Research on Effectiveness Assessment of Ecological Conservation in Xinjiang Based on the Cloud Model

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Abstract. Aiming for effective ecological conservation in Xinjiang, an effectiveness assessment system is built on the cloud model to examine the controllability of ecological conservation based on the practice in Xinjiang. It has been found that the cloud model for effectiveness assessment fully takes into account ambiguity and randomness where the expert review falls short and can effectively improve the influence of subjective factors in the assessment of ecological conservation through parameter setting and calculation. Therefore, it leads to accurate and practical assessment results. These findings can play an important referential role in improving the practicality and effectiveness of ecological conservation in Xinjiang.

1. Introduction

In order to improve the governance system for ecological conservation in Xinjiang and improve Xinjiang’s governance capacity in ecological conservation, it is necessary to devise a scientific method to objectively assess the achievements of ecological conservation in Xinjiang. Through the assessment model, factors that have positive and negative effects on ecological conservation in Xinjiang are analyzed to sustain this effort and make it more effective in practice.

At present, scholars worldwide mainly study ecological conservation from two perspectives. The first perspective focuses on the assessment system for regional ecological conservation. For example, He Lvna et al.[1] analyzed the key indicators that influence ecological conservation based on the status of ecological conservation in Yunnan Province and the position of Yunnan Province in the Belt and Road Initiative and thus built an indicator system for assessment. Wang Xinyu et al.[2] established an indicator system for the assessment of ecological conservation in impoverished mountainous areas in Western China by sorting out assessment indicators. Focusing on the effectiveness of ecological conservation, which is the research object, these studies only analyze relevant factors influencing ecological conservation as a part of the assessment system for progress in building an ecological civilization while paying little attention to the targeted assessment of ecological conservation. The second perspective focuses on the assessment methods for ecological conservation, and the main approach is to assess achievements and effectiveness of ecological conservation and ecological barrier construction through the formulation of models and theories. For example, the analytic hierarchy process (AHP) and the Delphi method were employed to analyze the level of ecological conservation in 9 provinces (autonomous regions) in the Yellow River Basins[3] from 2012 to 2018; the PSR model was employed to assess the status of ecological conservation and ecological barrier construction in a defined area[4]. With the main aim to assess the effectiveness, achievements and performance of ecological conservation, these studies cannot effectively reflect the extent to which the current ecological conservation efforts have fulfilled expected objectives.
Based on traditional mathematical models, the cloud model enables effective conversion between qualitative description and quantitative values, and more objectively reflects the characteristics of assessment indicators, making effectiveness assessment more effective and accurate. Therefore, based on the characteristics of the cloud model and the unique differences between Xinjiang and other areas in ecological conservation, relevant parameters and the expression of the weighted and integrated cloud were formulated and an adjustable assessment model for the effectiveness of ecological conservation in Xinjiang was constructed from the perspective of conversion between qualitative description and quantitative values.

2. The Development of the Assessment System for the Effectiveness of Ecological Conservation in Xinjiang

2.1. Research Object
Recent years have witnessed rapid economic growth of the Xinjiang Uygur Autonomous Region (Xinjiang), but the ecological functions of grasslands are often underplayed while their production functions are overplayed. Therefore, their restoration and service functions are tremendously weakened, an outcome that even poses a severe threat to China’s ecological barrier construction. In particular, due to the negative influence of geo-climate and other factors, the ecological environment in Xinjiang is inherently vulnerable and sensitive, making it become a key area of ecological conservation in China[5].

2.2. The Development of the Indicator System
The effectiveness of ecological conservation generally refers to what has been achieved in ecological conservation. In this paper, it specifically refers to the effectiveness of ecological conservation in Xinjiang, that is, the extent to which the predefined goal for ecological conservation has been fulfilled. As Xinjiang has a vast area with complex needs for ecological conservation, it is required to take various factors into account in developing the indicator system for effectiveness assessment. Therefore, not only has attention been paid to actual needs and characteristics of ecological conservation in Xinjiang, but also reference has been made to the Indicators for Demonstration Counties/Cities in Building an Ecological Civilization issued by the Ministry of Ecology and Environment of the People’s Republic of China as well as relevant research achievements on ecological conservation worldwide[6-8]. By analyzing the holistic distribution characteristics of and laws of change in ecological conservation efforts in Xinjiang and specific ones in such efforts in cities and autonomous prefectures of Xinjiang in the past ten years, the indicator system for the effectiveness assessment of ecological conservation in Xinjiang is established according to the actual level of ecological conservation in Xinjiang and the availability of assessment data. Details are shown in Table 1.

