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Coupling Dynamic Model of Natural Environment Protection and Environmental Pollution Based on Machine Learning

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Abstract: As artificial intelligence develops, Machine Learning (ML) has gained more development opportunities. In the ecological field, the application of ML to Natural Environment Protection (hereinafter referred to as NEP) and Environmental Pollution (hereinafter referred to as EP) is currently a relatively hot field, which has been studied by many scholars. In order to explore the relationship between NEP and EP, this article constructed a Coupling Dynamic Model (hereinafter referred to as CDM) of NEP and EP based on ML through discussing ML and dynamic model. The model could reveal the stability of the positive balance of the natural ecosystem. Compared with the traditional way of building the dynamic model, the positive equilibrium stability values of the dynamic model in this method were controlled between 0.5 and 1.5. Its peak value changed less and its stability was better. This paper analyzed the relationship between natural environmental protection and EP by optimizing and innovating the dynamic model, thus providing more basis for the sustainable development of ecology.

1. Introduction

The ecosystem is the material basis for human survival and development. However, with the continuous progress of human society, the natural environment pollution is becoming more and more serious. At present, the sustainable development of the natural environment is one of the hotspots in the current ecological field. At present, the world is facing three serious problems: increasing population, decreasing resources and deteriorating ecology. There is an "s" type relationship between natural resources and EP. This paper constructed a dynamic model. On this basis, the model was optimized with ML. The model discussed the practical utility of the model from the perspective of the stability of the positive equilibrium point and the impact of the stability

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of the positive equilibrium point of the model on the EP from the perspective of the time scale. This paper provided new ideas and theoretical basis for the efficient implementation and sustainable development of NEP, and could further enrich and improve the theory and application in this field.

Many scholars have analyzed the NEP and EP from different perspectives. They have put forward different views. Korchenko Oleksandr evaluated the mapping model of soil and surface water quality, and improved the scientific basis of existing monitoring. He proposed the idea of data collection and management through geographic information system, and finally used it in EP assessment and monitoring [1]. Sun Jing proposed that the spatial Durbin model could be used to explore the relationship between urbanization, economic development and EP, and said that economic development was an effective means to alleviate the contradiction [2]. Baloch Zulfiqar Ali proposed to evaluate energy efficiency and EP through the super-efficiency model of weighted priority schemes, and said that the model would help better monitor EP, thus improving energy performance, promoting environmental protection and achieving sustainable development of the environment [3]. These scholars' research on NEP and EP could provide a theoretical basis for it, but there were also some deficiencies. Although scholars' research involved EP models, there were no good methods for the construction of the dynamic analysis model of natural environmental protection and EP. At the same time, their research was rarely combined with the current hot ML, which made scholars' research not of great reference value. It could be seen that the application of ML in the CDM of NEP and EP was a relatively new field at present, and further discussion was needed.

In order to better improve the performance of the CDM of NEP and EP, this paper constructed a new CDM of NEP and EP based on the theoretical analysis of ML and the discussion of previous scholars on the model of NEP and EP. Through empirical research, it was found that the new model built in this paper had better stability and stronger anti-interference ability, and could better describe the impact of environmental self-purification on EP. Compared with the traditional model, the innovation of the model in this paper was to pay attention to the importance of ML and used it in the model construction, which helped to promote the protection of natural environment and ultimately achieve sustainable development.

2. Relevant Theories of NEP and EP

2.1. Overview of NEP and EP

2.1.1. Current Situation

Due to the current economic development, the ecological environment is facing severe challenges, which puts forward higher requirements for the sustainable development of the natural environment. Sustainable development is a common concern of ecological scholars and economists. In this problem, it is particularly important that in an ecosystem with multiple stationary states, EP or economic impact may drive it from one state to another, thus leading to catastrophic changes in the ecosystem, which can be regarded mathematically as the state transition of the ecosystem [4].

The state transition of the ecosystem is a discontinuous change, which is linked with the sudden loss of renewable resources productivity and would lead to the decline of the ecosystem's ability to support human beings. State transition is usually irreversible, such as soil erosion, groundwater depletion, drought, and the loss of biodiversity, which would greatly increase the cost of ecosystem reconstruction. The transition of ecosystem to unfamiliar state makes people more uncertain about the environmental impact of economic activities, and also increases the difficulty of environmental protection [5-6].

