Study on the Selection of Countries for Wildlife Conservation Based on Comprehensive Evaluation and Correlation Analysis

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Abstract. Illegal wildlife trade poses a huge threat to global biodiversity and ecological balance, and this thesis finds it difficult to regulate and constrain it. Based on the literature analysis this thesis believes that national governments are in an important position to regulate illegal wildlife trade, so this thesis collectes 10 indicators such as the total number of national nature reserves, and the country's financial ratings to measure whether countries are suitable to our project. The thesis determined the weights of the indicators based on the criteria importance through intercriteria correlation (CRITIC) method and calculated that the UK was the best client for the program with a score of 21. 822.Then, the thesis defines the index WIT to quantify the illegal wildlife trade in the UK. The thesis collected the import and trade statistics of ivory and humpback whales, etc in the UK as indicators, determined the weights of the indicators using entropy weighting and coefficient of variation method (EWM-CVM) and calculated the value of WIT using the method of TOPSIS. By the way, the thsis collectes 18 indicators in sustainable development and use the same method to calculate the index SHD. After that, the thesis calculates the Spearman's correlation coefficient between WIT and SHD to be -0.92, which indicates that the illegal wildlife trade seriously affects the British society.

Keywords: Integrated Evaluation, Correlation Analysis, Wildlife Conservation.

1. Introduction

Trade in wild species is now one of the world's most pressing conservation and devel- opment challenges. The global supply chain of wildlife provides livelihoods for hundreds of millions of the world's poor. At the same time, the illegal wildlife trade, one of the world's most lucrative criminal activities, is contributing to environmental degradation and economic loss. Trafficking in wild species is expanding globally, leading many species to extinction and threatening global security and public health. It is estimated that the annual value of illegal wildlife trafficking is as high as $23 billion is considered to be the fourth largest trading activity of all illegal trade globally. Moreover, almost every country in the world plays a role in this illegal trade.

According to the Global Wildlife Crime Report 2020 published by the United Nations Of- fice on Drugs and Crime, nearly 6,000 wildlife species were illegally trafficked globally dur- ing the period 1999-2019, involving mammals, reptiles, corals, birds and fish, among others, with suspects apprehended in more than 150 different countries and territories, reflecting the fact that the illegal wildlife trade has now become a global problem with serious impli- cations. Therefore, an interdisciplinary and comprehensive research approach is needed to propose solutions to achieve the goal of reducing illegal wildlife trade, and such solutions also need to be resistant to disturbances to ensure the ability to achieve the goal under the influence of disturbing factors.

Therefore, nowadays, the links between countries are getting closer, and countries have spontaneously started to take measures to control illegal wildlife trade activities, however, due to resource and capacity constraints, how to reduce the generation of such illegal activities in a more efficient way has become a problem, and how to start from the aspect of country selection, to choose countries that can make a greater contribution to the reduction of illegal trade activities in order to invest and take action has become a problem of the research in this paper.

Fangchao Shang and Xingxing Guo (2024) pointed out that wildlife conservation is an important strategy to mitigate climate change [1]. Chen, Y. (2023) explored the difficulties in proving the online illegal trade of wildlife and the solution path [2]. Zhang, F. et al. (2023) studied the illegal trade network of pangolin meat and the implications for intervention [3]. Chen Mulin (2023) studied the rule of law guarantee for pluralistic co-management of wildlife protection in his master's thesis [4]. Qiang Chen (2022) explored the legal protection of companion animals in China [5]. Jiao Yunbo (2021) discussed the regulatory dilemmas and countermeasures for wildlife protection and utilization in China [6]. Chen Jimin et al. (2021) examined the strategy of governance of illegal trade in wildlife and its products [7]. Cai D and Li Shaoshan (2021) discussed the endangered status of wildlife pangolin and the progress of conservation research [8]. Chen Jimin et al. (2021) analyzed the synergistic governance of illegal trade in wildlife in China [9]. Fei Yiling and Xu Yanhong (2020) compared the differences between the CITES Convention and domestic laws under the perspective of terrestrial wildlife protection [10].

