# Logistic Regression Prediction Model for Illegal Wildlife Trade

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**Abstract.** The aim of this study is to build a model to assess the success rate of the strategy to combat illegal wildlife trade, and to predict the probability of effective implementation of the strategy by quantifying the indicators of successful implementation of the project and building a probabilistic generative model. First, this paper defines successful implementation of the project as a 30% reduction in illegal wildlife trade, and considers the increase in public environmental awareness and the strength of law enforcement agencies as indicators of successful implementation. Based on these indicators, this paper establishes a probability-based model that combines a large amount of data and expert advice to improve the prediction of the probability of success using a Bayesian approach. Further, this paper hypothesises that the probability of strategy success is determined by enforcement efforts, the level of public environmental awareness, strategy interventions and external factors, and develops a logistic regression model for prediction. Multiple simplified datasets were used to demonstrate the effectiveness of model fitting, and the statsmodels library in Python was utilised to calculate the probability of success. The results of the sensitivity analysis show that increased public environmental awareness has a significant impact on the success of the strategy, the enforcement effort should be in the appropriate interval, and project interventions and external factors also have an impact on the probability of success. By analysing the sensitivity intervals and saturation points, decision-making guidance is proposed to rationally allocate resources to increase the probability of project success.

**Keywords:** Logistic Regression Modelling, Bayesian Approach, Sensitivity Analysis.

## 1. Introduction

Wildlife smuggling is an illegal activity that seriously affects the ecological environment and social stability. Although governments and environmental organisations have been fighting against it for many years, the scale of wildlife smuggling is still expanding [1], posing a major threat to biodiversity and sustainable development. The establishment of a model for assessing the success of wildlife smuggling projects can help to rationally plan the allocation of resources and improve the efficiency of project implementation.

The traditional assessment method of the strategy for combating illegal wildlife trade (hereinafter referred to as the strategy) is mainly based on expert experience and subjective judgement, and lacks quantitative analysis, which makes it difficult to comprehensively and objectively assess the influencing factors and their interactions [2]. At the same time, with the increase of data volume, probabilistic statistical models show a strong advantage in the field of prediction and decision support. In this study, a multifactor logistic regression model is developed to assess the probability of successful implementation of the strategy by using probabilistic statistical methods and combining the historical data of wildlife smuggling projects.

This study aims to provide a quantitative assessment tool to inform strategic decision-making. The results of the modelling and sensitivity analysis can guide resource allocation and increase the likelihood of successful project implementation, thus promoting the sustainable development of wildlife conservation. The modelling attempts to incorporate quantitative analyses into the traditional strategy assessment method, which is conducive to improving the efficiency and reliability of the assessment.

## 2. Principle and process

### 2.1. Logistic regression principle

The principle of logistic regression is to map the result of linear regression (-∞,∞) to (0,1) using a logistic function[3] used in machine learning models for solving dichotomous classification problems, which responds to the regression relationship between a dependent variable and a number of independent variables independent of each other[4]. The logistic regression function is shown in Figure 1.

