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Data-Driven Customer Assessments for Biodiversity Conservation

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Abstract. This study centers on addressing the critical challenge posed by illegal wildlife and plant trade to biodiversity, aiming to propose a client evaluation model designed for conservation efforts. Operative within a rigorous assessment framework that integrates sophisticated statistical tools, including McKinsey's Logic Tree Analysis, Analytic Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), the model conducts evaluations spanning both non-governmental organizations and government institutions. Following meticulous analysis, the United States government is identified as the optimal partner. The rationale behind this selection is multifaceted, examining the ecological, social, and economic dimensions to comprehensively scrutinize the validity and necessity of collaborating with the U.S. government in tackling the pressing issue of illegal wildlife and plant trade.

Keywords: Illegal Wildlife Trade, 5-year Project, AHP, EWM, Topsis method.

1. Introduction

Illegal wildlife trade has become one of the largest and most profitable illegal trades in the world, with an estimated annual value of $26.5 billion[1]. The continued expansion of this illegal trade will inevitably reduce the population of wildlife around the world and have long-term negative impacts on biodiversity and the environment. Reducing illegal wildlife trade worldwide has become one of the important goals for protecting wildlife.

Customer assessment models play a pivotal role in promoting biodiversity conservation by integrating environmental considerations into consumer decision-making[2]. Grounded in theories like the Theory of Planned Behavior and Value-Belief-Norm theory, these models utilize clear biodiversity impact indicators, user-friendly interfaces, and incentivization mechanisms such as eco-labels to guide consumer choices. Successful implementations across sectors, including sustainable seafood guides and eco-certification schemes in forestry, demonstrate their efficacy[3]. However, challenges like greenwashing, consumer awareness gaps, and standardization issues necessitate ongoing improvements. The future of these models hinges on enhancing transparency, leveraging technology, and fostering collaboration among stakeholders to transform consumption patterns and drive corporate sustainability, thereby safeguarding global biodiversity[4].

2. Client Determination Index Model

2.1 Indicator system for national Governments

Our client evaluation system uses the McKinsey Logic Tree Analysis to measure national government clients' value using economic, social impact, and ecological indicators, including sub-indicators. This helps assess their concern and capability to tackle illegal animal trade and implement our programs.

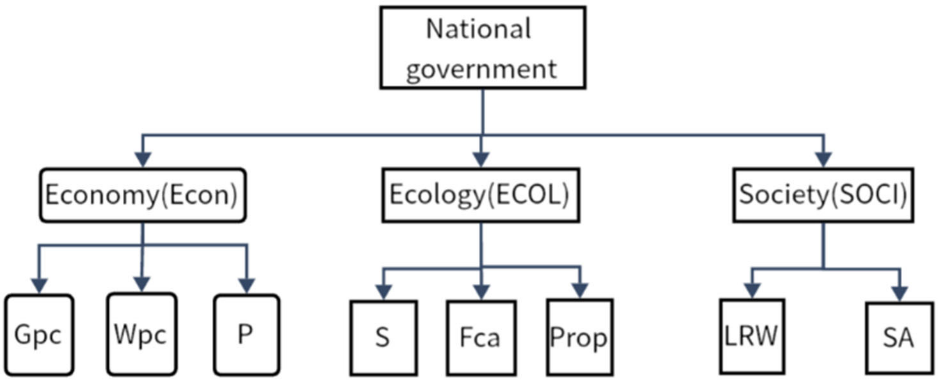

Figure 1. Indicator map of the national system of government

2.1.1 Economy Indicators

On the economic aspect, although illegal animal trade is prohibited by all countries in the world, if a country or region is so economically backward that illegal animal trade becomes the only industry left for the local people, any legal prohibition of this behavior is powerless, and the improvement of illegal animal trade itself requires a considerable part of the government to invest in the matter, so we took GDP per capita, the wage per capita , and the population growth index as the indexes reflecting the degree of the country's economic development, respectively.

$$ECON = Gpc，Pop，Wpc \tag{1}$$

$ECON$ is a country's economic index, Gpc is a country's GDP per capita, Pop is a country's population growth index and Wpc is the wage per captia of a country. Because a country's current population size and population growth rate can reflect a country's development trend, we define the population growth index of a country as:

$$Pop = \frac{P}{P_{max}}(1 + r) \tag{2}$$

P is the current population of a country, P_{max} is the maximum population of the country from 2010 to 2023 and r is the natural population growth rate of the country. When the ratio of a country's current population to its maximum population is smaller, it is said that the country has experienced a period of demographic decline and side by side reflects that the country may be experiencing an economic downturn, as does the natural population growth rate.