2.1.2. Impact of EP

The harm of EP to human beings and organisms can be spread through air, water, soil, food and other ways. It can not only affect for a long time, but also be affected by several pollutants at the same time [7]. In addition to humans, other creatures would also be affected, but the damage is different. The harm of EP to human body and organism has two aspects: On the one hand, in a short time, the concentration of pollutants is very high, which would be directly absorbed by human body and organism, thus causing acute injury [8]. On the other hand, it is a long-term injury, which mainly refers to the injury caused by the long-term impact of a small amount of pollutants. Some unpredictable long-term injuries, that is, the impact of EP on human body and organisms, usually appear after a incubation period. For human beings, pollutants in the air mainly enter the human body from the respiratory tract, water and soil, and some pollutants enter the human body from drinking water or food through the digestive tract and then spread to various parts of the body with body fluids. Some pollutants would accumulate and hide in the body, but more pollutants would still undergo metabolism, oxidation, reduction and hydrolysis, which would cause changes in the chemical structure of the body, thus resulting in a decline in the toxicity of most pollutants, and some would increase. Most pollutants are discharged from the body in their original form or transformed form, and some pollutants act in the body to affect the material conversion or destroy the cell structure. Some are directly used as inhibitors to hinder the smooth progress of the metabolic pathway and cause harm to the health of human body and organism [9].

2.1.3. Theoretical Basis of NEP

The natural environment refers to all natural factors that affect the existence and development of the region. It mainly includes two aspects: One is the ecological environment, and the other is natural resources. Among them, the ecological environment includes: water, atmosphere, vegetation, wildlife, soil, geology, etc., which are the basis of forming the natural environment structure. Natural resources refer to natural resources that have an impact on regional development, including natural landscape resources and natural energy (including wind energy, solar energy, tidal sand energy, wave energy, etc.). The protection of natural environment is to solve the relationship between natural ecosystem and development by taking natural ecosystem as the core and comprehensively using various means and methods. Sustainable development is an important theoretical basis for NEP. The main contents of natural resources are shown in Figure 1:

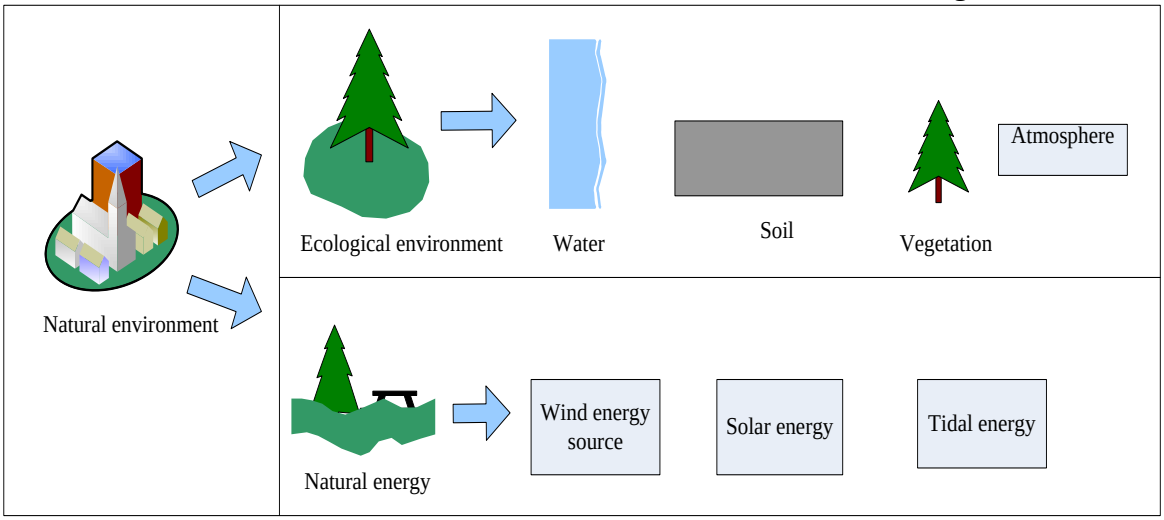

Figure 1. Main contents of natural resources

Sustainable development can meet the needs of contemporary human beings without affecting the next generation. This is not a negation of economic development, but a reflection on how to meet the requirements of economic development [10]. Sustainable development is based on natural resources and conforms to the carrying capacity of the natural environment. It confirms and reflects the value of natural resources [11]. The sustainable development of natural resources has important theoretical significance and practical value. It is to optimize the system on the basis of strengthening overall planning and coordination; it is also based on scientific planning and scientific management to realize the healthy operation of the natural ecosystem and the rational development of natural resources; at the same time, it is also a way to improve management level through scientific and technological progress.

