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The Evaluation Criteria of Vulnerable Regions Affected by Climate Change

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Abstract: Nowadays, the evaluation criteria of fragile states have become one of the world's focusing issue. Hence, conclude appropriate strategy adjusted to the vulnerable index for nations is of crucial importance. This dissertation aims to construct a mathematical method to identify countries' vulnerable index. Utilizing the interval number fuzzy analytic hierarchy process to obtain the weight of the first-class indictors and second-class indictors. Considering the interaction between these factors, we adopt the Weighted Power Averaging operator to get the final index of the countries' fragile crisis. According to the conditions of Pareto Optimal and simulate agricultural income under certain competition mechanism. For the sake of realizing climate change may push the nation to become more fragile in the future and analytical models can be adapted to climate circumstances.

Keywords: Vulnerable index; Climate change; Fuzzy analytic hierarchy process; Entropy method; Pareto Optimal

1. Introduction

In order to obtain the serious impact of fragile states and appropriate natural disasters for the different nations, we build the evaluation index model of climate crisis based on the collected data and establish the Multi-Objective Optimal model. As a result, we calculate and obtain the optimal fragility degree among the developing countries. Considering that climate resources will change over time, we simulate the evolution of the crisis based on the Pareto Optimal strategy and analyze the influences caused by climate change and deepened crisis.

Table 1. Structure of Asphalt Pavement of Test Section

Symbol	Meaning
m_{ij}	The membership grade of index i is higher than j
n_{ij}	The membership grade of index i is lower than j
w	Weight
x_{ik}	The impact of index i on nation k
G_k	The group of which nation k represented
e	The critical point at a state transforming its status
$\hat{x}_{k+1}^{0}$	The filmsy percentage of a state in the year $k+1$

In order to measure the degree of the evaluation criteria of fragile states, we provide a model with functions to figure out the first-class and second-class indicators, weigh the third-class indicators through using IFAHP Method and using the Entropy Method to weigh the second-class indicators, thus obtain the comprehensive score of the model using WPA operators.

first-class indicators: $w_{1i}=\frac{1}{n}\sum_{i=1}^{m}\frac{r_{ij}}{\sum_{j=1}^{n}r_{ij}}$

second-class indicators:

$$w_{2i}=\left(\frac{\sum_{j=1}^{n}m_{ij}}{\sum_{j=1}^{n}\sum_{i=1}^{n}(1-n_{ij})},1-\frac{\sum_{j=1}^{n}(1-m_{ij})}{\sum_{j=1}^{n}\sum_{i=1}^{n}n_{ij}}\right)$$

Choosing these indicators based on these scientific and reasonable principals. The figures are chosen from the lists can be calculated for the indicators. Utilizing these data to normalize the indicators consisting of GDP per capita, finical burden capita, land area, medical resources per capita. These indicators can be digitized in the model. We regard each country is a separate class, and the symbols of each class are as follows G_k ,following with clustering by means of the group average method, in addition we can set up definition of group average method: combining Gp with Gq into new class $Gr = \{Gp, Gq\}$, and the distance between the original symbol G_k (except Gp and Gq)and the new class index Gr :

$$D_{lr}^2 = \frac{n_p}{n_p + n_q} D_{kp}^2 + \frac{n_q}{n_p + n_q} D_{kq}^2$$

The chief element of all: n_p are the sample numbers which involved in G_p , n_p are the sample numbers which involved in G_p .

According to the basic law of cluster analysis, we can calculate the distance between the various types according to the above formula, and then combine the nearest two samples into one class until they are divided into three categories. For the purpose of measuring the degree of the refugee crises, we provide a flow chart through figuring out the second-class, third-class indicators and weigh the third-class indicators through using AHP Method and using the Entropy Method to weigh the second-class indicators. Receiving the comprehensive score using WPA operators.