The level of economic development of a country is directly dependent on its GDP and the salaries of its citizens, but in order to better characterize the level of economic development of a country, we introduced GDP per capita and salaries per capita.

$$Gpc，Wpc \tag{3}$$

2.1.2 Ecology Indicators

In terms of ecology, the richer the biodiversity of a country, the greater the likelihood of illegal wildlife trade in that country. Therefore, we used the species population index, the forest cover area, and the ratio of protected area to national land area as indicators of ecological factors in the country.

$$ECOL = S, Fca, Prop \tag{4}$$

$ECOL$ is the country's ecology indicator. Fca is forest covered area of a country, $Prop$ is the ratio of protected areas to national land area, unlike Fca , when a country designates an area as ecologically protected, it prioritizes wildlife and natural environment over short-term economic gains, indicating a commitment that may counter illegal wildlife trade.

S is species population index, which is defined as:

$$S = \frac{n\prime}{n} \tag{5}$$

n' is the rate of change in the species population of the country (here the rate of change between 2022 and 2023 is taken) and n is the current species population in the country (taken as 2023).

2.1.3 Social Awareness Indicators

The amount of energy invested by the national government in illegal wildlife trade partially depends on the country's social attention. Therefore, we introduce the social attention index and the number of laws and regulations protecting wild animals as indicators to evaluate the social attention of each country.

$$SOCI = LRW, SA \tag{6}$$

LRW is the number of laws and regulations protecting wild animals in the country. The more laws and regulations a country has on a certain matter, the more often such incidents occur in that country.

SA is social attention. To quantify it, we chose to construct a social attention indicator using the time trend of Internet search heat on the Convention on International Trade in Endangered Species (CITES) thematic issues in each country in Google trend.

$$\begin{cases} SA = \sum_{t=2}^{T} \omega(t) \Delta y(t) \\ \omega(t) = \lambda^{(T-t)} \end{cases} \tag{7}$$

$\Delta y(t)$ is the amount of change in search heat for CITES topic issues between two adjacent years and T is the total number of years of data collected in that country. Since the CITES heat time trend data we collected started in 2004 and has a large time span, we introduced a weight increasing function $\omega(t)$ to give higher weight to the recent changes in CITES search popularity, to more accurately judge a country's comprehensive social attention to issues and recent social attention.

2.2 Indicator system for international non-governmental organizations

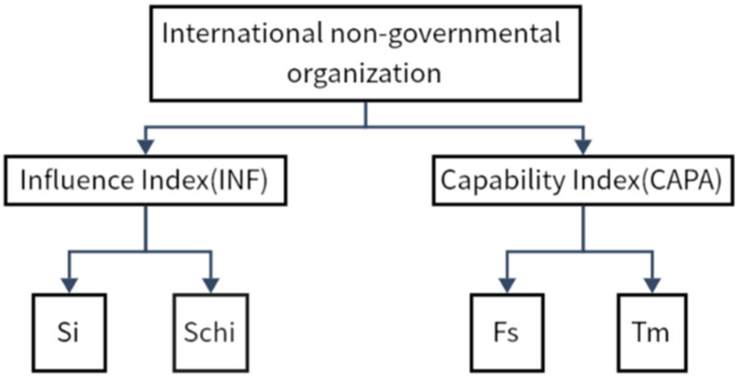

Figure 2. Indicator map of the system of international non-governmental organizations

We use the following indicators to evaluate the value of NGOs.

2.2.1 Influence Index

For an organization's influence index, we divided it into two subcomponents: the Social Impact Index and the Scholar Influence Index.

$$INF = Si，Schi \tag{8}$$

INF is the organization's influence index. Si is the social influence index. Because NGOs tend to vary in their social influence, to more intuitively demonstrate an organization's social influence, we define it as:

$$Si = \frac{V}{V_{max}}(1 + r') \times T \tag{9}$$

We use the definition formula of population growth index in national government evaluation indicators for reference, where V is the current number of volunteers in the organization, V_{max} is the maximum number of volunteers the organization has ever reached since its inception, and r' is the proportion of annual increase in the number of volunteers.