2.2. Dynamic Model

The dynamic model is also known as the dynamic analysis model, which is mainly used to analyze the load on aerospace or other dynamic distribution. At present, there have been obvious achievements in applying dynamic models to EP. Scholars have built many mathematical models and said that when combining natural resources and EP, logistic model can be used to build dynamic models. The model can not only describe the changes of population and various species (such as trees in the forest and fish in the pond), but also be widely used in social and economic aspects. Among them, the continuous dynamic model evolved from the catastrophe theory has the following formula:

$$\frac{aM}{ar} = sM\left(1 - \frac{M}{M_{max}}\right) - K - G \tag{1}$$

Formula 2 is as follows:

$$K = \frac{kM(r)A(r)^p}{A(r)^p + A_a^p} \tag{2}$$

Among them: K-death rate;
p-shape parameters;
A-pollutant concentration;
M-natural resource stock;
M_{max}-maximum natural resource stock;
G-extraction speed of natural resources;
s-renewable power of natural resources.
The dynamic model of EP is as follows:

$$\frac{aA}{ar} = q - \theta A \tag{3}$$

Among them: θ-self-purification rate of environmental system to pollutants;
q-the speed at which human beings input pollutants into the environmental system.

On this basis, a dynamic model that can reflect both its sudden characteristics and its economic importance is established, and the relationship between the dynamic system and the changes of various parameters in economic activities is obtained by using the steady-state analysis method. However, this model still has some defects, and it is difficult to solve the problems of NEP and EP as a whole. The ML method can ensure the completeness and accuracy of the model by weakening the randomness and constructing continuous calculus formulas.

2.3. ML

Due to the continuous collection and integration of data on EP and environmental factors, massive data poses a new challenge to the traditional source term analysis method. This requires people to find new prediction methods and new models, and extract new information from them to better analyze EP. In order to solve this problem, people use ML method to analyze the source of pollutants. ML is an interdisciplinary research involving probability, statistics, approximation theory, convex analysis, algorithm complexity and other fields [12-13]. ML mainly studies how computers simulate or realize human learning behavior to obtain new knowledge or skills, and reorganize the existing knowledge structure, so as to continuously improve their performance [14]. Among them, Back Propagation (BP) neural network, k-means clustering, decision tree, support vector machine and Apriori in ML have been widely used in the research of EP problems [15]. The process of ML is shown in Figure 2:

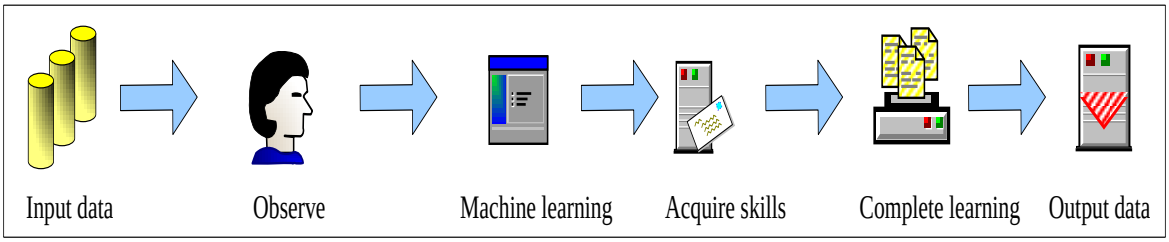

Figure 2. Process diagram of ML

BP neural network is a multilayer feedforward neural network, which has a wide range of applications. This method uses a gradient descent method that minimizes the sum of the deviations between the real output and the expected output. The transfer function is the neuron type. The output function of the system is in the range of 0 to 1, and it can be transformed into a continuous nonlinear map. In theory, as long as there is a proper weight and a reasonable framework, BP neural network can be used to approximate any nonlinear continuous function. The basic idea of BP neural network is to use an error gradient descent algorithm to minimize the mean square error between the real output values of the network. In BP neural network, when the output layer does not get the expected result, they would adjust the weight and threshold of the network according to the prediction error to achieve the desired result.

On this basis, this paper constructed a linear function by assuming that the natural resources extracted by human beings were the total amount of natural resources, and analyzed the change rule of environmental self-purification rate and pollutant discharge rate in the total amount of natural resources by constructing the coupling relationship between the total amount of natural resources and the concentration of pollutants. This paper also discussed the impact of the total amount of natural resources on sustainable development.

This paper assumed that the increment of natural resources satisfied the Logistic law without considering biological death and human demand:

$$M(r+1) - M(r) = sM(r)[1 - M(r)/M_{max}] \quad (4)$$

Among them: $M(r)$-the stock of natural environmental resources at moment r.

