Reducing the illegal wildlife trade based on multiple linear regression model

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Abstract. Illegal wildlife trade has serious negative impacts on the ecological environment and species diversity, and it is of practical significance to propose projects to reduce it for the protection of the ecological environment. By analyzing the problem around illegal wildlife trade, we constructed and continuously monitored and evaluated the improvement model to present the factors, formulate solutions and predict results affecting the illegal wildlife trade. We use EWM to calculate the weighting coefficients of the three organizations in relation to power, resources and interest. Finally we choose the UNEP as our client. 5a sliding window algorithm and social awareness rate formula are developed by us for comprehensive data analysis, ultimately resulting in a strong adaptation of program content to client goals. So as to achieve the goal of reducing the illegal wildlife trade behaviors and protecting the ecological environment. The paper could effectively reduce illegal wildlife trade, enhance public awareness of animal protection, maintaining an accurate level of prediction when responding to unforeseen events.

Keywords: Illegal Wildlife Trade, EWM, Multiple Linear Regression, Markov Forecast.

1. Introduction

1.1. Background

Illegal wildlife trade is a real-life common phenomenon with many complexities, which ranks as the fourth largest illegal trade in the world and poses a great threat to ecosystems and biodiversity worldwide. At the same time, due to the seasonal migratory behavior of some wild animals, there are wild animals that cross national borders, resulting in disputes over the territorial jurisdiction of wild animals among countries [1]. Therefore, global cooperation and innovative development are needed to address this issue.

1.2. Main work

We construct the indicators for the three aspects of power, resources and interest required by our project. Using the entropy weighting method (EWM) [2] to calculate the weighting coefficients of the three organizations in relation to power, resources and interest, we finally choose the United Nations Environment Programme (UNEP) [3] as our client. Secondly we constructed a data-driven model from three aspects: economic, ecological, and social. Governance-economic impact differential function, 5a sliding window algorithm and social awareness rate formula are developed by us for comprehensive data analysis, ultimately resulting in a strong adaptation of program content to client goals. By constructing a multiple linear regression model with funding, influence, data and platform cooperation as indicators, we finally obtained and further analyzed the insufficiency of the project's existing resources and the need to increase additional resources to meet the project's needs. We developed GM (1, 1)-Markov models [4], ARMA models [5] and BP neural network prediction models [6] to address the issues related to the likelihood of success and sensitivity of the project, and finally demonstrated that the project could effectively reduce illegal wildlife trade, enhance public

awareness of animal protection, and maintain an accurate level of prediction when responding to unforeseen events.

2. Preliminary

2.1. Assumption

1. The pursuit of economic profit is the main driver of illegal wildlife trade.
2. Enhanced enforcement can reduce illegal wildlife trade behavior.
3. International cooperation is an important factor in the success of the project.
4. The use of advanced technologies can improve the effectiveness of monitoring and combating the illegal wildlife trade.

But the determination of the number of nodes in the hidden layer is a very important and complex problem.

2.2. Notations

The symbols used in the paper are listed in Table 1.

Table 1. Notations.

Symbol	Definition
Q^T	Total economic losses in the illegal wildlife trade industry
β	Trends in increasing and decreasing ecosystem resilience
Sr	Rate of social awareness for wildlife conservation
Ap	Population with wildlife conservation awareness
Tp	Total population
F	Funds required for project implementation
I	Impact required by UNEP
D	More comprehensive database required by UNEP
Pc	Number of platform collaborations that UNEP needs to advance
a	Development coefficients for the size of the illegal wildlife trade in the GM (1, 1) prediction model
b	GM (1, 1) predicts the amount of role of the illegal wildlife trade industry in the model
a_t	White noise sequences satisfying 0 mean and constant variance in ARMA (p, q) models
φ_i	Parameters to be estimated for the ARMA(p) model
θ_i	Parameters to be estimated for the ARMA(q) model

The above Data are derived from the World Bank (https://data.worldbank.org.cn/), global statistical database (www.statista.com), our worldin Data (https://ourworldindata.org/), Trade Statistics website (https://waimao.163.com), China Business News (https://www.yicai.com), World Economic Forum (https://cn.weforum.org), and Chinese Academy of Sciences (https://www.cas.cn), the data in the paper are based on time serials which the time comes from 2018 to 2023.