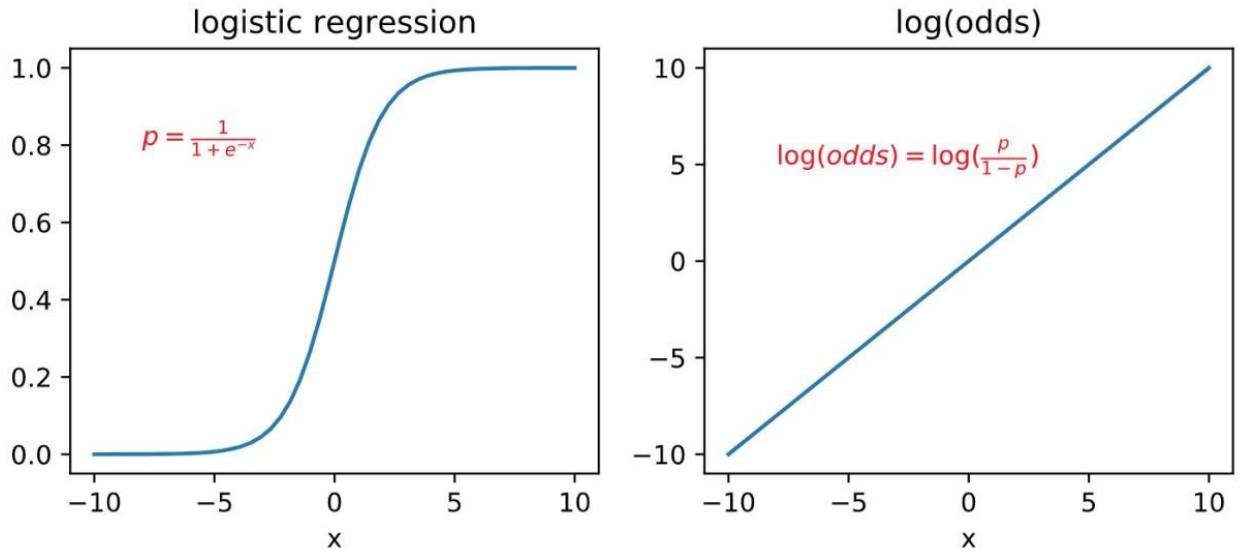


**Figure 1.** logistic regression function

### 2.2. Modelling

In this paper, we assume that the probability of success of the strategy is P(success) and that P(success) is determined by the following factors

-The degree of improvement of law enforcement (E)

-The degree of increase in public environmental awareness (A)

-Project interventions (I)

-External factors (X): e.g. international co-operation resources

(1) Based on these variables, this paper develops a logistic regression model to handle multiple input variables and is used to predict the probability of whether a strategy is successful or not.

$$P_{success} = \frac{1}{1 + e^{-\beta_0+\beta_1 E+\beta_2 A+\beta_3 I+\beta_1 x}} \quad (1)$$

where:

-e is the base of the natural logarithm

-β0, β1, β2, β3, β4 are model parameters that need to be obtained by fitting a large number of data

### 2.3. Modelling analysis

This paper uses multiple simplified datasets to demonstrate the fit of this logistic regression model and to reflect the likelihood of project success based on this dataset.

The multi-group simplified dataset is as follows, where the success of the project has two indicators (1 for success and 0 for failure), while each row represents the data of a historical project containing the degree of improvement in enforcement (E), the degree of improvement in public awareness of environmental protection (A), project interventions (I), and external factors (X). As shown in Table.1

**Table 1.** Multiple simplified data sets

| Number | Symbol | Significance |
|---|---|---|
| 1 | E | Enforcement efforts |
| 2 | A | Public Awareness |
| 3 | I | Project Intervention |
| 4 | X | External Factors |
| 5 | Success | Project Success |

In this paper, the statesmodels library in python is used to build a logistic regression model and also used to calculate the probability of success of a project given the factors[5]. One of the dataset has the following conditions: e=4, a=3, i=4, x=2 after running it got its probability of success as 0.87. this means that the results are visualised as follows: as shown in Figure 2. for that given set of conditions

