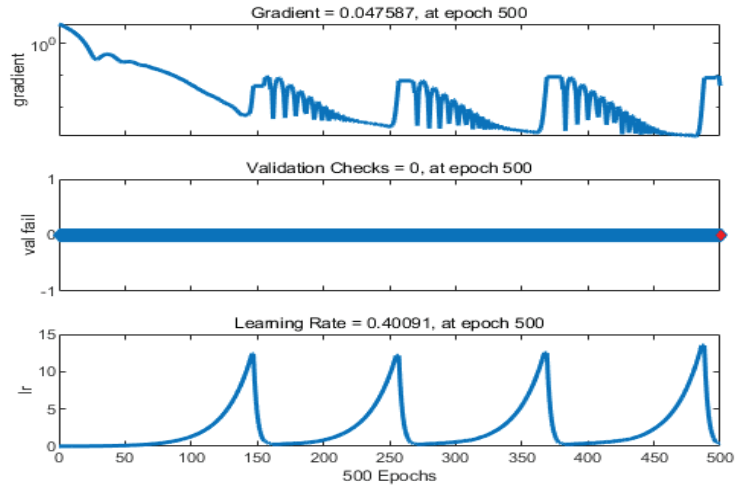

Fig. 4: Neural network training process diagram.

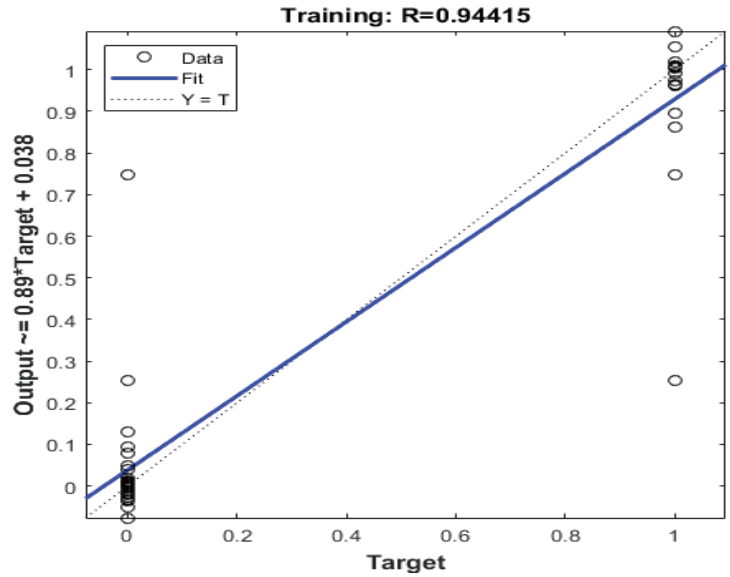

Fig. 5: Image of neurons for regression analysis.

(1) In the survey and data acquisition, a lot of data comes from statistical yearbooks and papers. Some data are missing. In our model, the fitting method is used, which has certain inaccuracy.

(2) Some parameters are based on common sense because very little data can be used.

CONCLUSIONS

Mathematical formulas are established through specific mathematical meanings, and the recovery cost method, preventive expenditure method and pollution function method are defined to quantify the environmental cost and environmental degradation cost, and the true economic cost of the project is clearly expressed in the form of data. The InVEST model is used to evaluate the value of ecosystem services, and the BP neural network method is used to optimize the ecosystem service model. Through the sensitivity analysis of the data, the model simulation results of the ecosystem service system were obtained. Taking a paper mill as an example, based on data generated in previous years, the value of ecosystem services in paper mills was assessed. It can be concluded that the paper mill's management of pollutants has reached an excellent state, and its management method can

be improved and promoted. This research has guiding significance and practical enlightenment for the environmental management of heavy polluting enterprises and has a good market utilization value.

This paper takes a paper mill as an example to evaluate the ecology of the paper mill's location using the ecological service assessment model and the evaluation results were analysed. Compared with the actual situation, the model has a certain reliability. However, the relevant data of this paper mill are insufficient, and the model of this paper cannot be applied to the assessment of ecological services in other places. I hope that there will be more data in the later stage, and I will continue to improve through verification to get a more reliable model.

ACKNOWLEDGEMENT

This work was supported by the horizontal cooperation research project of Fuyang Municipal Government: "Research and Application Demonstration of Key Technologies of Wisdom Agricultural Internet of Things Commonality" (No.XDHX2016018).

REFERENCES

Li, J.W. and Ren, B.P. 2011. Research on the path of coordinating China's environmental pollution and economic growth conflict. China Population, Resources and Environment, 21(5): 132-139.

Pan, W.X. and Liu, S.D. 2019. Optimization research and application of BP neural network. Computer Technology and Development, 5: 1-3.

State Forestry Administration 2014. Results of the 8th National Forest Resources Inventory. Forestry Resources Management, 2: 1-2.

Wang. C.M. 2014. Cost Calculation Model and Application Research of Environmental Degradation Based on Air Pollution Intensity. Nanjing: Nanjing University of Information Science and Technology.

Yang, Y.Q. 2017. Research on Enterprise Environmental Cost Accounting System. Zhengzhou: Zhongyuan Institute of Technology.

Yang, Y. Y., Dai, E.F. and Fu, H. 2012. Research framework of value evaluation of ecosystem service function based on InVEST Model. Journal of Capital Normal University, 33(3): 41-47.

Yu, H.F. 2018. Research on Environmental Cost Accounting of X Steel Company. Xi'an: Xi'an Petroleum University.

Zhao, L.M. 2016. Research on Air Quality Prediction and Spatial-Temporal Distribution in Guangzhou Based on Genetic Algorithm and BP Neural Network. Jiangxi University of Technology.

Zhao, Q.X. 2016. Research and Implementation of Land Ecological Assessment System. School of Environment and Surveying.

Zheng, Q.H. 2013. Material flow analysis of timber resources in China's paper industry supply chain. China Paper, 6: 21-27.