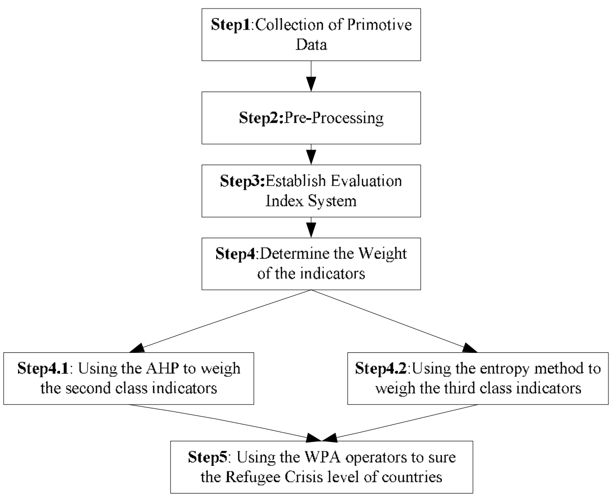

Figure 1. Flow Chart to Measure the Crises of Refugee based on Comprehensive Metrics Model

2. Establish the Metrics Index System

Investigating the fragile crisis is a difficult and complex problem, so we need to choose these indicators based on these scientific and reasonable principals, utilizing figures to normalize the indicators consisting of GDP per capita, social resources per capita, water and food per capita, traffic resources per capita,. Considering the vigorous effect caused by climate adaptation, the contemporary massive effect of natural hazard has sparked cosmopolitan scare among global nations, especially the developing countries and appropriate methods are beneficial to the results of indicator selection from grades based on expert's evaluation. Apart from that, the weights on weather, politics, economy and society are graded result to intuitionistic fuzzy judgment matrix. The degree of the climate change crisis can be calculated eventually.

2.1. Climate Change Influence tea Production in Sri Lanka

Although it is generally accepted that an increasing production in temperature increases tea yield, as well as this correlation has been used in many fields, the recent findings show that at higher temperature regimes (greater than 25-26℃), the increase in temperatures reduces tea yield. In addition, heavy rainfall also causes considerable lesion to camellia sinensis through soil erosion, poor growth due to lack of sun, and increases in disease incidence. According to climate change scenarios, the increases in global atmospheric carbon dioxide concentrations and temperatures by 2100 could be in the range of 600-700 ppm and 1.0-3.5 °C, respectively.

In the recently published Sri Lanka country report, it was shown that Sri Lanka will experience frequent droughts, warmer spells, and extreme rainfall events as a result of the climate change (greenhouse effect). It is also predicted that there will be a 10% increase in the length of dry and wet seasons per year in the main tea plantation area. Although the increase in rainfall is predicted, any significantly favorable impact on tea plantation is unlikely because of increased evaporation losses brought about by high temperatures and the possibility of the distribution of rainfall being erratic or uneven. Hence, it has become a current need to address the possible impacts of global climate change on the tea industry in Sri Lanka. In this study, the effects of environmental factors on growth and yield of tea were studied using data on annual variation of climatic factors and yield parameters of tea and other agricultural plantation, the relationship between the climatic factors and tea yield was analyzed using linear regression analysis.

As described previously, since there is no irrigation, tea yield is greatly influenced by weather. Tea grows well under air temperatures in the range of 18-25 °C. A well-distributed rainfall of about 1,300-1,400 mm per year is generally considered adequate for the growth of tea in Sri Lanka. It is also reported that an annual rainfall of about 2,500-3,000 mm is optimum for tea cultivation. There is a wide variation in temperature and rainfall in the different tea growing regions in Sri Lanka. The relationship between weather and tea yield has shown that increases in rainfall and temperature increase tea yield, recent observations have shown that at higher temperature regimes (25-26), the yield components of tea (shoot population density, shoot weight, and shoot extension rate) tend to decrease with increasing temperatures:

$$SW = 0.647(4\text{-}0.059)\text{-}\ 0.017(4\text{-}0.002)\ T.$$

$$R^2 \approx 40\%,\ p < 0.001.$$

$$SER = 225\ (\pm 38)\text{-}\ 6.62\ (\pm 1.37)\ T.$$

$$R^2 \approx 29\%,\ p < 0.001,$$

SW, SER, and T are the shoot dry weight (g/shoot), shoot extension rate (mm/week), and temperature (°C), respectively. Low R^2 values were obtained because this experiment was conducted under field conditions where none of the environmental factors were controlled.

