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Research on wildlife conservation strategy based on gray prediction and entropy weight method

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Abstract. This study provides an in-depth examination of nature reserve programs and their feasibility, focusing on the challenges posed by illegal wildlife trade. Through an extensive literature review of scientific databases such as SCI and EI, the thesis illuminates the frontiers of current conservation efforts and assesses the compatibility of nature reserve programs with stakeholders. The research includes a comprehensive case study of wetlands in Patagonia, Brazil, analyzing the correlation between illegal wildlife trade crime indicators and selected socio-economic factors. Using advanced modeling techniques, including the gray predictive model GM (1,1) and the information entropy weighting method (EWM), the paper predicts trends in endangered species such as the jaguar and assesses the effectiveness of conservation measures. In addition, an assessment improvement framework is proposed that integrates a perspective through vector autoregression (VAR) analysis to enhance the assessment of conservation strategies and stakeholder empowerment.

Keywords: Gray prediction; Entropy right method; Wildlife conservation strategy.

1. Introduction

In today's world, the challenges of environmental protection and biodiversity are becoming increasingly prominent, with issues such as illegal wildlife trade and the overexploitation of natural resources raising concerns about ecological balance and the survival of species. These problems not only threaten many precious biological resources on Earth, but also directly affect the sustainable development and future of human society.

First, the illegal wildlife trade has become a global problem, not only leading to the extinction of many endangered species and the destruction of habitats, but also contributing to the formation of organized criminal activities and transnational illegal trading networks. Such trade not only infringed on the stability of natural ecosystems, but also posed a great threat to the global ecological balance. At the same time, the over-exploitation of natural resources and environmental pollution have also exacerbated the loss of biodiversity and the destruction of ecosystems, bringing many negative impacts to human society.

Secondly environmental protection and ecological governance face many complex problems and challenges. Governments and relevant organizations are facing enormous pressure and responsibilities in environmental policymaking, resource management and ecological protection, but the existing protection measures and management mechanisms are often unable to respond effectively to the growing environmental problems. At the same time, there are objective problems such as limited resources, insufficient manpower and outdated technology, which constrain the progress and effectiveness of environmental protection work.

Therefore, in response to these realistic backgrounds and problems, there is an urgent need to find effective solutions and innovative management models. How to establish a scientific and reasonable environmental assessment system and customer assessment mechanism, how to utilize advanced technological means and scientific methods to enhance the efficiency and quality of ecological protection and environmental management, and how to promote economic development and social stability while protecting the ecosystem are all key issues that need to be addressed urgently.

Against this background, this study aims to explore the applicability of nature reserve projects and the optimization of client assessment systems, with the aim of providing innovative ideas and practical experience for environmental protection and ecological governance. Through in-depth analysis of the real situation and study of cutting-edge theories, this study seeks to propose feasible solutions and effective management measures to contribute to the development and progress of environmental protection.

2. Suitability Study

Literature Review**:** By reading and collecting valuable forward-looking literature from SCI and EI, this paper summarizes the frontiers and feasibility of nature reserve projects, and further summarizes the compatibility between project and client on the basis of model evaluation.

Case Study: Taking Brazil as a case study, the correlation between the illegal wild trade crime indicator and the selected indicators is studied. Then, according to the crisis situation faced by the local jaguar, the development trend of its number was predicted, and the results and reasons for the lack of further development of the nature reserve were analyzed. Further analysis of its hazards, highlighting the comprehensiveness and superiority of the project.

2.1. Suitability Analysis Based on Literature Review

The illegal wildlife trade, as the world's fourth-largest illicit commerce, has captured the attention of local authorities, institutions, and scholars both domestically and internationally [1]. This trade not only involves transnational luxury goods transactions but also local habits that drive the demand for wild animals, highlighting the need for conservation efforts [1].

The rise of the internet has resulted in a trend wherein illegal wildlife trade is shifting from physical to online platforms, necessitating innovative strategies for monitoring and enforcement to protect wildlife [2].

