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Study on Eco-Management Program of Status of Illegal Trade in Wildlife

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Abstract: This study is dedicated to exploring the use of the "Satellite + Artificial Intelligence + Blockchain" technology project to effectively reduce the negative impacts of the illegal wildlife trade on global ecosystems, biodiversity economic security, and analysing them through a management perspective. By pre-processing a large amount of data and selecting key sub-indicators in terms of power, resources and benefits, and combining the AHP and CRITIC methods to calculate the weights and composite scores, this study identifies TRAFFIC organisations as the best performing organisations in terms of their commitment to wildlife conservation. Trends in global rainforest area, number of endangered species, and illegal trade cases were analysed using the ARIMA model, revealing a downward trend in the number of investigated cases, while an increase in illegal hunting indicators suggests an intensification of covert operations with insufficient response capacity. Therefore, the Satellite + AI + Blockchain project aims to enhance the management capacity of TRAFFIC organisations to combat illegal wildlife trade.Pearson coefficient analysis revealed a significant negative correlation (-0.973) between the incident detection rate and the actual occurrence of incidents, which was further clarified by linear regression. The likelihood of the project achieving its objectives was calculated to be 95 per cent, supported by relevant literature and model confidence levels. Finally, the study also assessed the strengths and weaknesses of the model, analysed the sensitivity of the detection rate indicator and confirmed the validity of the model assumptions. The critical role of the managerial perspective in project implementation is emphasised by exploring the impact of various aspects of PESTLE on project success.

1. Introduction

The illegal wildlife trade, ranking as the fourth largest illicit market globally, poses significant threats to biodiversity, ecosystems, and public health. This concealed trade exacerbates species extinction risks and ecological imbalances while facilitating disease spread. Addressing this challenge is hindered by the covert operations of traffickers and the current limitations in surveillance technology, suggesting the actual scale of the trade might be underestimated. This paper proposes a strategic approach to enhance monitoring and enforcement against this trade by leveraging advanced technologies. It focuses on identifying key stakeholders based on their resources and interests, justifying the project's relevance through literature and analysis, outlining the necessary authority and resources for implementation, and forecasting the impact on reducing wildlife trafficking. The goal is to present a viable five-year project plan that aligns with stakeholders' capabilities, offering a potential pathway to significantly diminish the illegal wildlife trade [1].

2. Identifying Suitable Clients Through Key Metrics

2.1 Evaluation Model for Customer Selection

In this analysis, the assessment of potential clients is conducted by examining their power, resources, and interest, utilizing a comprehensive AHP-CRITIC model developed from extensive data collection. This model serves to calculate the weights of various indicators, ensuring a thorough evaluation of client suitability for the project [2].

The evaluation framework comprises six meticulously chosen indicators that reflect the clients' capabilities and alignment with the project's objectives. These indicators, derived from both the project's specific requirements and best practices within related fields, include the power to enforce and legislate against illegal wildlife trade, the resources available for project implementation, and the level of interest in addressing wildlife trafficking.

Power is evaluated based on the client's legal authority and effectiveness in prosecuting wildlife trade crimes, including the annual number of cases managed, which underscores the client's active role in law enforcement and the severity of penalties imposed on offenders. Resources are gauged through the client's financial commitment and the breadth of international collaboration, as indicated by the average annual investment in related projects and the number of countries engaged in the initiative. Interest is measured by the client's involvement in wildlife rescue efforts and awareness-raising activities, providing insight into their dedication to combating the illegal wildlife trade.

This comprehensive approach to client evaluation ensures that selected clients are not only capable of contributing to the project's success but are also genuinely committed to the cause of mitigating illegal wildlife trade.

2.2 Solutions and Results

Weighting models play a crucial role in assessing the contribution of indicators to the overall evaluation results. This section details two different weighting models and utilizes them to accurately calculate the weight vector [3].

(1) AHP

The Analytic Hierarchy Process (AHP) systematically deconstructs the decision-making dilemma into a hierarchical structure predicated on the interdependencies among associated elements, subsequently ascertaining the significance weights through pairwise comparisons concerning the relative prominence of each criterion.