The full paper is divided into two tasks, in task 1 we reviewed a large amount of literature and identified the clients as governments. We conducted a comprehensive assessment of the countries based on the CRITIC weighting method and selected the best client. In Task 2, we measured the sustainability of illegal wildlife trade and national health using the EWM-CVM-TOPSIS method and analyzed the Spearman correlation between them.

2. Project Client Selection

2.1. Model Construction

We found that the state is the most involved and plays an irreplaceable role in regulating illegal trade practices, so we first limited our clients to the state. In order to further rate the capacity of countries, we studied the capacity of the state, and found that when discussing the capacity of the state, it is usually divided into two subcategories, namely, the coercive capacity of the state and the administrative capacity of the state. In the context of crisis management, the information capacity, decision-making and implementation capacity, coercive capacity, and mobilization and cooperation capacity of the state are important factors that influence the response of countries to crises.

On this basis, we believe that regulating illegal wildlife trade can also be seen as part of crisis management in countries, so in assessing national capacity, we included information capacity, decision-making and implementation capacity, enforcement capacity, and mobiliza- tion and cooperation capacity. In addition, due to the limitation to the specific crisis target of wildlife trade, we have included the capacity of countries to implement conservation mea- sures for wildlife in the assessment of national capacity.

We selected 10 indicators, which are categorized into two groups:

One category is project-specific in terms of competency requirements and is related to wildlife conservation measures: NR(the indicators of total number of nature reserves), TV (number of protected areas assessed through management effectiveness),EM(other effective conservation measures), LC (coverage of terrestrial protected areas) and MC (coverage of marine protected areas).The first set of indicators reflects the strength of national awareness of responsibility and regulatory capacity for biodiversity and wildlife conservation;

The other category is universal indicators for crisis management: PR (the CPIA ratings of property rights and rule-based development), TR (CPIA trade ratings), PM (CPIA quality ratings of public management), FP (CPIA fiscal policy ratings), and BF (CPIA quality ratings of budgetary and financial management). These indicators serve as a basis for the analysis of the State’s capacity for decision-making implementation, coercive capacity, and mobilization and cooperation capacity.

A decision matrix is constructed for the above indicators through equation (1), where $ai\ j$ denotes the evaluation value of the jth indicator for the ith country.

$$A = (a_{ij})_{n*m} \tag{1}$$

2.2. CRITIC Weight Calculation

Prior to weighting, we divided the data indicators into benefit and cost indicators and standardized them according to equation (2) and equation (3), respectively.

• For benefit indicators:

$$X_{ij} = \frac{a_{ij} - mina_{ij}}{maxa_{ij} - mina_{ij}} \tag{2}$$

• For cost-based indicators:

$$X_{ij} = \frac{maxa_{ij} - a_{ij}}{maxa_{ij} - mina_{ij}} \tag{3}$$

Subsequently we obtained a data normalization matrix X and processed this matrix to calculate the variability of the data for each indicator:

$$S_j = \sqrt{\frac{\sum_{i=1}^{n}(x_{ij} - x_j)^2}{n-1}} (j = 1,2,3, \ldots, m) \tag{4}$$

Using equations (5) and (6), we calculate the Pearson correlation coefficient between indi- cator j and indicator p and obtain the degree of conflict between indicators where p belongs to (1, 2, · · ·, m)

$$r_{pj} = \frac{\sum_{p=1}^{m}(x_{ip} - x_p)(x_{ij} - x_j)}{b}, b = \sqrt{\sum_{p=1}^{m}\left(x_{ip} - x_p\right)^2 \sum_{j=1}^{m}\left(x_{ij} - x_j\right)^2} \tag{5}$$

$$R_j = \sum_{p=1}^{m}\left(1 - r_{pj}\right) \tag{6}$$

The stronger the correlation between the indicators, the less conflict between the indicator and other indicators is reflected, and the more the same information is repeated between the two, so we reduce the allocation of weights to the indicator. Based on the variability and con- flict of each indicator, we calculate its information and determine the objective weight value according to the information of each indicator. Equation (7) is the formula for calculating the amount of information and weight values.

$$C_j = S_j R_j, W_j = \frac{C_j}{\sum_{j=1}^{m} C_j} \tag{7}$$

2.3. Calculation of Pas

We define PA as the national wildlife conservation program acceptance value. Based on the previous weighting calculations, the PA of acceptance of our program by countries around the world was calculated according to equation (8).

$$PA = 100 \sum_{j=1}^{m} W_j \, x_{ij} \tag{8}$$

The acceptance PA scores for each country are presented in the map in Figure 1.