3. The Model of Choosing the Client

The weights calculated by the entropy weight method are determined by the information entropy of the indicator, which reflects the degree of change of the indicator. The larger the information entropy is, the more important the indicator is in the evaluation. By collecting data from international authoritative websites, we determined the weights of three clients about power, resources and interest using the entropy weighting method (EWM), so it is very objective for us to calculate the information entropy using the EWM.

In this question, we evaluated the UNEP, the WWPA and the EEA after a preliminary data survey and analysis. A trio of power, resource and interest indicators were constructed. The power indicator reflects the client's international decision-making power; the resource indicator reflects the client's possession and deployment of a series of resources, such as financial assistance and human resources; and the interest indicator reflects the client's high willingness to participate in the program to combat illegal wildlife trade.

First, we normalize all the data:

$$Y_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_i) - \min(x_i)} \tag{1}$$

Second, the information entropy of each indicator is calculated

$$p_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i = 1, 2, 3;\ j = 1, 2, 3 \tag{2}$$

The entropy value of the i th indicator is then calculated:

$$e_i = -\frac{\sum_{i=1}^{n} p_{ij} \ln p_{ij}}{\ln n} \tag{3}$$

Then, based on the information entropy, the weights of the indicators can be calculated:

$$w_i = \frac{1 - e_i}{\sum_{j=1}^{m} (1 - e_i)} \tag{4}$$

Find the weights of the indicators, combining the 3 indicators, and the composite evaluation value of sample j:

$$s_j = \sum_{j=1}^{m} w_i p_{ij} \tag{5}$$

In the end, through calculations and comprehensive analysis, we arrived at the scores of each of the three clients: the UNEP scored 0.67, the WWCO calculated a score of 0.51, and the EEA scored 0.34. As a result, UNEP scored the highest. From the analysis of institutional power, UNEP's competence mainly involves major responsibilities such as environmental assessment, environmental management activities, construction of environmental support facilities, and designation of environmental management and environmental law. By carrying out globally relevant tasks while actively participating in decision-making and discussion of major global environmental issues, the index of interest in environmental protection is very high, and therefore it should be selected as the most suitable partner.

3.1. Determine the Suitability of the Project for the Client

We have decided to pursue the implementation of the Reducing Illegal Wildlife Trade program and believe that this program is the most appropriate for the international United Nations Environment Program (UNEP). We believe that the rationale for the program is as follows.

1. Layout of a global network: UNEP, as a United Nations-affiliated agency, has a global authority and network, which enables our projects to achieve synergy and international cooperation on a global scale, which is a unique advantage of the organization.

2. Consistency and professionalism with the client’s mission: UNEP is committed to global environmental protection, and the illegal wildlife trade has serious negative impacts on species

diversity and ecological balance. The environmental objectives of our project are highly consistent with the core mission of UNEP, which in turn can help realize the goal of ecologically harmonious development.

3. Cross-cutting cooperation and pool of expertise: The issue of illegal wildlife trade is not just an environmental issue per se, but also has economic and social dimensions, and UNEP has a deep pool of expertise and specialists in the environmental, economic and social fields that can provide effective solutions to the problem in a cross-cutting context.

4. Data-driven Analysis

The international utilization of wildlife resources is huge, and as of 2019, the annual global trade in wildlife and its products is about $5 billion or more. In addition to this, the illegal trade in wildlife and its products is even more alarming, and it is estimated that the annual illegal wildlife trade is as high as $50 billion, making it the third largest smuggling industry after arms and drugs. Therefore, it is urgent to reduce illegal wildlife trade.