Step 1: Construct the Judgment Matrix. To initiate, delineate the hierarchical structure comprising the goal layer, criterion layer, and alternative layer. Employing a rigorous methodology assesses the relative significance of each element within the preceding level. Subsequently, indices residing in the identical tier are subjected to pairwise comparisons, utilizing a standardized 9-point scale. And the judgment matrix is obtained, where x_{ij} represents the result of the comparison between the i-th factor and the j-th factor, and x_{ij}>0, x_{ij}= 1/x_{ij}:

$$A = \left(x_{ij}\right)_{n*n} \tag{1}$$

Step 2: Calculation of weights. The relative weights of the criteria were obtained by applying different methods, namely the arithmetic mean, geometric mean, and eigenvalue methods. The decision matrix was used as a basis for obtaining the weight of the criteria.

Step 3: Check the consistency. λ is the maximum eigenvalue of the judgment matrix. When $CR = \frac{CI}{RI} < 0.10$,the consistency of the judgment matrix is acceptable, and the matrix.

Can be used as the weight vector of the evaluation factor. Otherwise, it should be amended.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{2}$$

Through the above steps, we obtained the target weight vector ω_{AHP}.

(2) CRITIC

Since the AHP subjective assignment method has a keen sense of subjectivity and uncertainty in the assignment process, this paper introduces the Critic objective assignment method and combines it to conduct the comprehensive assignment of indicators.

Critics determine the importance of each criterion by analyzing the differences and conflicts between the criteria. The specific steps are as follows:

Step 1: Construct the original assessment matrix: Let the number of evaluation clients be a, the number of assessment indicators be b, and the j-th assessment indicator of the i-th assessment sample be denoted as t_{ij}, then the original assessment matrix is constructed:

$$T = \left(t_{ij}\right)_{a*b} \tag{3}$$

Step 2: Standardized matrix: when there is a positive or negative correlation between an evaluation indicator and the outcome of the evaluation, the indicator needs to be treated positively or negatively.

$$m_{ij} = \frac{t_j - t_{max}}{t_{max} - t_{min}} \tag{4}$$

$$m_{ij} = \frac{t_{max} - t_j}{t_{max} - t_{min}} \tag{5}$$

Determination of the standard deviation of the indicator:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{n}\left(m_{ij} - \overline{m_j}\right)^2}{n-1}} \tag{6}$$

$$\overline{m_j} = \frac{1}{n}\sum_{i=1}^{n} m_{ij} \tag{7}$$

Step 3: Determine the conflicting nature of the indicators:

$$R_J = \sum_{i=1}^{n}\left(1 - r_{ij}\right) \tag{8}$$

$$r_{ij} = \frac{\sum_{i,j=1}^{n}(m_i - \overline{m})(m_j - \overline{m})}{\sqrt{\sum_{i=1}^{n}(m_i - \overline{m})^2 \sum_{j=1}^{n}\left(m_j - \overline{m}\right)^2}} \tag{9}$$

Step 4: Define the information carrying capacity:

$$c_j = \sigma_j R_j \tag{10}$$

Based on the amount of information, we can obtain the objective weight W_j of the j-th indicator with the following formula:

$$W_j = \frac{c_j}{\sum_{j=1}^{n} c_j} \tag{11}$$

(3) Weighted Combination of AHP and CRITIC

The final weights of the indicators are computed using the Mon formula, which integrates the AHP and CRITIC methods of indicator weighting. The resulting weights consider both subjective and objective perspectives, enabling the calculation of a comprehensive weight vector of indicators based on AHP-CRITIC.

$$\omega_{total} = \alpha \cdot \omega_{AHP} + (1-\alpha) \cdot \omega_{CRITIC} (0 < \alpha < 1) \tag{12}$$

Based on experience, $\alpha = 0.6$, the final weights for each indicator are shown in Figure 1.