T is the time the organization has been in existence, the more volunteers an organization has， the more social influence it proves to have. A rise in the number of volunteers also indicates that the organization's influence is gradually growing. The longer the organization has existed, the longer the organization has served, the deeper the social impact, and thus the greater the social influence.

The academic influence of an organization is also a factor we take into account when clients make their selection. We define it as follows:

$$Schi = Np^{\frac{Nc}{Np}} \tag{10}$$

$Schi$ is the scholar influence index, Np is the number of papers published by members of the organization or related to the organization and Nc is the total number of citations of the aforementioned articles. These two indicators generally show a positive correlation with the overall index of the organization's academic influence.

2.2.2 Capability Index

A critical element of running a non-governmental organization is the amount of organizational funding and the size of the expert team. Therefore, we define the organizational capacity index as:

$$CAPA = Te, Tm \tag{11}$$

$CAPA$ is the capacity index of the organization, Te is total expenditure of the organization, and Tm is the total expert member size of the organization. The activity expenditure of an organization largely determines the upper limit of the impact that the organization can have on society.

Tm also influences the quality of organizational decision-making from a strategic perspective. A sufficient number of experts can ensure that organizational decisions are considered from multiple aspects, thereby leading to the most impactful actions.

2.3 Analytic Hierarchy Process (AHP)

In order to measure and select the best clients, we consider the economic, ecological and social indices for clients in the national government category, and we consider the social influence and capability for international organizations in the non-government category, so we need to combine the weights of the sub-systems in the indicator hierarchy system to form a composite weight for that client.

For clients in the national government category, their economic, ecological and social indices are considered. Then we build the initial judgment matrix.

$$A = (a_{ij}) \tag{12}$$

a_{ij} represents the importance of indicator i relative to indicator j.

First, we need to calculate the eigenvector corresponding to the largest eigenvalue λ_{max} of the judgment matrix. Next the consistency test is performed on the largest eigenvalue λ_{max}.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{13}$$

$$CR = \frac{CI}{RI} \tag{14}$$

For the above judgment matrix, $CR < 0.1$, therefore this judgment matrix is acceptable.

According to the nature of consistency of judgment matrix, the weights of the indicators can be derived from the eigenvectors corresponding to the largest eigenvalue of the matrix A. Combining the results of the four judgment matrices, we finally get the weights of the indicators.

Table 1. Weighting of national government (AHP)

Economy	Ecology	Society
Gpc 53%	S 46%	LRW 46%
Wpc 32%	Fca 24%	
P 15%	Prop 30%	SA 54%

Table 2. Weighting of international non-governmental organizations (AHP)

Influence Index	Capability Index
Si 42%	Fs 63%
Schi 58%	Tm 37%

2.4 The entropy weight method determines the weight.

Entropy weight method is a method that uses the law of data itself to assign weight objectively. Since our assignment of the secondary indicators using hierarchical analysis is somewhat subjective, we next used the entropy weighting method of objective assignment to re-assign the secondary indicators of national governments and non-government international inter-organizations in order to improve the utilization of the data and strengthen the reliability of the model. The calculation steps are as follows.

We need to calculate the information entropy for each metric:

$$e_j = -\frac{\sum_{i=1}^{n} p_{ij} \ln (p_{ij})}{\ln n} \tag{15}$$

e_j is the information entropy of the j th indicator, p_{ij} is the weight of the i th data in the j th indicator and n is the amount of data.

We need to calculate the information utility value of each indicator and normalize it to get the weights.

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{16}$$

d_j is the information utility value of the jth indicator , W_j is the relative weight of the jth indicator,m is the number of indicators.

Based on the above analysis, the final weighting results are shown below.