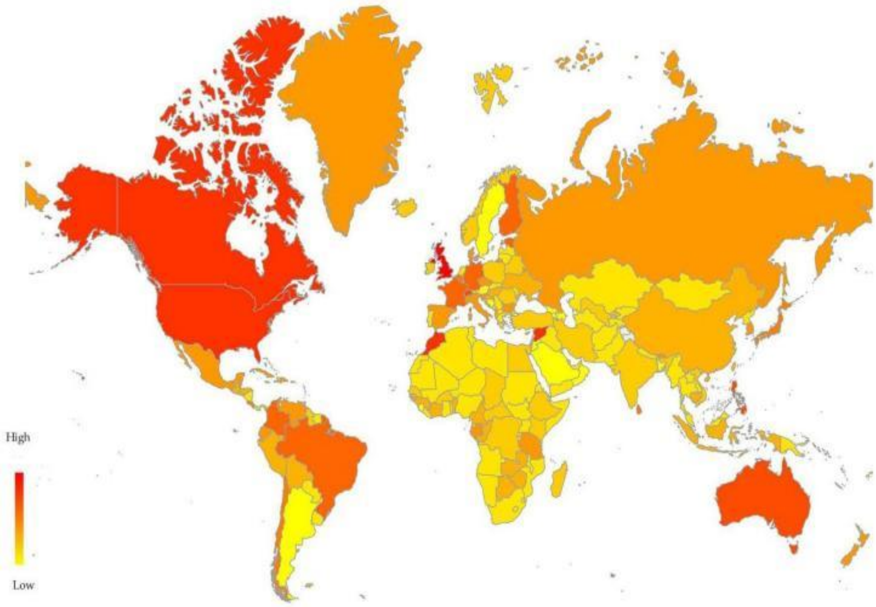

Figure 1. PA Scores by Countries

The closer the color to red on the graph, the higher the score, with the top five scoring countries being the United Kingdom (21.822), Canada (16.584), Switzerland (15.386), Mo- rocco (14.843), and the United States (14.819). In terms of scores, the UK is at the top of the list, reflecting its ability to meet the project's estimated capacity needs.

In addition, the UK, as a founding member of the Global Alliance for Oceans, has com- mitted to bringing 30% of its land under nature conservation management by 2030, and has introduced a Net Biodiversity Gain (NBG) indicator to facilitate the growth of its NBG, which was announced at the 2018 The UK government has also shown a strong commitment to con- trolling the illegal trade in wildlife at the Illegal Wildlife Trade Conference in London in 2018. We chose the UK as the client for our project based on our client's capacity and interest, need and commitment to tackle illegal wildlife trade.

3. Vertification of Project Necessity

In this section, we define the Wildlife Illegal Trade Index (WIT) and the National Health Sustainability Index (SHD) and verify the necessity of the project implementation for a specific client by performing data calculations and correlation analysis for both.

3.1. Calculation of the Wildlife Illegal Trade Index (WIT)

3.1.1. Indicator Description

According to the CITES report, both Asia and Europe are the largest import and export markets for illegal wildlife trade, with Asia accounting for 37% of total export trade and 31% of total import trade, and Europe accounting for 34% of total export trade and 38% of total import trade. The United Kingdom, on the other hand, ranks among the top European countries in terms of illegal wildlife trade.

In a study of data on illegal trade in the UK we found that the species with the highest amounts of terrestrial and marine wildlife traded were the pronghorn oryx, the African elephant, the parrot and the humpback whale. As it accounts for the majority of total UK trans- actions covering both terrestrial and marine organisms, we have selected the big antelope sample ($bone\ and\ skin\ meat$) ($\beta1$), humpback whale sample ($\beta2$), ivory sample($\beta3$), parrot trade number($\beta4$) as the indicator for the illegal wildlife trade index because it accounts for the majority of the total trade in the UK and covers both terrestrial and marine organisms.