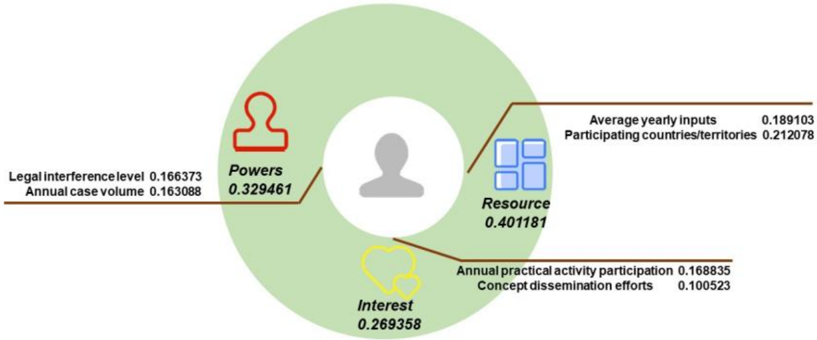

Figure 1: Weights for Each Indicator

In the conducted evaluation, TRAFFIC emerged as the leading candidate with a composite score of 0.682591382, underscoring its exceptional alignment with the project's requirements in terms of power, resources, and interest. This organization's focus on wildlife trade monitoring has equipped it with substantial legal and advocacy capabilities, crucial for combating wildlife trafficking. Following closely, the World Health Organization (WHO) achieved a score of 0.642228795, ranking second. Despite its primary focus on human health, WHO's involvement highlights the significant overlap between public health issues and illegal wildlife trade, such as the risk of disease transmission. The Worldwide Fund for Nature (WWF) secured the third position with a score of 0.548143728, reflecting its considerable contributions to wildlife conservation and the effectiveness of its resources and influence in environmental advocacy.

Further analysis revealed the multidisciplinary nature of addressing illegal wildlife trade, requiring collaborative efforts from entities in conservation, health, and legal sectors. The International Union for Conservation of Nature (IUCN) and the Global Environment Facility (GEF) were ranked fourth and fifth with scores of 0.458386404 and 0.359953346, respectively, highlighting the diverse range of organizations involved in this effort. The rankings not only illustrate the specific strengths of each organization but also the potential for cross-sectoral cooperation to enhance the effectiveness of combating illegal wildlife trade. Based on these results and the detailed evaluation, TRAFFIC was identified as the optimal partner for this project, given its strong focus on wildlife trade issues, active engagement in relevant activities, and the alignment of its capabilities with the project's goals.

3. Justifying the Project's Alignment with Client Goals

3.1 Literature and research to support our project.

The illegal wildlife trade has escalated into a critical global issue, undermining ecosystems, biodiversity, and national economies. Despite international efforts to counteract these activities, the persistent challenge of surveillance and enforcement necessitates innovative solutions. This study advocates the adoption of an integrated system combining Artificial Intelligence (AI), satellite technology, and blockchain to bolster global surveillance and curtail illegal wildlife trafficking [4].

Leveraging the constructive collaboration between satellite remote sensing and AI, this approach offers novel avenues for real-time, accurate monitoring of biodiversity and illegal activities. AI's capacity to analyze satellite imagery enables the identification of illicit actions, such as poaching or deforestation, thereby facilitating the immediate protection of vital habitats. This technology-integrated method has shown promise in achieving precise wildlife monitoring across diverse landscapes through machine learning algorithms. Furthermore, AI's predictive analytics can anticipate potential illegal trade occurrences, empowering conservation entities and authorities to implement preventative strategies [5].

Blockchain's attributes of transparency, immutability, and decentralization render it an effective instrument in this battle. Its application in tracking transactions can extend to wildlife product supply chains, making them transparent and traceable, thereby disrupting the flow of illicit goods. The proposed project's foundation is robust, supported by literature and case studies of technology applications in conservation. The envisioned integration of AI, satellite technology, and blockchain holds the potential to enhance the efficiency and impact of efforts against the illegal wildlife trade, contributing significantly to the preservation of global biodiversity and ecological equilibrium.

3.2 Data-driven persuasion of client

ARIMA model is a widely used time series analysis method [6].

Firstly, the raw data were curve-fitted to fill in missing values.

Secondly, determine the type of model, the order of model and undetermined parameters by analyzing the characteristics of ACF and PACF of stationary sequence.

Thirdly, evaluate the validity of the model.

Finally, analyze and predict the future time series.

ARIMA model can be known as ARIMA $(p,\ q,\ d)$, where p is the autoregressive order number and q is the sliding average order number. This model represents making differences on the non-stationary random sequence variable Y for d times, and then we obtain the stationary series X.

After that, we fit the series X, with ARMA $(p,\ q)$ model, which can be expressed as

$$X_t = \varphi_1 X_{t-1} + \cdots \varphi_p X_{t-p} + \varepsilon_t - \left(\theta_t \varepsilon_{t-1} + \cdots \theta_q \varepsilon_{t-q}\right) \tag{13}$$

Where the former part is the autoregressive process, and $\varphi_1, \ldots, \varphi_p$, are regression coefficients; the latter part is the sliding average process, $\theta_1, \ldots, \theta_q$, are sliding average coefficients, $\{\varepsilon_t - q, , \varepsilon_t\}$ is the white noise sequence not observed which obeys gaussian distribution.