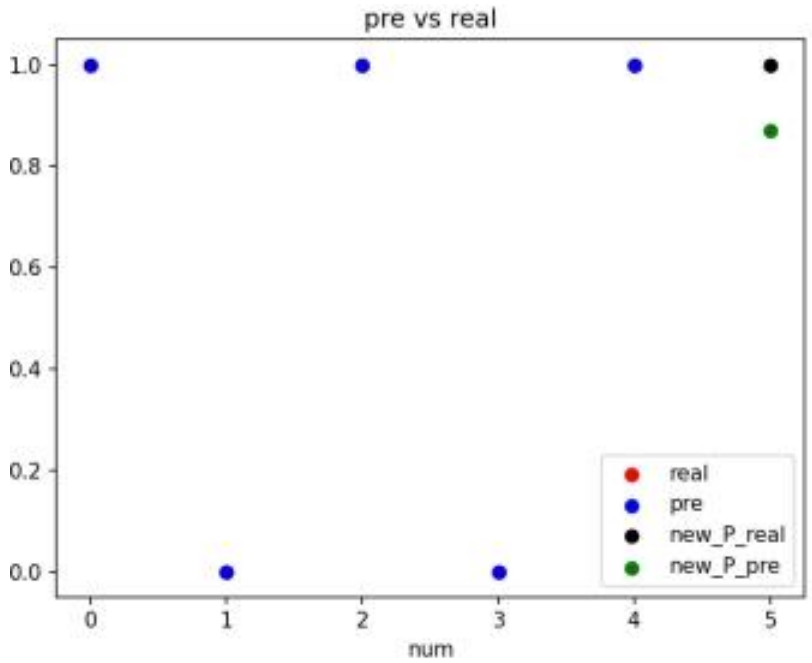


**Figure 2.** Probability of Success Visualisation

### 2.4. Sensitivity analysis

Based on the requirements of sub-question 5 and the above logistic regression model developed in this paper, this paper conducts a sensitivity analysis of the four main parametric factors in the logistic regression model developed in this paper[6], i.e., the degree of increase in public awareness of environmental protection (A), the degree of increase in law enforcement (E), the project interventions (I), and the external factors (X)

The results are visualised as follows: as shown in Figure 3.

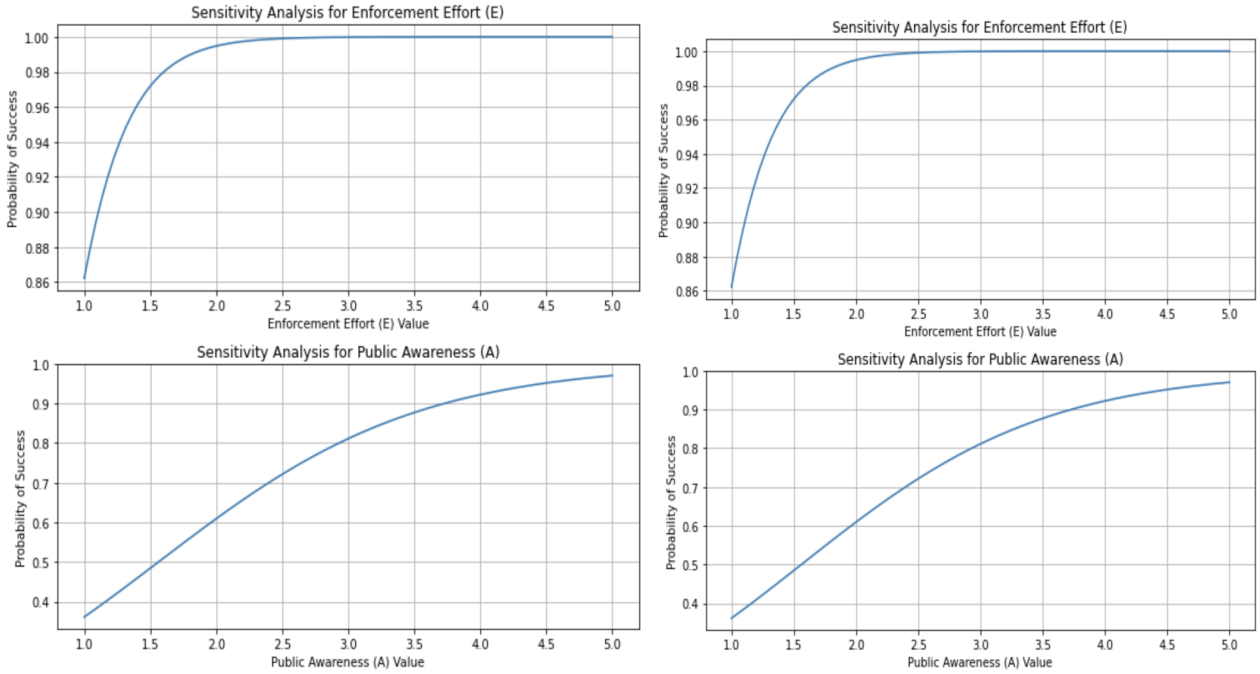


**Figure 3.** Visualisation of sensitivity analysis

Degree of improvement of public environmental awareness (A)

After model simulation, this paper finds that the probability of project success and the degree of public environmental awareness in the beginning of the almost stable linear growth, in this paper set the range of variables, with the increase in the degree of enhancement, the probability of successful implementation of the strategy is still steadily increasing, does not show the imminent threshold of the state of the strategy to successfully implement the probability of the strategy has always been in the state of growth, which suggests that the intensity of the public environmental awareness of the actual implementation of this strategy plays a very positive and positive impact on promoting the successful implementation of the strategy has a significant role. This shows that the strength of public environmental awareness in the actual implementation of this strategy plays a very positive positive impact, and plays a significant role in promoting the successful implementation of the strategy. Therefore, in the actual implementation of this strategy, this paper should pay attention to the enhancement of public environmental awareness, which will become one of the decisive factors for the success of this strategy.