Table 3. Weighting of national government (EWM)

Economy	Ecology	Society
Gpc 56%	S 49%	LRW 31%
Wpc 32%	Fca 21%	
P 12%	Prop 30%	SA 69%

Table 4. Weighting of international non-governmental organizations (EWM)

Social influence		Capability	
Si	45%	Fs	53%
Schi	55%	Tm	47%

2.5 Composite weights

Based on the results of the subjective assignment hierarchical analysis method and the results of the objective assignment entropy weighting method, we can make a comprehensive assignment of the final weights, and since the importance of the subjective method and the objective method are comparable, there is the following relationship.

$$w = 0.5w_{AHP} + 0.5w_{EWM} \tag{17}$$

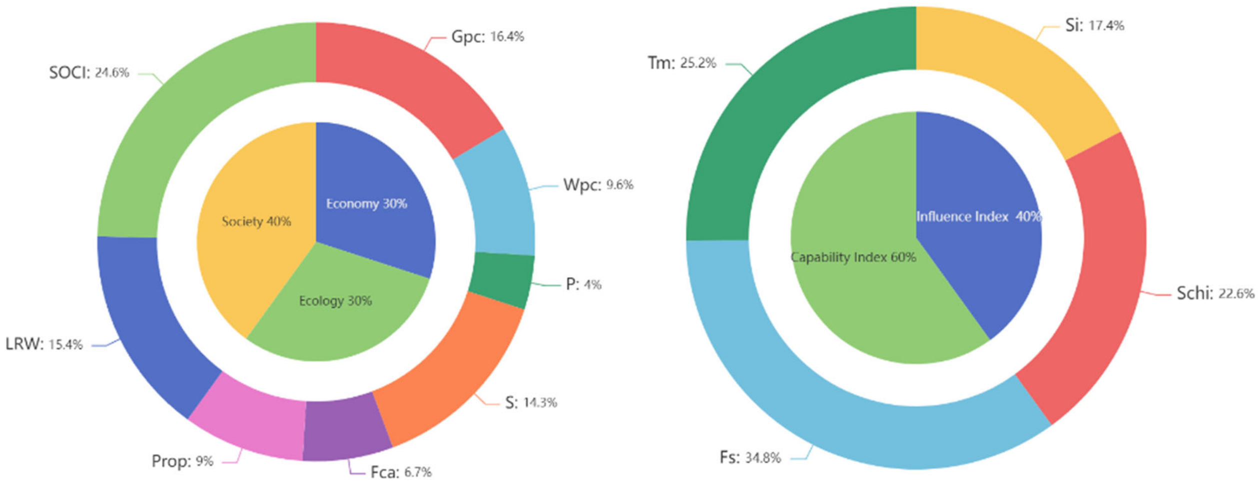

Figure 3. Combined weights

2.6 Score Calculation

After the above calculation, we have obtained the weights of the indicators. Because the indicator system is more complex and more objects are selected, we use the Topsis method to calculate the final score.

Define the optimal ideal type and the worst ideal type in a standardized data matrix.

$$Z^+ = (max_{i=1}^{n}(x_{i1}), max_{i=1}^{n}(x_{i2}), max_{i=1}^{n}(x_{i3}), \ldots max_{i=1}^{n}(x_{i9})) \tag{18}$$

$$Z^- = (min_{i=1}^{n}(x_{i1}),\ min_{i=1}^{n}(x_{i2}),\ min_{i=1}^{n}(x_{i3}), \ldots min_{i=1}^{n}(x_{i9})) \tag{19}$$

We combine the score calculation with the weights to calculate the distance from the ith choice object to the optimal ideal type and the worst ideal type.

$$d_i^+ = \sqrt{\sum_{j=1}^{4} w_j (x_{ij} - Z_j^+)^2}\ ,\ \ d_i^- = \sqrt{\sum_{j=1}^{4} w_j (x_{ij} - Z_j^-)^2} \tag{20}$$

Calculate the relative posting rate of the ith selected object:

$$\boldsymbol{f_i} = \frac{\boldsymbol{d_i^-}}{\boldsymbol{d_i^+ + d_i^-}} \tag{21}$$

Final normalization of relative posting progress

$$f_i = \frac{f_i}{\sum f_i} \tag{22}$$

3. Presentation of Results

3.1 Score ranking

After the above calculations, we get the following scores for each selection object.