In this paper, we pick up area of rainforest globally, number of endangered species, number of cases of illegal wildlife trade dealt with in representative areas as indexes, for more intuitive analysis of energy indices and more accurate predictions we use ARlMA model to predict each index individually.

These indicators were chosen because rainforests are the most biodiverse and host the largest number of wildlife, representing the relationship between wildlife survival and the natural environment; the number of endangered species is a direct symbol of biodiversity; and the countries with the highest number of incidents of illegal trade in wildlife on each of the four continents were selected as representative of the world's illegal trade in wildlife.

We then plot the ACF and PACF graphs for this sequence to select the appropriate p and q for the ARIMA $(p,\ q,\ d)$ model.

As is shown in Figure 2, Based on the confidence intervals obtained, the ARIMA models we chose for the front two indices are (0,2,0), (0,1,0), and in the same way the third index hold (0,0,0), (0,0,0), (0,0,0), (0,1,0).

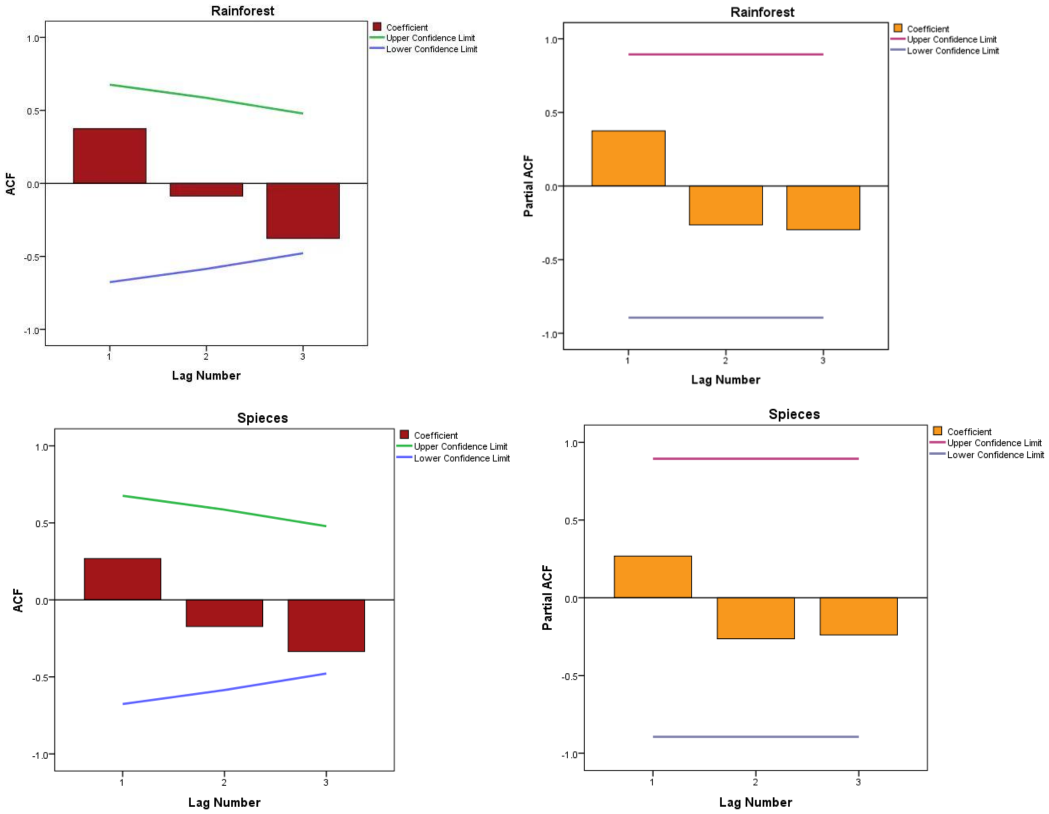

Figure 2: ACF and PACF of Indices

Afterwards, using the method mentioned above (Figure 2), we can predict the values of all indices. Our prediction of them is shown in Figure 3 and Figure 4.