4.1. Economic impact

In order to predict the economic effects of the program after implementation, we collected data on the economic losses of illegal wildlife trade in the last decade. Based on this data, we developed a governance-economic impact differential function to predict the relationship between our proposed program strategies and the resulting economic impacts [8].

$$Q^T(t) = x^T \int_{t=0}^{T} q^T(t)dt \tag{6}$$

Using the differential equation prediction model, we predicted the economic loss of illegal wildlife trade in the five years after the implementation of the project based on the data collected on the economic loss of illegal trade. According to the figure, we predicted that the economic loss in 2024 would be 26.5 billion dollars, and after the project is continuously promoted, the economic loss generated by illegal wildlife trade can be reduced to 19 billion dollars by 2028, and the rate of decrease of the economic loss reaches 28%, which greatly reduces the scale of the illegal wildlife trade, and vigorously combats the illegal hunting behavior.

4.2. Ecological impact

Trade in wildlife is one of the main causes of biodiversity decline. Millions of animals are killed and trapped each year worldwide as a result of the illegal wildlife trade, leading to an increase in endangered species and exacerbating the decline in biodiversity. And controlling illegal wildlife trade as a project strategy is an urgent action aimed at stopping biodiversity loss.

We developed a 5a moving time window algorithm to analyze temporal changes in ecosystem resilience from 2024-2028. The time window was slid every 1a, and the trend of ecosystem resilience was calculated through 5 time windows at the image metric scale using Sen+Mann-Kendall trend analysis. In this case, the Sen Trendiness analysis equation is:

$$\beta = Median\left[\frac{v_j - v_i}{j - i}\right] \tag{7}$$

Finally, we derived the trend of ecosystem resilience within the 5-year plan of project implementation through the above formula and prediction method [9]. As can be seen from the figure, the predicted $\beta>0$ indicates that the project strategy has led to the enhancement of ecosystem resilience, and the overall trend is increasing, the project effect is significant.

4.3. Social impact

The number of criminal cases of illegal capture of wild animals has been rising year by year, and rampant hunting and poaching activities have led to a drastic reduction in the number of wild animals, which runs counter to the advocated construction of ecological civilization and has resulted in irreparable losses. From the perspective of the criminal population, the criminal group shows the characteristics of youthfulness and diversification, which will greatly affect the spiritual civilization construction of the society. In order to stop illegal trade behavior at the source, raising the public's awareness of wildlife protection is an indispensable strategy [10].

In order to quantify the effectiveness of the implementation of the program strategy, we developed the Social Awareness Rate formula to classify the level of social awareness, which in turn predicts the prevalence of wildlife conservation awareness.

$$Sr = \frac{Ap}{Tp} \times 100\% \tag{8}$$

The rate of social awareness of wildlife protection shows an upward trend, reaching about 49.14% in 2028. Therefore, it can be concluded that the implementation of the project can significantly increase the social awareness of the public to protect wildlife and resist illegal trade.

5. The Model of Project Feasibility Analysis

We used data on the range of funding, level of cooperation and social concern in combating illegal wildlife trade in 20 major consuming countries for the last 10 years. To ensure the accuracy of the predictive model, we used the first 7 years of the last 10 years of data as the training set to ensure that the total number of training samples met the training requirements.

5.1. Implementation of a BP neural network prediction model

The Implementation of a BP neural network prediction model is shown in Figure 1.

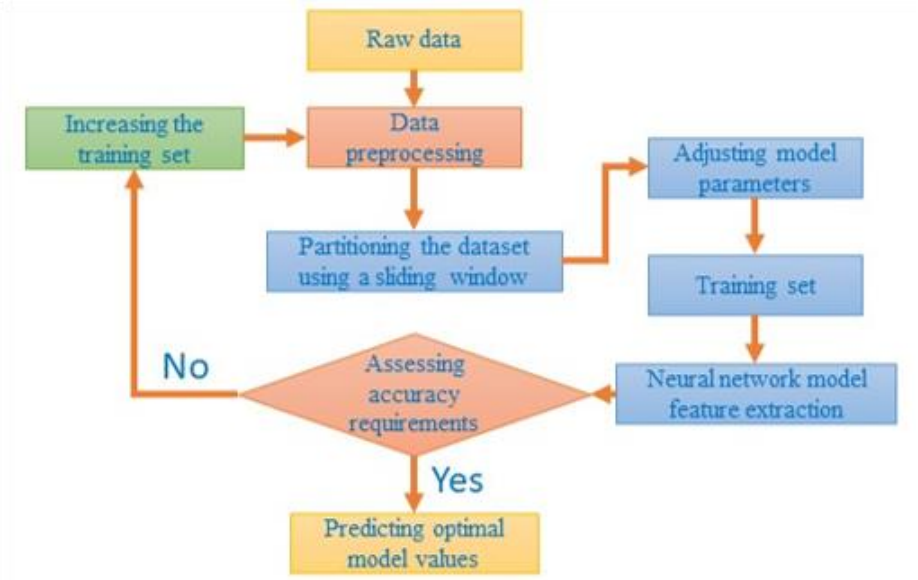

Figure 1. Implementation of a BP neural network prediction model.