In addition, to increase the accuracy of the index calculation, we additionally selected the importer report number ($\beta5$), and the amount of illegal wildlife trade found($\beta6$) as indicators for calculation.

The number of importer reports measures the number and value of import transactions, the structure of imported commodities and trading partnerships; and the amount of illegal trade in wildlife detected is a direct assessment of the Illegal Trade in Wildlife Index.

Then we standardize the data to obtain the available data set.

3.1.2. Weight Calculation

(1) Entropy Weight Method

Entropy Weight Method is an objective comprehensive evaluation method to determine the weight value of each index by calculating the information entropy of each evaluation index after improving the quantifiable evaluation index system. We use this method to avoid the influence of subjective factors on the weight.

• Normalize the data in the standardized matrix:

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} (j = 1,2,\cdots,m) \tag{9}$$

• Calculation of information entropy:

For the jth index, we use the equation (10) to calculate its information entropy.

$$e_j = -\frac{1}{lnn} \sum_{i=1}^{n} r_{ij}\, lnr_{ij} (j = 1,2,\cdots,m) \tag{10}$$

• Calculation of entropy weight.

Based on the principle of information entropy, we calculate the entropy weight of each evaluation index by the following equation (11):

$$\omega_{Ej} = \frac{1-e_j}{\sum_{j=1}^{m}(1-e_j)} \tag{11}$$

(2) Coefficient of Variation Method

Next, we use the coefficient of variation method to objectively weight each index by calcu- lating the dispersion degree of each index. We process the standardized matrix (X). Firstly, the mean and standard deviation of each index data were solved according to equation (12). The mean and standard deviation of each index data were solved firstly, and then the coefficient of variation was obtained according to the ratio of standard deviation and mean value of each index data in accordance with equation (13).

$$u_j = \frac{1}{n} \sum_{i=1}^{n} x_{ij}\ (j = 1,2,\cdots,m), \sigma_j = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(x_{ij} - \mu_j\right)^2}\ (j = 1,2,\cdots,m) \tag{12}$$

$$CV_j = \frac{\sigma_j}{\mu_j} (j = 1,2,\cdots,m) \tag{13}$$

The coefficient of variation eliminates the effect of measurement scale and magnitude on the measure of data dispersion, and finally we normalize the coefficient of variation of each indicator to obtain the coefficient of variation weight of each indicator according to equation (14).

$$\omega_{Cj} = \frac{CV_J}{\sum_{j=1}^{m} CV_j} \tag{14}$$

(3) Combination Weight Calculation

In order to improve the accuracy of the model, we take the average of the two weights calculated above as the final weight of each index.

$$\omega_j = \frac{\omega_{Ej} * \omega_{Cj}}{2} \tag{15}$$

3.1.3. WIT Calculation and Result Analysis

Through the above processing, we obtain the quantitative data of each index and its weight value. On this basis, we use the TOPSIS method to calculate the specific WIT scores of each year. See equations (16), (17) and (18) for specific calculations.

$$Z = (z_{ij})_{n\times m}, z_{ij} = \omega_j \times r_{ij} \tag{16}$$

$$S_j^* = max(r_{1j}, r2j, \cdots, r_{nj}), S_j^* = max(r_{1j}, r2j, \cdots, r_{nj}) \tag{17}$$

$$Sep_i^* = \sqrt{\sum_{j=1}^{m}(S_j^* - z_{ij})^2}, Sep_i^- = \sqrt{\sum_{j=1}^{m}(S_j^* - z_{ij})^2}, WIT = \frac{Sep_i^-}{Sep_i^* + Sep_i^-} \tag{18}$$

The calculation results are shown in Figure 2. The WIT score shows a significant upward trend from 2015 to 2023, and the WIT score of 0.1376 in 2023 reflects that the current situation of illegal wildlife trade in the UK is not optimistic, and the number of illegal trade transactions is likely to reach a new high in the future. In addition, the UK government promised in the 2018 Wildlife Illegal Trade Conference that it would continuously combat illegal wildlife trade, and the solution measures adopted by the UK government nowadays may not be adapted to the illegal activities in the internet environment, so it seems that our proposed MCP project can provide.