Table 1 Indicator System for Effectiveness Assessment of Ecological Conservation in Xinjiang

| First-level Indicator | Second-level Indicator |
|-----------------------|-----------------------|
| Progress in Developing the Responsibility Systems and Institutions for Ecological Conservation Objectives | The Status of Planning |
| Quality of Ecological Resources | The Status of Enforcement |
| Ecosystem Conservation | The Status of Information Disclosure |
| The Defense against Ecological Risks | Quality of Air |
| | Quality of Water |
| | Quality of Land Resources |
| | The Status of Ecology |
| | Vegetation Coverage in Deserts |
| | The Status of Biodiversity Protection |
| | The Status of Hazardous Waste Utilization and Disposal |
Land Pollution Prevention and Land Restoration  
The Progress in Developing the Management System for Ecological Emergencies  

The Awareness of Ecological Security  
The Status of Training on Ecological Emergencies  
The Satisfaction of Residents with Ecological Conservation Efforts  
The Involvement of Residents in Ecological Conservation  

The Status of Ecological Crimes  
The Occurrence of Ecological Crimes  
The Registration of Cases of Ecological Crimes  
The Clearance of Cases of Ecological Crimes  

3. Model Construction for Effectiveness Assessment of Ecological Conservation in Xinjiang

3.1. Introduction to the Normal Cloud Model
The normal cloud model is a cloud model mainly employed in this research to enable mutual transformation between qualitative description and quantitative values\(^9\). Usually expressed by expectation (\(E_x\)), entropy (\(E_n\)) and hyper entropy \((H_e)\), the model represents qualitative description with quantitative values. Cloud generation algorithms mainly include two types: the forward cloud generation algorithm (hereinafter the FCGA) and the reverse cloud generation algorithm (hereinafter the RCGA). While the FCGA transforms description into a certain value, the RCGA reverses the process. Formulated based on the normal distribution function, the cloud model is widely applicable.

3.2. Model Construction

(1) Constructing the Set of Comments
As can be seen in Table 1, the indicators for effectiveness assessment of ecological conservation are mainly qualitative indicators which are difficult to quantify during analysis. Therefore, it is necessary to convert descriptive indicators into quantitative indicators or quantitative intervals. Based on the one-dimensional cloud model, the qualitative indicators are converted into quantitative ones referentially to establish a set of quantified cloud models for the effectiveness assessment of ecological conservation. Depending on the criteria for the effectiveness assessment of the ecological conservation system in Xinjiang, grading levels and scoring intervals are established for the set of comments: very poor \([0, 4]\), poor \([4, 6]\), average \([6, 8]\), good \([8, 9]\) and excellent \([9, 10]\), and \(H_e\) is 0.03. Based on this, the digital characteristics of the standard cloud for ecological conservation in Xinjiang are concluded through analysis, as shown in Table 2:

| Set of Comments | Very Poor | Poor | Average | Good | Excellent |
|-----------------|-----------|------|---------|------|-----------|
| Standard Cloud Model | (0,0.667,0.03) | (5,0.333,0.03) | (7,0.333,0.03) | (8.5,0.1667,0.03) | (10,0.1667,0.03) |

Generate the standard cloud diagram using Matlab and based on the above data.

(2) Weigh Assignment
After the indicator system is developed for the effectiveness assessment of ecological conservation in Xinjiang, it is necessary to judge the degree of membership between indicators at different levels in order to determine their relationships. In this paper, the AHP is employed to assign the weight of each indicator. First, a 1-9 scale\(^{10}\) is used to compare and analyze the importance of indicators at the same level. On this basis, a matrix is constructed and verified for consistency, followed by the calculation of each indicator’s weight.
(3) Cloud Model Construction for Each Indicator
Experts are hired to perform security assessment for each indicator depending on research objects and needs and then a cloud model is generated for each indicator according to the reverse cloud generation formula.