Countries signed the CITES convention in 2013 to curb the occurrence of illegal trade, incorporating human, natural, and other factors into their evaluation systems [3]. This international agreement plays a crucial role in wildlife conservation by addressing the root causes of illegal trade and promoting sustainable practices.

Factors triggering illegal trade include high profits, misleading market information, transmission of incorrect knowledge, and non-scientific traditional understandings [4-5]. These factors not only threaten endangered species but also lead to a reduction in regional biodiversity and changes to the natural environment [6-7].

Efforts proposed by researchers, such as Tlusty M.F. and Wang Jing, focus on improving conservation through measures like plant passports, CITES monitoring and regulation, strengthening local species conservation, establishing management systems, creating information sharing platforms, and enhancing scientific outreach and education [8-10]. These policies aim to address the complex challenges posed by illegal wildlife trade and promote sustainable practices for protecting wildlife and biodiversity.

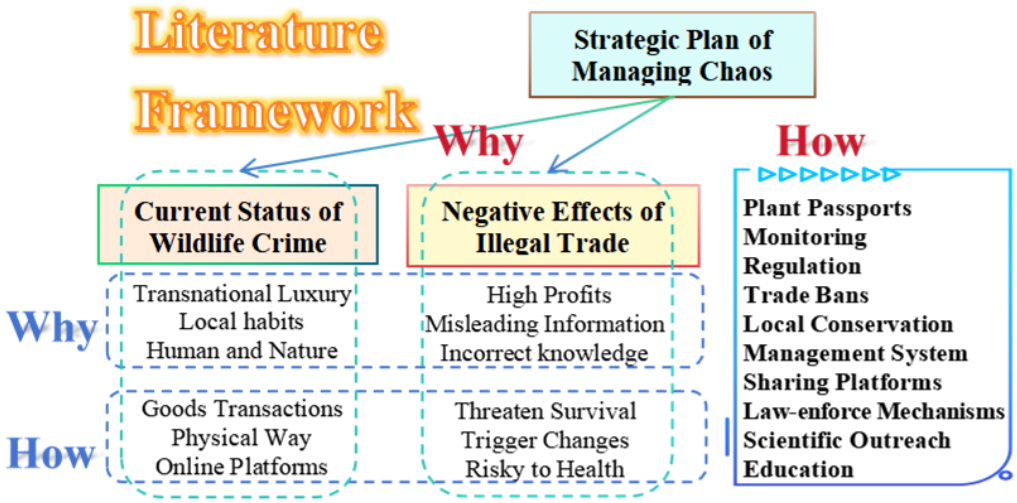

Figure 1. Literature Framework

Based on the above literature(figure 1), we can find that the setting of protection regulations and protected areas is basically based on the government or national decision-making organs. Entrusting the government to establish a nature reserve can more effectively coordinate the interests of all parties, with the maximum resource acquisition rate, efficient resource scheduling, and unified protection with high authority. The formulation and implementation of laws and regulations improve the consistency and continuity of protection measures, and have sufficient capacity and rights to build nature reserves within the scope of management to ensure the effectiveness of biodiversity and environmental governance.

2.2. Case study of a Brazil Area

WILDLIFE TRAFFICKING IN BRAZIL report pointed that "direct jaguar killings by poachers were motivated mainly by conflict with humans over jaguar attacks on livestock, and by fear of jaguar attacks on people in remote areas." Moreover, based on the information we searched on the Google website, we found that the decrease in jaguar was also related to frequent wildfires. We found that Brazil has established a nature reserve in the Pantanal wetland, but the area is not enough to cover the range of wild leopards, and the management capacity is insufficient, and there is still no effective response strategy for human-animal conflicts and frequent wildfires. Figure 2 shows some facts of the reserve[11]:

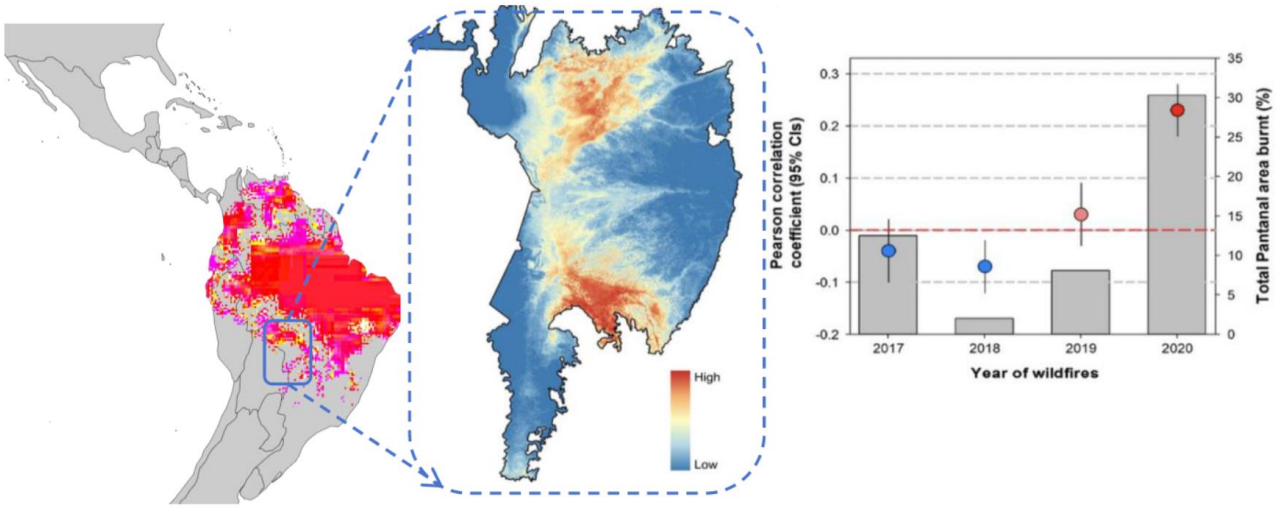

Figure 2. *The location of Pantanal wetland in Brazil.; Jaguar distribution model (JDM) of the Brazilian Pantanal wetland biome. The red and blue regions are encoded with color as the probability of occurrence of jaguar from high to low.; Pearson correlation coefficient between jaguar habitat suitability and wildfire-affected areas in the past 4 years (2017-2020). (QGIS development team, 2021)*

2.3. Case-based Relevance and Prediction Model

Taking Brazil's natural reserves as an example, the index data of food production, GDP, total population, per capita renewable freshwater resources, and population density represent the relevant social and natural factors that will change with the development of Brazil's national strength. The number of illegal wildlife trade cases represents an indicator of illegal wildlife trade crime, and the number of wild jaguars in the Pantanal wetland represents an index of the death degree of unprotected animals. Figure 3 shows their correlation:

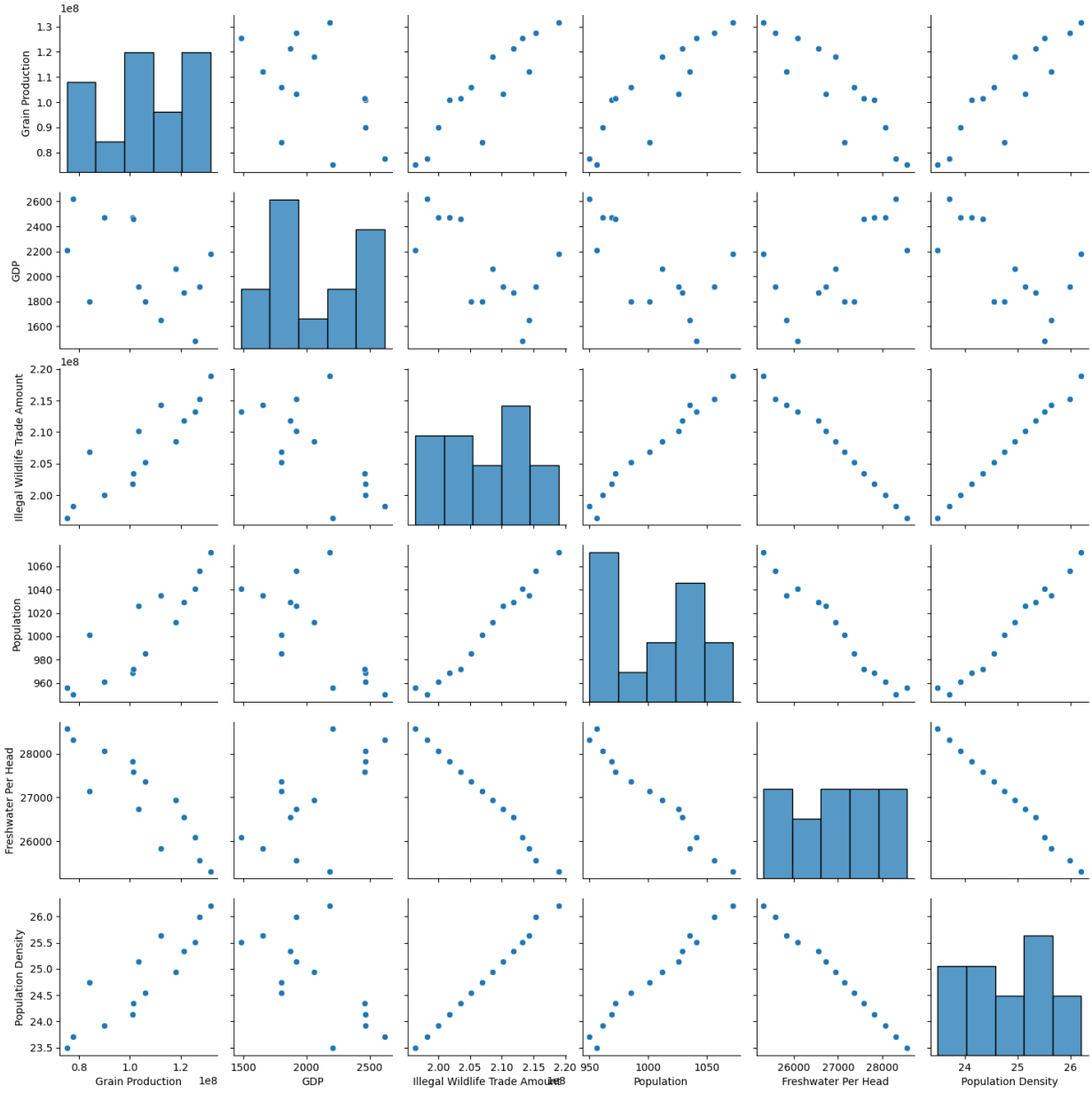

Figure 3. Scatter plot matrix

While paying attention to illegal wild trade, the number of wild animals is also the focus of the project. Therefore, we use the grey prediction model GM (1, 1) to predict the number of jaguars living in the Pantanal wetland of Brazil.

Grey prediction model GM (1, 1) is a time series prediction method based on grey system theory, which is suitable for dealing with incomplete information. The original data sequence is accumulated to generate a sequence (1-AGO) to weaken the randomness of the data. For 1-AGO, a single fitting equation is obtained:

$$x^{(0)}(k) + ax^{(1)}(k) = b \tag{1}$$

Where a and b are constants.

Then the differential equation model is established based on the cumulative generation sequence and solved:

$$x^{(1)}(t) = (x^0(1) - \frac{b}{a})e^{-ak} + \frac{b}{a} \tag{2}$$

Then, the parameter estimation is carried out, and the predictive value equation is obtained according to the solution, and then the prediction sequence is generated. Finally, the cumulative reduction is performed to obtain the predicted value.

$$\hat{x}^{(1)}(t) = (x^0(1) - \frac{b}{a})e^{-ak} + \frac{b}{a} \quad , k = 1,2,3,\cdots, n-1 \tag{3}$$

$$\hat{x}^{(1)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) \quad , k = 1,2,3,\cdots, n-1 \tag{4}$$