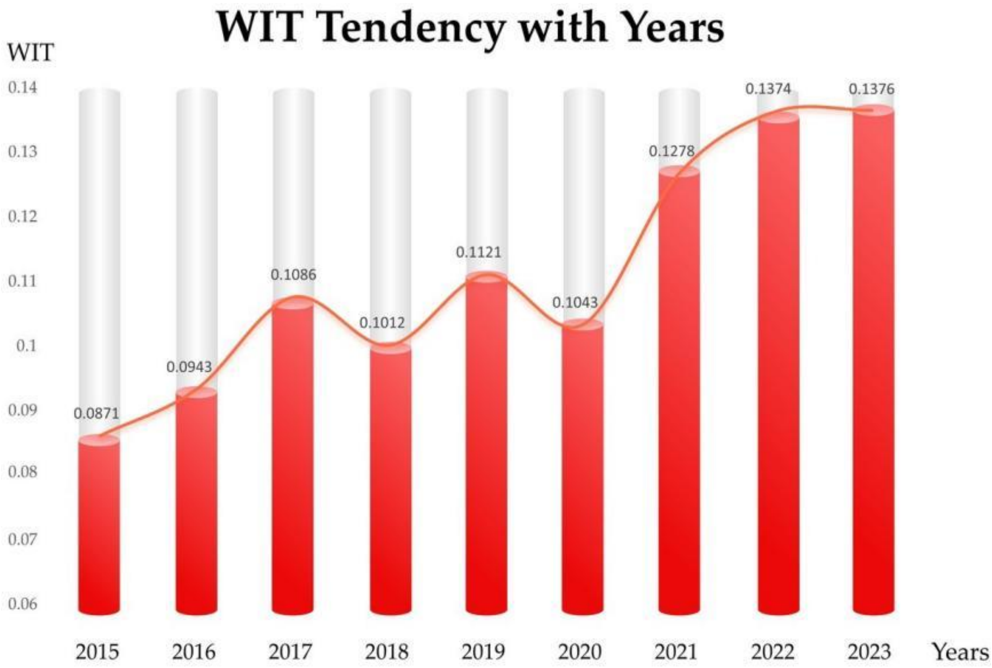

Figure 2. WIT score

3.2. Calculation of the National Health Sustainable Development Index (SHD)

3.2.1. Indicator Description

We define the National Health Sustainable Development Index as SHD. At the same time, in order to enhance the comprehensiveness and authenticity of the SHD calculation results, we selected four first-level indicators of Species and Ecology, Security and Stability, Health and Hygiene, and Economy and Livelihood to calculate SHD from the three major directions of society, economy and ecology. Each of the first-level indicators has multiple secondary indicators for data support, and the specific content is shown in Figure 3.