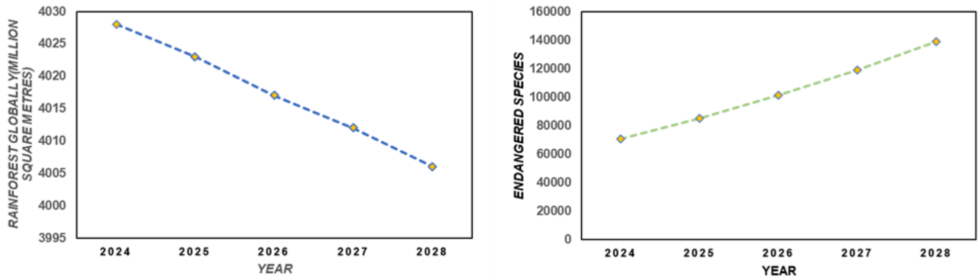

Figure 3: Prediction of Indices (1)

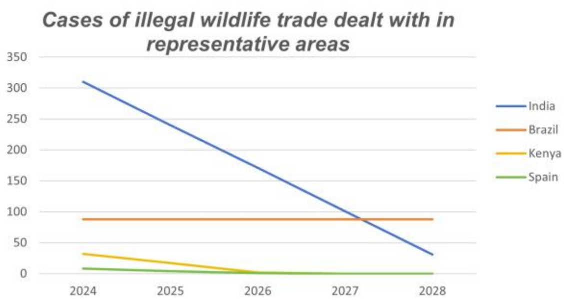

Figure 4: Prediction of Indices (2)

We can see from the predicted results that if no action is taken, both wildlife habitat and diversity of life will continue to deteriorate, but fewer and fewer criminals will be able to be disarmed by officials. This suggests that the criminal techniques of illegal hunters are improving year by year, and that the illegal animal trade will become increasingly uncontrollable and harmful if the official monitoring and control techniques are not improved. Therefore, we need to ask Traffic to implement our project to avoid such a situation.

4. Evaluating the Project's Impact on Illegal Wildlife Trade Reduction

4.1 Composite model

To conduct a thorough statistical analysis, this study integrates several analytical methods, including curve estimation, Pearson's correlation analysis, and linear regression, into a composite model. The process begins with the preprocessing of raw data to prepare it for analysis. Following this, the data intended for prediction is visualized, with an emphasis on identifying and fitting the most appropriate curve to capture the underlying trends.

A key step in the analysis involves using Pearson's correlation coefficient to assess the strength and direction of the relationship between selected indicators. This step helps in identifying pairs of variables that exhibit a high degree of correlation, either positive or negative. Based on these findings, linear regression is applied to the highly correlated indicators to establish a linear relationship between them. The quality of this linear model is evaluated based on its fit, with a good fit indicating that the linear equation reliably describes the relationship between the variables.

This structured approach, from data preprocessing to the application of regression analysis, enables a comprehensive examination of the data. The aim is to draw meaningful conclusions by identifying significant relationships and trends within the dataset, thereby enhancing the understanding of the subject matter under investigation. The entire process looks like Figure 5.

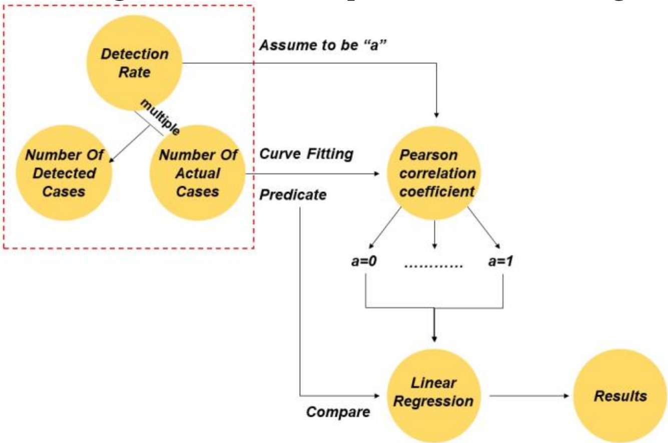

Figure 5: Whole Process

4.2 Analysis of experimental results

Examining the scatter plot depicted in Figure 6, it is evident that the number of illegal trade cases investigated and resolved by various countries exhibits an upward trend from 2017 to 2020. This pattern suggests that the efficiency in managing such incidents has been improving over the years, influenced by growing social awareness and advancements in technology. The scatter plot aggregates the average data from different countries to reflect the global situation, illustrating the increasing momentum in combatting illegal trade activities during this period.