It is assumed that the concentration increment of pollutants is related to the speed of human input of pollutants into the environmental system and the environmental self-purification rate. At the same time, pollution concentration would have an impact on the regeneration capacity of natural resources. BP neural network can be used to build the latest CDM of NEP and EP. The specific system model is as follows:

$$\begin{cases} M(r+1) = M(r)[1 - 1/s - M(r)/M_{max}] - K(r) - G(r) \\ A(r+1) = q + A(r)\big(1 - vM(r)\big) \end{cases} \quad (5)$$

The CDM of natural environmental protection and EP is established through the BP neural network under the above ML, and the nonlinear dynamic analysis between natural environmental protection and EP is realized. The existence, stability and local bifurcation of the positive equilibrium point of this kind of system are further studied, and the global solution of this kind of system is given. Moreover, according to different natural environmental factors, the sustainable use of natural resources can be ensured. In addition, it is also combined with the self-purification rate of NEP, which can effectively limit the rate of man-made pollutants entering the environmental system, and provides great help for natural resource management decision-makers in formulating resource utilization and protection policies.

3. CDM Experiment of NEP and EP

On the basis of discussing the shortcomings of the current CDM of natural resources and EP, and combined with ML technology, this paper proposed an innovative method to construct the CDM of natural environmental protection and EP. In order to verify the performance of this method, this paper also needed to carry out practical verification.

3.1. Experimental Method of CDM of NEP and EP

In order to verify the actual performance of the CDM of NEP and EP based on ML proposed in this paper, this paper compared it with the traditional dynamic model, and compared the stability of the positive equilibrium point of the two models, so as to draw relevant conclusions.

3.2. Stability Comparison of Two Models

The positive balance point is a state in which the ecosystem is in ecological balance. It reflects the stability of the medium-sized model of the relationship between ecosystems. Therefore, the stability of the positive equilibrium point is an important method to measure the performance of the CDM of natural environmental protection and EP. Therefore, this paper compared the stability of the positive equilibrium points of the two models, and the specific results were shown in Figure 3.

It could be seen from Figure 3 (A) and Figure 3 (B) that the stability of the positive equilibrium point under the traditional method was controlled between 0.5 and 2.0. On the whole, its stability fluctuated greatly. The stability value of the positive equilibrium point under this method was controlled between 0.5 and 1.5. Compared with traditional methods, its stability fluctuated less. This showed that the method in this paper had better performance, and its positive equilibrium point was more stable. This was because this method combined ML to optimize the dynamic model and made it more stable.

To sum up, through the empirical analysis of the CDM of NEP and EP that integrates ML, it was found that this method was feasible. Compared with the traditional method, the stability figures of the positive equilibrium point of this method were controlled between 0.5 and 1.5. Its peak change was small and its stability was better, which was more helpful to analyze the impact of environmental self-purification rate on the sustainable use of natural resources.

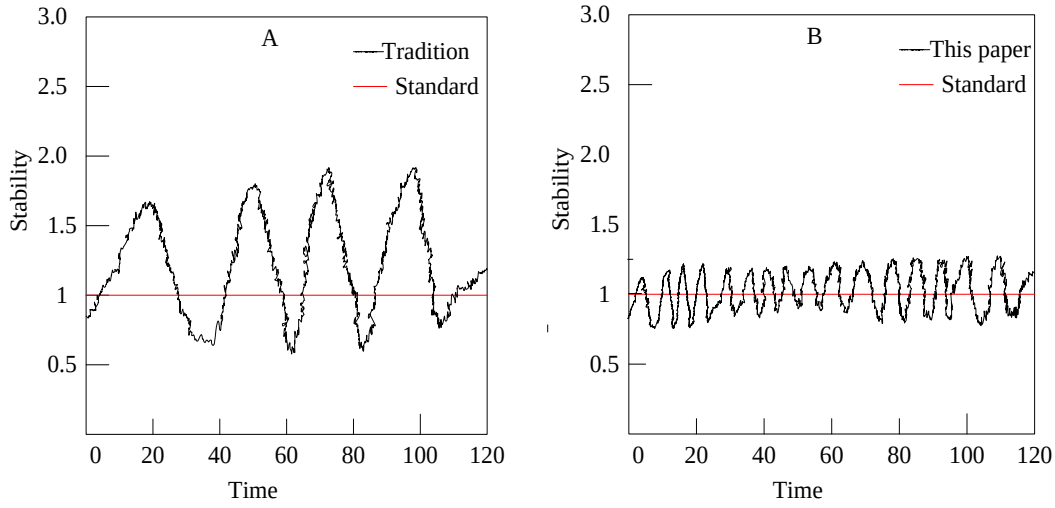

Figure 3(A): Positive equilibrium stability of traditional model;

Figure 3(B): Positive equilibrium stability of the model in this paper.