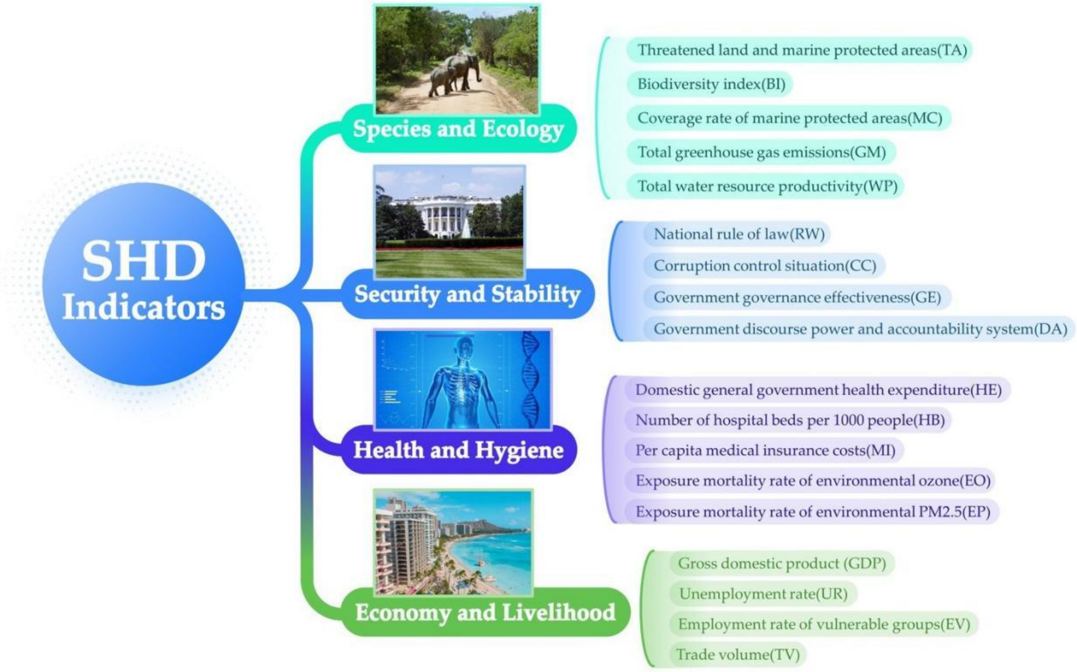

Figure 3. First-level indicators

3.2.2. Calculation of weights and SHD index

We first calculate the weight value of each secondary index according to the methods mentioned in 3.1.2 and 3.1.3, and further obtain the score of each primary index. Then we process the score of the first-level index to calculate the score of the SHD index. The weight distribution and SHD change trend of each first-level index are shown in the following figure 4.

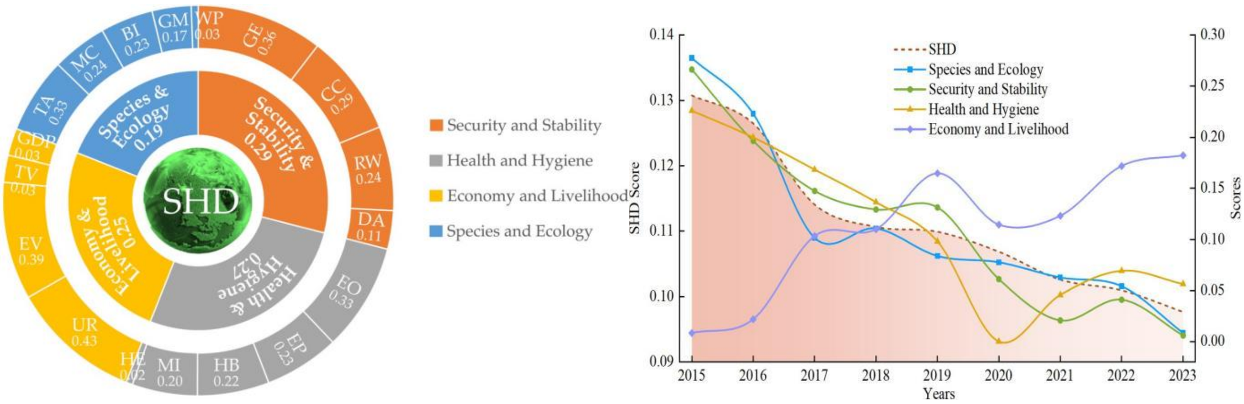

Figure 4. Indicator weight distribution and SHD trends

We found that the weight ratio of species and ecological first-level indicators is 0.19; the proportion of Security and Stability weight is 0.29; the proportion of Health and Hygiene weight is 0.27; the weight ratio of Economy and Livelihood is 0.25. From the overall point of view of SHD score, the three first-level indicators of Species and Ecology, Security and Stability, Health and Hygiene showed a significant downward trend in time series. The SHD scores of Species and Ecology and Security and Stability were close to 0 in 2023, and the SHD scores of Securities and Stability were close to 0.05. Among the four indicators, only Economy and Livelihood are in a state of fluctuation and stability, and the overall SHD score also shows a significant downward trend. How to improve the current situation of Britain ’s social health and sustainable development has become a dilemma it is currently facing.