According to the gray prediction of jaguar in Pantanal wetland number, the development of jaguar number without intervention is shown in the figure 4:

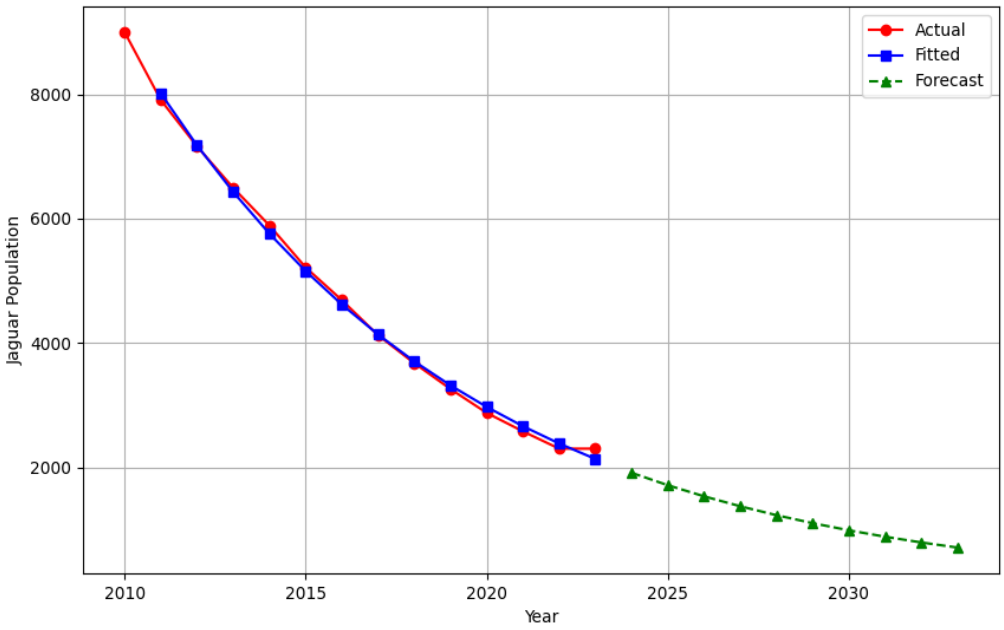

Figure 4. Prediction of jaguars' number in Pantanal wetland

The forecast results show that the number of wild jaguars in Brazil 's Pantanal wetland will continue to decrease or even become extinct without further strengthening the protection of wild animals. It can be seen that no project intervention will have a huge negative impact on the client.

3. Evaluation Improvement

The evaluation system of the client is optimized from the static point of view and the point of view respectively.

Firstly, from the static point of view, based on the conditions required by the project and the additional resources needed by the case analysis, the emphasis on the additional power obtained by the client in the future and the situation after obtaining the resources are evaluated, and the demand for additional power or resources is obtained.

From a point of view, this paper analyzes intercorrelation or influence between the indicators.

3.1. Static Evaluation Based on EWM

The following is based on the entropy weight method to improve the work of Objective 1:

The empowerment steps of entropy weight method are as follows:

Information Entropy (e): According to the proportion gained, the e of the j-th index is:

$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij}\ln p_{ij} \tag{5}$$

Information Utility Value (d): The amount of information valid to measure an indicator:

$$d_j = 1 - e_j \tag{6}$$

Weights (%): The final weight of the indicator is calculated from the ratio of the Information Utility Value of the indicator to the sum of the Information Utility Value of all the indicators:

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{7}$$

Hint: w_j is the weight of the j-th index and m is the total number of indicators. The sum of each indicator is 1, or 100%.

When selecting the government as the client, we assigned the four candidate indicators to the level, but as the final client, the government still lacks in resources, promotion capabilities, and cooperation capabilities. Therefore, it is necessary to have additional power and resources in these three aspects.