Figure 3. Stability comparison of positive equilibrium points of two models

4. Conclusion

With the current sustainable theory gradually gaining popularity, natural environmental protection and EP have attracted more people's attention. How to better analyze the relationship between natural environmental protection and EP so as to achieve sustainable development is the current problem. The subject of this paper was the CDM of NEP and EP, which integrated ML. First of all, this paper gave a brief overview of the background of the paper, and then analyzed the advantages and disadvantages of previous scholars' research. Through the analysis of ML, a method to optimize the CDM of NEP and EP was proposed. Finally, in order to verify the practical utility of this method, this paper also verified it. It was found that the positive equilibrium of the CDM of NEP and EP built by ML was more stable and had better practical value. However, there were also some shortcomings in this paper. Due to the limitations of actual conditions, the scope of this study was small, which might have a certain impact on the results. In the follow-up study, the persistence of the model could be emphasized.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Korchenko Oleksandr. GIS and remote sensing as important tools for assessment of environmental pollution. International Multidisciplinary Scientific GeoConference: SGEM. (2019) 19(2.1): 297-304. https://doi.org/10.5593/sgem2019/2.1/S07.039

[2] Jing Sun. Urbanization, economic growth, and environmental pollution: Partial differential analysis based on the spatial Durbin model. Management of Environmental Quality: An International Journal. (2019) 30(2): 483-494. https://doi.org/10.1108/MEQ-05-2018-0101

[3] Baloch Zulfiqar Ali. Assessing energy efficiency in the Asia-Pacific region and the mediating role of environmental pollution: evidence from a super-efficiency model with a weighting preference scheme. Environmental Science and Pollution Research. (2021) 28(35): 48581-48594. https://doi.org/10.1007/s11356-021-13663-6

[4] Strassburg Bernardo BN. Global priority areas for ecosystem restoration. Nature. (2020) 586(7831): 724-729. https://doi.org/10.1038/s41586-020-2784-9

[5] Jacobides Michael G., Carmelo Cennamo, Annabelle Gawer. Towards a theory of ecosystems. Strategic management journal. (2018) 39.8: 2255-2276. https://doi.org/10.1002/smj.2904

[6] Gordin Igor. Environmental protection systems during periods of economic downturns. Ekonomika i matematicheskie metody. (2021) 57(2): 55-63. https://doi.org/10.31857/S042473880014913-3

[7] Zandalinas Sara I., Felix B. Fritschi, Ron Mittler. Global warming, climate change, and environmental pollution: recipe for a multifactorial stress combination disaster. Trends in Plant Science. (2021) 26(6): 588-599. https://doi.org/10.1016/j.tplants.2021.02.011

[8] Ng Archie. Fate of environmental pollutants. Water Environment Research. (2019) 91(10): 1294-1325. https://doi.org/10.1002/wer.1225

[9] Luka Yusufu, Bitrus Kwaji Highina, Abdu Zubairu. Bioremediation: A solution to environmental pollution-a review. Am J Eng Res. (2018) 7(2): 101-109.

[10] Tomislav Klarin. The concept of sustainable development: From its beginning to the contemporary issues. Zagreb International Review of Economics & Business. (2018) 21(1): 67-94. https://doi.org/10.2478/zireb-2018-0005

[11] Bali Swain, Ranjula, Fan Yang-Wallentin. Achieving sustainable development goals: predicaments and strategies. International Journal of Sustainable Development & World Ecology. (2020) 27(2): 96-106. https://doi.org/10.1080/13504509.2019.1692316

[12] Janiesch Christian, Patrick Zschech, Kai Heinrich. Machine learning and deep learning. Electronic Markets. (2021) 31(3): 685-695. https://doi.org/10.1007/s12525-021-00475-2

[13] Shiliang Sun. A survey of optimization methods from a machine learning perspective. IEEE transactions on cybernetics. (2019) 50(8): 3668-3681. https://doi.org/10.1109/TCYB.2019.2950779

[14] Ping Wang, Yan Li, Chandan K. Reddy. Machine learning for survival analysis: A survey. ACM Computing Surveys (CSUR). (2019) 51(6): 1-36. https://doi.org/10.1145/3214306

[15] Hopkins Emily. Machine learning tools, algorithms, and techniques. Journal of Self-Governance and Management Economics. (2022) 10(1): 43-55. https://doi.org/10.22381/jsme1012023