The mean of samples is

\[ \bar{X} = \frac{1}{n} \sum_{i=1}^{n} x_i \]  

(1)

the variance is

\[ S^2 = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{X})^2 \]  

(2)

and the expectation is

\[ E_X = \bar{X} \]  

(3)

Based on the mean, the entropy is

\[ E_n = \frac{\pi}{2} \times \frac{1}{n} \sum_{i=1}^{n} |x_i - E_x| \]  

(4)

Based on the variance and the entropy, the hyper entropy is

\[ H_e = \sqrt{S^2 - E_n^2} \]  

(5)

(4) Analyzing assessment results based on the diagram of the cloud model
After the cloud model is derived and the weight is assigned for each second-level indicator, the cloud model of each upper-level indicator is derived through calculation based on Formula 6-8. Among them, \( E_X, E_n, H_e \) composes the cloud model of the n-1th-level integrated cloud model; \( E_{X_n}, (E_{X_1}, E_{X_2}, \ldots) \) is the expectation of the nth-level integrated cloud model; \( E_{n_i}, (E_{n_1}, E_{n_2}, \ldots) \) is the entropy of the nth-level integrated cloud model; \( H_{e_n}, (H_{e_1}, H_{e_2}, \ldots) \) is the hyper entropy of the nth-level integrated cloud model; \( i \) is the number of nth level indicators; \( \omega_1, \omega_2, \ldots, \omega_n \) are the weights of the nth level. Based on them, the integrated cloud model of the uppermost level is derived through calculation.

\[ E_X = \frac{E_{X_1} \times E_{n_1} \times \omega_1 + E_{X_2} \times E_{n_2} \times \omega_2 + \cdots + E_{X_n} \times E_{n_n} \times \omega_n}{E_{n_1} \times \omega_1 + E_{n_2} \times \omega_2 + \cdots + E_{n_n} \times \omega_n} \]  

(6)

\[ E_n = \frac{E_{n_1} \times \omega_1 + E_{n_2} \times \omega_2 + \cdots + E_{n_n} \times \omega_n}{E_{n_1} \times \omega_1 + E_{n_2} \times \omega_2 + \cdots + E_{n_n} \times \omega_n} \]  

(7)

\[ H_e = \frac{H_{e_1} \times E_{n_1} \times \omega_1 + H_{e_2} \times E_{n_2} \times \omega_2 + \cdots + H_{e_n} \times E_{n_n} \times \omega_n}{E_{n_1} \times \omega_1 + E_{n_2} \times \omega_2 + \cdots + E_{n_n} \times \omega_n} \]  

(8)

Finally, the integrated cloud model of the upper-most level is converted into a cloud diagram to verify the grade of the entire system.

4. Results and Analysis
Based on the AHP, the cloud theory and other methods as well as the practice in Gongliu County, this paper conducts a reasonable and effective analysis of indicators for the effectiveness assessment of ecological conservation in Xinjiang Uygur Autonomous Region from 2012 to 2020. Earning a spot in the third batch of demonstration cities and counties in building an ecological civilization, Gongliu County has played a representative role in ecological conservation with its ecological efforts paying off significantly. Based on data specific to the effectiveness of ecological conservation, the indicator system for effectiveness assessment and the cloud model in Table 1 are employed to verify accuracy and effectiveness of the assessment. Below is the detailed process.

First, an expert group is organized to perform a security assessment of all indicators in the indicator system for the effectiveness assessment of ecological conservation based on the AHP 1-9 scale and matrices are established for them. Next, the weight of each indicator is calculated based on its matrix, followed by consistency verification. However, in order to ensure its effectiveness, it is still necessary to calculate each indicator’s weight relative to the one at the uppermost level. Therefore, the AHP analysis is performed to perform this step.
According to the risk level defined in Table 2, experts are asked to analyze and score each indicator, and then formula 1-5 is used to calculate the cloud models \((Ex, En, He)\) of second-level indicators, and results are shown in Table 3.