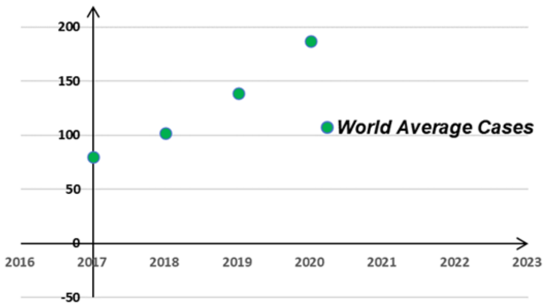

Figure 6: World Average Cases from 2017 to 2020

Analyzing the scatterplot (Figure 6) reveals that a cubic curve closely matches the data trajectory, suggesting a complex relationship between time and the number of investigated and disposed illegal trade cases. Utilizing this cubic curve model, the study projected future trends in illegal trade case volumes for the years 2024 to 2028. These projections, integrated with ARIMA model predictions from a prior analysis, offer a comprehensive view of expected illegal trade activities and detection rates in the coming years, as illustrated in subsequent Figure 7.

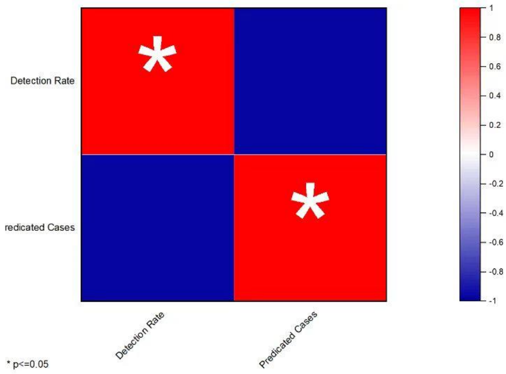

Figure 7: Pearson Coefficient Heat

To assess the impact of the proposed project on combating illegal trade, a correlation analysis was conducted between the detection rates and the actual number of trade events. By employing Pearson's coefficient, which measures the strength and direction of a linear relationship between two variables, the study aims to establish the efficacy of intervention strategies without being influenced by the detection rate's specific value. The results of this correlation analysis are visually represented in Figure 8, providing insights into the potential effectiveness of the proposed measures in addressing illegal trade activities.

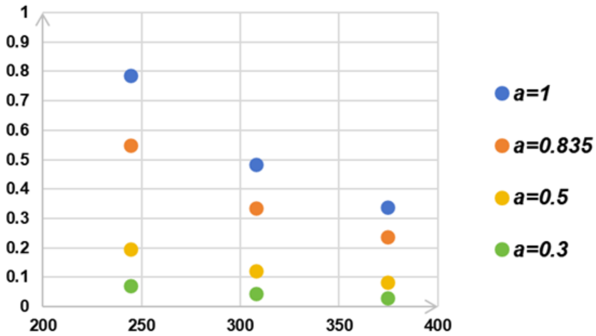

Figure 8: Correlation Between two Indicators

From the analysis depicted in the figure, it is evident that there is a linear relationship between the studied variables, with a stronger negative correlation as the detection efficiency nears perfection. This suggests that the impact of the project might lessen as detection rates improve. Setting the detection rate at its maximum efficiency for the analysis, the study forecasts a substantial improvement in the detection of illegal wildlife trade incidents over the next five years, with an ambitious target of increasing the detection rate to 83.5% by 2028. The projections indicate a notable decrease in wildlife trade incidents, with the potential to reduce the crime rate by more than 65.22% by the end of the period. This simulation underscores the significant role that the implementation of advanced technologies, such as AI, satellite remote sensing, and blockchain, could play in enhancing the effectiveness of conservation efforts, particularly in organizations focused on combating illegal wildlife trade.

5. Conclusions

This study evaluated five potential partners by developing the Wildlife Liking Index (WLI) and conducting a multidimensional analysis of power, resources and benefits using the AHP-CRITIC model, and ultimately selected TRAFFIC as a partner. Based on the analysis and predictions, the integration of Satellite+Artificial Intelligence+Blockchain technology will significantly increase the detection and reduction of illegal wildlife trade in the next five years, with a probability of success of more than 95 per cent. This study is also aware of the potential impact of PESTLE factors on project outcomes. Although the impact of emergencies was not fully considered, the use of a complexity framework enhanced the comprehensiveness of the analysis and the robustness of the solution, contributing to a deeper understanding of the complexity of the problem, while also encouraging interdisciplinary collaboration to effectively address the illegal wildlife trade. This integrated analysis from a managerial perspective provided a more solid basis for project implementation, emphasising the importance of the selection of partners and the integration of technologies, while highlighting the critical role of promoting project success in cross-functional teams and interdisciplinary cooperation.

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