We divided the data samples into three parts: the first part for training. Our training optimization algorithm is Levenberg-Marquardt [11], which produces results at a faster rate. Once we specify the training set, the number of nodes in the input layer and the number of nodes in the output layer are determined, and based on the correspondence between the number of nerve cells in the hidden layer and the accuracy of fitting the nonlinear function, we determine the number of hidden layers of the BP neural network to be 1.

5.2. Implementation of a BP neural network prediction model

After a large amount of literature search and data analysis, we initially set the need of $850 million for project implementation, and the BP neural network model predicted that UNEP could provide $920 million, therefore, at the financial level, UNEP could complete the project 100%.

By looking at the number of international cooperation projects in recent years and the number of countries involved in the fight against illegal wildlife trade, we assessed that the completion of the project would require 80 countries to work together, exchange information, share resources, collaborate in the fight against illegal wildlife trade, and strictly control the wildlife trade chain, but based on the game of interests between countries and the abundance of different types of resources, we predicted that the number of countries that would be firmly involved in combating the illegal wildlife trade in the next five years would be 65, and that the project would be able to be completed by 80% at the level of international cooperation.

In order to significantly reduce the illegal wildlife trade, we need to work together globally to maintain a high level of attention to wildlife conservation events. The ideal level of social attention for the project should reach 70%, and we use BP neural network model to predict that in the next 5 years, the level of social attention can reach 70%, and the project can be implemented 100% successfully.

5.3. Model evaluation

The data used in the model is authentic and reliable. Our dataset is sourced from authoritative international websites, providing support for the veracity of the model's predictive results. We made use of a large amount of official data to assess the power and resources required in the process of project implementation, and analyzed the resources lacking by the client through the prediction model, and actively sought the cooperation of other organizations to help implement the project. As a result, our project has good realistic feasibility. We use a variety of forecasting models for different indicators, maximizing the combination of economic, ecological and social factors and forecasting from a macro perspective. By quantifying the project and analyzing the future impacts, we demonstrate to the client the value of the project plan and the effectiveness of the fight against illegal wildlife trade, so that the client can understand the project more comprehensively.

The accuracy of the model relies on statistical data. Our model contains a large number of metric calculations, so the predicted results are highly dependent on the amount and accuracy of the data. The computational process of our model is relatively complex and requires a lot of work to prepare it during the run. For abrupt and uncontrollable factors in the development of the world, which our models are currently unable to predict.

6. The Model of Project Feasibility Analysis

We evaluated the strengths and weaknesses of the models in the project and concluded that the client can achieve the goal of reducing illegal wildlife trade and achieving ecosystem stability and species diversity by implementing our project.

First of all, for the problem of selecting the target client, we use EWM to calculate the weighting coefficients of the three organizations in relation to power, resources and interest, we finally choose the UNEP as our client.

Secondly, Governance-economic impact differential function, 5a sliding window algorithm and social awareness rate formula are developed by us for comprehensive data analysis, ultimately resulting in a strong adaptation of program content to client goals.

Then, By constructing a multiple linear regression model with funding, influence, data and platform cooperation as indicators, we finally obtained and further analyzed the insufficiency of the project's existing resources and the need to increase additional resources to meet the project's needs. Also, GM(1, 1)-Markov models, ARMA models and BP neural network prediction models to address the issues related to the likelihood of success and sensitivity of the project, and finally demonstrated

that the project could effectively reduce illegal wildlife trade, enhance public awareness of animal protection, maintaining an accurate level of prediction when responding to unforeseen events.

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