3.2.3. Correlation Analysis and Project Necessity Evaluation

In order to analyze the relationship between illegal wildlife trade and national health and sustainable development, we conducted a correlation analysis between WIT and SHD. The Shapirowilk model is used to test the normal distribution of the comprehensive evaluation scores of WITS and SHD. The results show that the scores of the two are not normally distributed, so we choose Spearman rank correlation coefficient to measure the correlation between WIT and SHD. For the sample data with sample size n, we define R as the correlation coefficient between WIT and SHD, t as the test statistic, df as the degree of freedom. The formulas are given in equations (19) and (20).

$$R = \frac{\sum_{i=1}^{n}(WIT_i - WIT_a)(SHD_i - SHD_a)}{\sqrt{\sum_{i=1}^{n}(WIT_i - WIT_a)^2 - \sum_{i=1}^{n}(SHD_i - SHD_a)^2}} \tag{19}$$

$$t = R\sqrt{\frac{n-2}{1-R^2}}, df = n = 2 \tag{20}$$

In summary, we get $R = -0.92$, $p = 0.0013$, p is much smaller than the significance level $\alpha = 0.05$, so the significance test is passed. The relationship between WIT and SHD is shown in Figure 5.

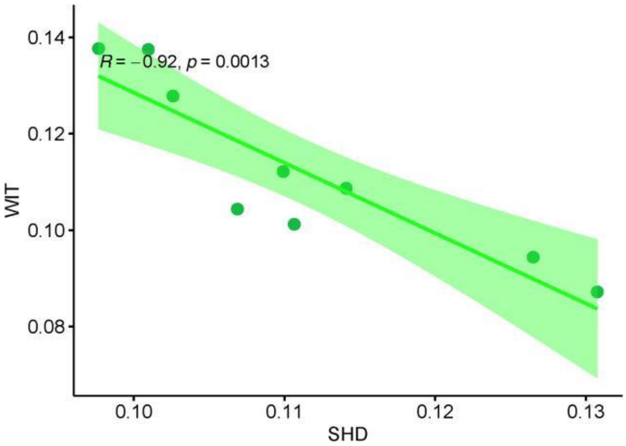

Figure 5. Spearman Correlation Analysis

Wildlife crime is extremely destructive to biodiversity, and an analysis by the University of Oxford in the United Kingdom concluded that the global illegal trade in wildlife could threaten more than 2,200 species of plants and animals. Biodiversity is not only important for livelihoods, the environment and ecology, it also makes an indelible contribution to eco- nomic output. The World Economic Forum estimates that $44 trillion of economic output is moderately or highly dependent on nature and its services. According to the Forum, the transition to a nature-positive economy could create $4.5 trillion in business opportunities by 2030 if nature losses were managed. In addition, according to the GRPS results, failure to mitigate climate change and failure to adapt to climate change are the most serious risks globally.

Illegal wildlife crime has a negative impact on natural ecosystems globally, triggering a range of responses. It is estimated that more than half of the world’s economic output is moderately to highly dependent on nature, and the collapse of ecosystems would have far-reaching economic and social consequences. These include an increased incidence of zoonotic diseases, a decline in crop yields and nutritional value, the potential for violent conflict exacerbated by increasing pressure on water resources, the loss of livelihoods de- pendent on food systems and natural services, such as pollination, and increasing flooding, sea-level rise and erosion due to the degradation of natural flood control systems, such as water meadows and coastal mangroves, thus affecting social security.

4. Conclusion

The study outlines a model for assessing national capacities in addressing illegal wildlife trade. It identifies indicators related to crisis management capacities and wildlife conservation measures, providing a basis for evaluation. Through CRITIC Weight Calculation, objective weight values are determined for each indicator, aiding in comprehensive capacity assessment. Program Acceptance (PA) scores highlight countries' readiness to implement wildlife conservation programs. Analysis of indices such as the Wildlife Illegal Trade Index (WIT) and the National Health Sustainability Index (SHD) reveals increasing trends in illegal wildlife trade and downward trends in various sustainability indicators. Correlation analysis underscores the negative impact of illegal wildlife trade on biodiversity and societal health, necessitating proactive intervention strategies.

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