Degree of Enforcement Improvement (E)

From the visualisation graph, when the enforcement intensity is at a low level, the corresponding project success rate increases rapidly as the enforcement intensity rises, and when the enforcement intensity reaches a certain level, the project success rate also reaches a certain threshold, and within the range of variables set in this paper, no matter how the enforcement intensity changes, the success rate of the project will not be significantly increased. This suggests that in the actual implementation of the project, the paper should find the most appropriate interval of law enforcement strength, grasp the strength of law enforcement strength to prevent excessive waste of national resources and too strong law enforcement power to cause counterproductive effects. Maximising the efficiency of the law enforcement agencies will promote the successful implementation of the project.

Strategic Interventions (I)

The visualisation of the strategic interventions as a whole shows an S-shape, which indicates that the impact of the strategic interventions on the effective implementation of the strategy is insignificant at lower and higher levels, respectively, and that the probability of the effective implementation of the strategy increases rapidly when the strategic interventions reach an interval in the intermediate range, which indicates that this paper should continue the idea of increasing the degree of law enforcement efforts, and controlling the intensity of the project's interventions at an interval in the middle range in order to save resources and drive project success most efficiently.

External Factors (X)

The source of external factors encompasses a variety of unpredictable external factors, such as international economic issues and levels of international co-operation, which make their impact difficult to describe and explain. This paper analyses the data visualisation and learns that the project success rate can only be maintained at a high level when the external factors are kept at a low level, once the intensity of the external factors reaches a medium-high intensity in the range set by this paper, the probability of success of the project will decline at a very high rate, which suggests that this paper should avoid the influence of external factors as much as possible, and try to keep the external factors at a low level, to ensure the success of the project. implementation.

Sensitivity interval and saturation point analysis

Most of the above visualisation charts present a typical S-curve pattern, where when the input variable floats in the lower or too high range, the model predicts a very small degree of change in the results, close to a saturation state of 0 or 1. When such a state is presented, the input variables are close to the saturation point[7], and when the input variables are floating in the steep part of the middle interval of the range set in this paper, the project success rate is very sensitive to changes in the input factors. At this point the input variables are then in the middle of the sensitive interval. This suggests that this paper in controlling variable factors should control each controllable factor in its sensitive interval to avoid approaching the saturation point and to improve the likelihood of project success.

Decision-making guidance

Through the above sensitivity analysis, this paper can reasonably allocate the existing resources, make decisions, analyse the saturation point and sensitivity interval of each controllable factor, so that each factor is as much as possible in its sensitivity interval, avoiding the saturation point. Thus making the project more likely to succeed[8].

## 3. Result

### 3.1. Some strategies to reduce illegal wildlife trade

Illegal trade in wildlife refers to the collection, transport and sale of wildlife and their products through illegal means for economic gain. This illegal practice poses a serious threat to the conservation of biodiversity and requires this paper to take active measures to reduce and stop it. This paper will explore some effective methods and strategies to reduce illegal trade in wildlife and protect biodiversity.

#### 3.1.1. Strengthening law enforcement

In order to effectively combat the illegal trade in wildlife, Governments should strengthen law enforcement. Firstly, they should intensify their efforts to combat illegal wildlife trade, establish and improve relevant laws and regulations, and impose severe penalties on offenders. Secondly, strengthen the training of law enforcement agencies and improve the professionalism of law enforcement personnel to increase the effectiveness and success of law enforcement. In addition, international cooperation is also very important, and countries should strengthen intelligence-sharing and establish a joint action mechanism to combat transnational illegal wildlife trade.

#### 3.1.2. Raising public awareness

Increased public awareness is crucial to reducing the illegal trade in wildlife. The Government and non-governmental organisations should step up publicity and education to educate the public on the importance and significance of wildlife protection. By organising exhibitions, lectures and promotional films, they can convey to the public the correct concepts and knowledge of conservation and guide people to treasure wildlife resources and not to buy illegal wildlife products. In addition, school education is also an important way to incorporate knowledge of wildlife conservation into the curriculum and to cultivate students' awareness of conservation and their sense of responsibility

### 3.1.3. Strengthening international cooperation

Since the illegal trade in wildlife often involves different countries, there is a need to strengthen international cooperation to reduce the problem. Governments can work together to combat the illegal trade in wildlife by signing and enforcing international agreements, strengthening intelligence-sharing and cooperating in joint operations. In addition, countries can strengthen technical exchanges and share successful conservation experiences and methods to jointly promote the development of wildlife conservation.