To better compare the relationship between the additional power and the resources, the entropy weight method is assigned based on the RSR, and the actual values of the number of digital TV users, the national financial environmental protection expenditure, the area of the nature reserve, the fiscal revenue, the number of foreign contracted projects, and the number of patent applications are used to eliminate the influence of the dimension, which are used to represent the six aspects of promotion, decision-making, land management, funds, cooperation, and technology, so that it is more in line with the objectivity of the power and resources themselves. Reduce subjectivity and make full use of the additional empowerment of resources. Again, the six indicators of the data are further weighted ,result is shown in figure 5:

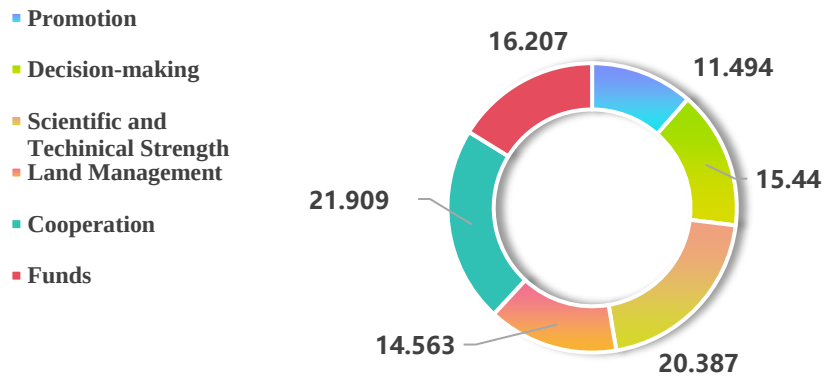

Figure 5. Weights for indicators

3.2. Evaluation Based on VAR

If we give client more power and resources, will other aspects be affected? Static EWM can only reflect the static weight, but can not meet our needs. The evaluation based on VAR vector auto-regression is introduced here:

Time series $y_1, y_2, \ldots, y_n$ generation process is often unknown. It may be more complex than a simple auto-regressive process. Generally speaking, this process has the following forms:

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + u_t \tag{8}$$

Where u_t is the white noise, which is called the pth auto-regressive process and denoted as *AR(p)*.

When we analyze multiple time series, a natural extension of the AR model is the VAR model. In VAR, each time series in a set of vectors is modeled as a lag term determined by itself and all other variables in this set of vectors. The one-stage VAR model:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 x_{t-1} + \epsilon_{1t} \tag{9}$$

Then, calculate the auto-regressive equation for all indicators.

$$\mathrm{Ni(t)} = \sum_{i=1}^{p} k_i N_i(t-1) + \mathrm{bi} \tag{10}$$

Hint: k_i are effect constants, b are constants. All 6 indicators' equations are calculated and p is number of indicators.

According to the above procedure, we solve the equations to gain the AR root diagram of the VAR model:

The AR root diagram in the VAR model is observed. All points are located in the unit circle, so it can be judged that the VAR system is stable.

The model is further analyzed by impulse response analysis and variance decomposition. The results of variance decomposition are sorted out, and the most influential non-self. Root diagram influencing factors and the proportion of each indicator factor in each time stage are summarize. As the Figure 6:

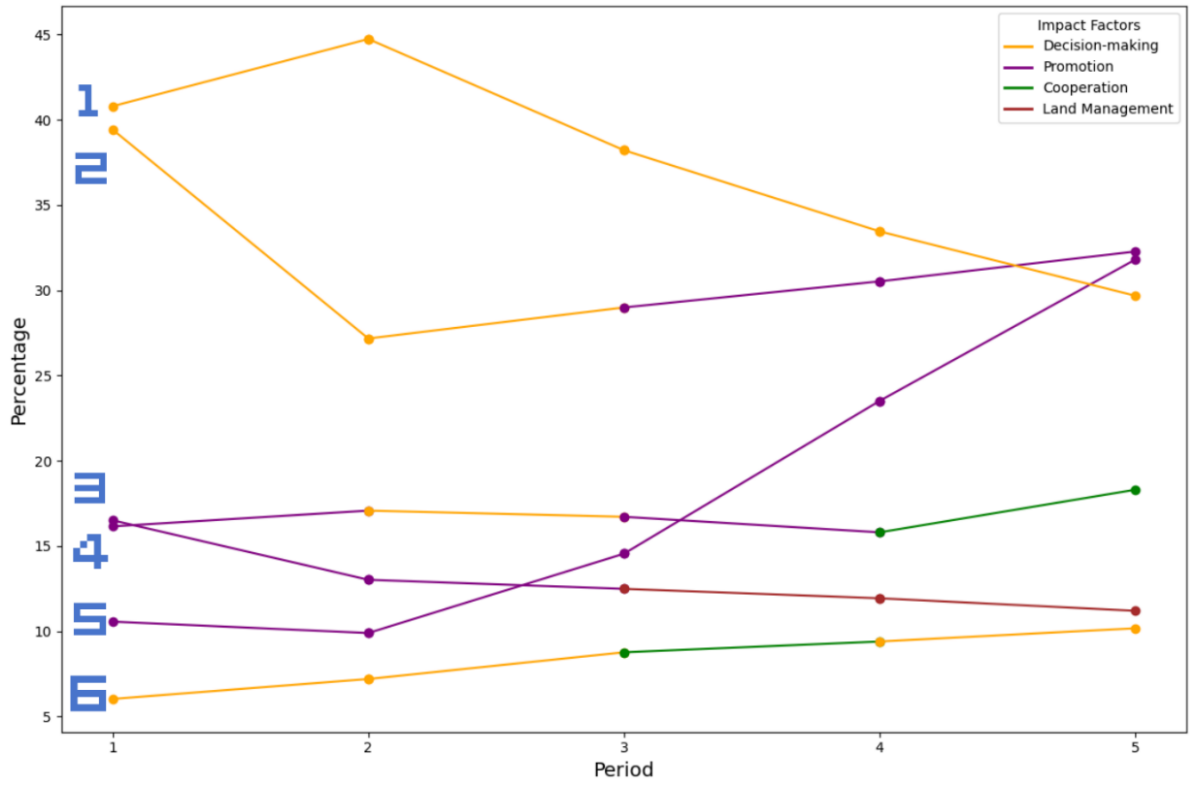

Figure 6. Percent relationship stacking map of each influence indicators at each stage

Hint: 1-6 Represent indicators: scientific and technological strength, land management, cooperation, funds, decision-making and promotion respectively.

VAR conclusion shows that promotion, decision-making and cooperation have a greater impact on the six indicators, and land management has a greater impact on cooperation in the third and fourth stages.

4. Conclusion

This paper has achieved a series of important results through the applicability study of nature reserve projects and the optimization of customer assessment system, and has provided useful thinking and practical experience in the field of environmental protection and ecological governance.

First, in terms of the applicability research of nature reserve projects, this paper provides in-depth analysis from multiple perspectives, including literature review, case study and model evaluation. Through combing relevant literature and summarizing cutting-edge theories, this paper clarifies the prospect and feasibility of nature reserve projects, and deeply explores the compatibility between projects and clients through case studies. Meanwhile, through model evaluation and data analysis, this paper finds the high correlation and suitability between the project and the client, which provides important theoretical support and practical guidance for the implementation and promotion of the project.

Secondly, in terms of the optimization of the customer assessment system, this paper researches and improves it from both static and perspectives. By introducing analytical methods such as entropy weight method and VAR model, this paper successfully optimizes the index system and weight allocation of the customer assessment system, and improves the accuracy and reliability of the assessment results. Especially in the assessment, this paper introduces the gray prediction model and VAR analysis method, which realizes the effective prediction and analysis of the future development trend and influencing factors of the client, and provides an important reference basis for the long-term development of the client and the continuous promotion of the project.

Overall, the work and results of this paper highlight the concern and exploration of environmental protection and ecological governance issues, and provide useful theoretical support and practical experience for solving current environmental challenges and promoting sustainable development. Through the in-depth study and optimization of the nature reserve project and the client assessment system, this paper points out the direction for future environmental protection and improvement, which is of positive significance and value in promoting the construction of ecological civilization and building a beautiful China.

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