### Table 3 Cloud model feature table of second-level indicators

| Second-level Indicator | Weight | Cloud Model            |
|------------------------|--------|------------------------|
| \(A_{11}\)             | 0.0268 | \((8.6042, 0.8706, 0.2749)\) |
| \(A_{12}\)             | 0.0757 | \((8.5065, 1.3408, 0.3204)\) |
| \(A_{13}\)             | 0.1423 | \((8.3143, 1.2841, 0.1489)\) |
| \(A_{21}\)             | 0.0423 | \((8.8735, 1.0159, 0.2073)\) |
| \(A_{22}\)             | 0.1438 | \((9.1046, 1.3204, 0.3068)\) |
| \(A_{23}\)             | 0.2446 | \((8.6329, 1.2461, 0.2683)\) |
| \(A_{31}\)             | 0.0037 | \((8.9051, 1.3067, 0.4103)\) |
| \(A_{32}\)             | 0.0122 | \((9.2503, 1.4573, 0.4805)\) |
| \(A_{33}\)             | 0.0302 | \((9.3764, 1.3573, 0.4018)\) |
| \(A_{41}\)             | 0.0070 | \((8.8621, 1.2794, 0.3793)\) |
| \(A_{42}\)             | 0.0125 | \((9.7814, 1.5623, 0.4689)\) |
| \(A_{43}\)             | 0.0548 | \((9.3497, 1.4231, 0.3744)\) |
| \(A_{51}\)             | 0.0067 | \((9.2344, 1.3241, 0.3541)\) |
| \(A_{52}\)             | 0.0512 | \((9.5731, 1.3415, 0.2431)\) |
| \(A_{53}\)             | 0.0186 | \((9.4379, 1.2374, 0.3122)\) |
| \(A_{61}\)             | 0.0125 | \((9.0610, 1.1048, 0.2056)\) |
| \(A_{62}\)             | 0.0725 | \((8.9532, 1.1436, 0.2523)\) |
| \(A_{63}\)             | 0.0426 | \((9.2123, 1.2953, 0.4809)\) |

The cloud models of the first-level indicators are derived through calculation based on the data in Table 3 using Formula 6-8, and the results are shown in Table 4.

### Table 4 Cloud model feature table of first level indicators

| First-level Indicator | Weight | Cloud Model            |
|-----------------------|--------|------------------------|
| \(A_1\)              | 0.2448 | \((8.3997, 0.3076, 0.2151)\) |
| \(A_2\)              | 0.4307 | \((8.8187, 0.5376, 0.2770)\) |
| \(A_3\)              | 0.0461 | \((9.3056, 0.0636, 0.4245)\) |
| \(A_4\)              | 0.0743 | \((9.3875, 0.1065, 0.3921)\) |
| \(A_5\)              | 0.0765 | \((9.5121, 0.1006, 0.2688)\) |
| \(A_6\)              | 0.1276 | \((9.0572, 0.1519, 0.3311)\) |

Similarly, the integrated cloud model for the effectiveness assessment of ecological conservation in Gongliu County is \((8.7733, 0.3448, 0.2702)\), which is derived through calculation based the data in Table 4, and the resulting cloud diagram is shown in Figure 1:
From Figure 1, it can be seen that the score from the effectiveness assessment of ecological conservation in Gongliu County in Xinjiang Uygur Autonomous Region mainly falls in the interval [9, 10], which means the final grade is Excellent, complies with the results of expert reviews and surveys, and proves the status of the county as one of the third batch of demonstration cities and counties in building an ecological civilization. The entropy and hyper-entropy of the integrated cloud model are small, which demonstrates concentrated distribution of clouds, unified comments, and reliable assessment results. Besides, the effectiveness assessment model can convert assessment results into intuitive and visualized diagrams through the cloud model on the basis of calculation, which facilitates judgment and prediction at the later stage.

5. Conclusions
Compared with traditional methods for effectiveness assessment, the one discussed in this paper pays more attention to eliminating the randomness and ambiguity of assessment comments, thus achieving more reliable and authentic results. The cloud theory is applied to explore a proper model for effectiveness assessment of ecological conservation, and the resulting assessment system based on the cloud model is employed to explore the controllability of regional ecological conservation based on the practice in Gongliu County. Experimental results show:

(1) The cloud model for effectiveness assessment can greatly increase the influence of subjective factors in the assessment of ecological conservation through parameter setting and calculation and the results are accurate and practical.

(2) Although the effectiveness assessment model leads to accurate and practical results in the effectiveness assessment of ecological conservation in Gongliu County, inadequate efforts have been dedicated to the comparative study of different cloud models due to limited conditions.

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