### 3.1.4. Strengthening regulation and management

Strengthening regulation and management is one of the important measures to reduce illegal wildlife trade. Government departments should establish a sound regulatory mechanism for wildlife protection and strengthen monitoring and combating illegal wildlife trade. At the same time, the management of wildlife resources should be strengthened to ensure their rational use and sustainable development. In addition, regulation of the channels and technologies used in wildlife trade should be strengthened to prevent illegal trade.

### 3.1.5. Provision of alternatives and economic support

To reduce the illegal trade in wildlife, alternatives and economic support can be provided. For example, support and recognition can be given to arts and crafts made with alternative materials as substitutes for illegal wildlife products. In addition, economic support can be provided to local people through the development of industries related to wildlife conservation, such as eco-tourism and environmental education, so that they can be converted from illegal trade to active participants in wildlife conservation.

### 3.1.6. Strengthening scientific research and monitoring

Scientific research and monitoring are fundamental to reducing illegal trade in wildlife. Through scientific research and monitoring, it is possible to gain an in-depth understanding of the ecological characteristics, abundance and distribution of wildlife and to provide a scientific basis and guidance for wildlife conservation. In addition, monitoring can also detect and combat illegal wildlife trading activities in a timely manner and prevent their development and spread.

To sum up, reducing illegal wildlife trade is one of the important tasks for biodiversity conservation. By strengthening law enforcement, raising public awareness, enhancing international cooperation, strengthening regulation and management, providing alternatives and economic support, and strengthening scientific research and monitoring, this paper can work together to reduce illegal wildlife trade and protect rare species and biodiversity for a better future.

## 3.2. Assess the likelihood of success of the strategy

a. Indicators for determining the effectiveness of the strategy

b. Successful implementation of the strategy is quantified in this paper as a 30 per cent reduction in illegal wildlife trade after the project is actually implemented. At the same time, the public awareness of environmental protection and the improvement of enforcement efforts and effectiveness of law enforcement agencies will also be used as indicators to measure whether the strategy is effectively implemented.

c. Establishment of relevant probabilistic models

d. Based on the requirements of sub-problem 5, this paper establishes a probability-based model [9] for assessing whether the project can be successfully implemented, which takes into account variables such as the intervention of the project, the impact of the improvement of public environmental awareness and the enforcement efforts of law enforcement departments on the reduction of illegal trade volume. The model is based on a large amount of data and expert advice and is combined with a Bayesian approach to improve the probability of a successful model prediction fit[10].

## 4. Conclusions

This paper proposes a logistic regression model for the prediction of illegal wildlife trade by combining logistic regression, Bayesian methods and sensitivity analysis and introducing them into the prediction of illegal wildlife trade. Firstly, taking the intervention measures of the project, public awareness of environmental protection, the degree of improvement of law enforcement and external factors as variables, this paper establishes a logistic regression model based on probability to assess whether the project can be successfully implemented, and the probability of success is 0.87 after running; then, based on a large amount of data and expert advice, and combined with Bayesian method, this paper conducts sensitivity analysis on four main parameter factors in the established logistic regression model. The four main parameters of the factors in the sensitivity analysis, learned that this paper in the control of variable factors should be controlled in each controllable factor in its sensitive interval, to avoid close to the saturation point, to improve the likelihood of success of the project.

The logistic regression model is more sensitive to outliers and correlation between features, which means that extreme values in the dataset may have a greater impact on the results of the model, and when there is a strong correlation between features, such as the presence of a multicollinearity problem, it may lead to overfitting of the model, making the model's predictive performance degrade . When the successful probability training samples are sufficiently typical and large enough, the prediction results can be made more accurate, so attention should be paid to the effective and reasonable selection of training samples. Illegal wildlife trade volume is affected by a variety of factors, this paper only introduces four variables to establish a model for prediction, and the variable indicator system needs to be further improved. How to introduce more variables, so that the variable indicator system can be more scientific and comprehensive response to the volume of illegal wildlife trade needs further research.

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