Table 5. Ranking of country scores

Country	Score	Ranking
China	86.74	5
Japan	79.82	7
Korea	88.61	4
England	86.73	6
France	94.25	1
America	98.75	2
Italy	91.42	3

Table 6. Ranking of organization scores

Organization	Score	Ranking
WWF	92.44	2
TRAFFIC	98.15	1
WCS	88.39	4
IFAM	89.16	3
AWI	78.96	5
ASPCA	75.28	6

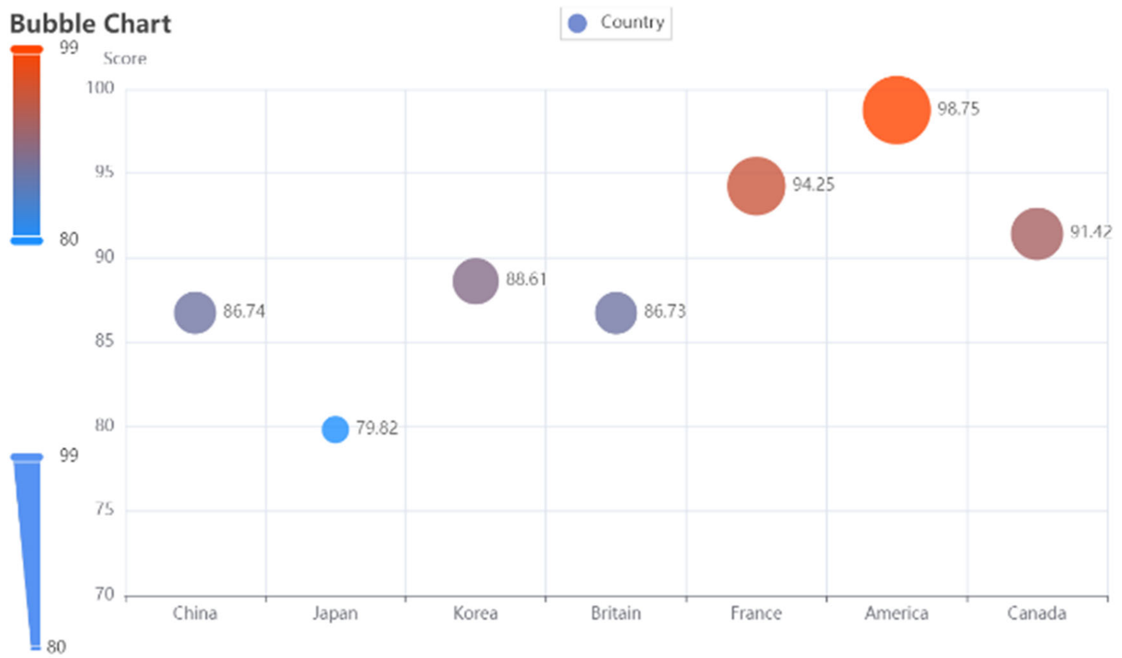

Figure 4. Score by Client

3.2 Client Selection and Analysis

Based on these results, we identified the U.S. government as the client for our project.

For the **social** dimension of the indicator system, the U.S. government as a client has sufficient **authority** to do the following:

3.2.1 Strengthening of laws and regulations

Formulate and strengthen laws and regulations that clearly prohibit illegal wildlife trade and provide appropriate penalties. Increase the level of penalties to ensure that criminal sanctions can serve as a deterrent, including penalties for smugglers, illegal hunters and relevant organizations.

3.2.2 Raising public awareness

Conduct educational and publicity campaigns to increase public awareness and appreciation of wildlife conservation. Utilize various channels, such as social media, television and radio, to convey the dangers and effects of illegal wildlife trade.

3.2.3 Promoting Sustainable Development

Provide alternative economic opportunities to support local communities to shift to sustainable livelihoods and reduce dependence on wildlife. Support and promote the construction and management of wildlife sanctuaries to protect wildlife habitats.

3.2.4 Enhancing International Collaboration

Strengthen international cooperation to combat cross-border illegal wildlife trade. This includes information sharing, coordinating actions, and developing common standards and protocols. Participation in international organizations and conventions, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), to promote global cooperation on wildlife conservation.

3.2.5 Increase in per capita salary levels

Implement policy measures to promote higher per capita wages, improve the standard of living of the population and reduce the economic attractiveness of the illegal wildlife trade. Strengthen the protection of labor rights and interests to ensure that workers have access to reasonable wages and benefits, and reduce the incentives to engage in illegal activities due to poverty.

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