Figure 2. Total Tea Production and Average Yield in Sri Lanka

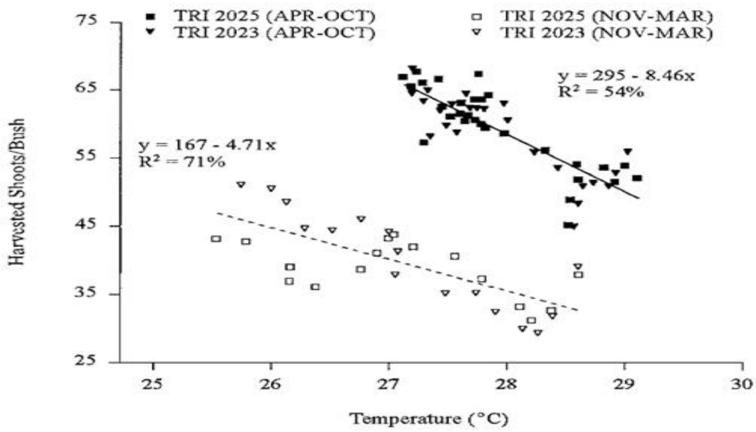

Figure 3. Effect of Temperature on Population Density of Tea Shoots

Experiments under controlled environments have revealed that shoot extension rate increases with increasing temperatures up to 22°C, and further increases in temperature up to 34°C result in a decline in the extension rate.

2.2. The Dynamics of the Climate Movement

The parameters, which we have chosen previously, will change relatively over time, along with the evolution of the grey system theory. At the same time, it will analyze the degree of the crisis, once the country's climate resource provided by nature has changed, incorporating the changes of theses parameters and the effect from natural impact into our model. Besides, we ensure that the indicators are guided to the countries with higher crisis level. As to solve the obscure system analysis model and the vulnerability index provides us a new way to solve the dynamic problem.

3. Determining the Weight of the Climate Indicators by using Entropy Method

Entropy Method is a way to measure the weight of index and each index transfers the amount of information to the decision-maker. We can use influential indicators Pk, k stands for the serial number of the quarters, and then make a sequence of all quarters as the original sequence of the prediction model as Grey Model $GM(1,1)$ —— Grey time series prediction.

To measure weight of indicators, each index transfers various message to the mathematical model and the result of residual size is about each point for the residual of both the model value and the actual value, the theorem of reduction generating number(IAGO), original sequence of the inverse operation of its accumulation is: $X^1=\{x_1^1,x_2^1,\cdots,x_n^1\}$,and cumulative reduction to generate this sequence $X^0=\{x_1^0,x_2^0,\cdots,x_n^0\}$, while $x_k^0=x_k^1-x_{k-1}^1$, in case we regulate $\hat{X}_{i+1}^1$ Calculating the index $\hat{X}_{i+1}^1$ follow as former models let $\hat{X}_{i+1}^1$ generated to $\hat{X}_i^0$ initialize the parameters and residual error sequence, which we have chosen before and add it to this task.

$\Delta^0=\{\Delta_i^0, i=1,2,\cdots,n\}$, $\Delta_k^0=\left|x_k^0-\hat{x}_k^0\right|$.

Based on the correlation coefficient of the original sequence is to evaluate the degree of crisis of nodes and the degree of crisis of edge, the correlation degree $\hat{X}_i^0$ and X_i^0 is calculated. According to experience, the correlation degree is greater than 0.6, which is satisfactory. the generalized-related-degree coefficient is ：

$$\hbar_k^0=\frac{\min\limits_j\min\limits_l\left|x_l^0-\hat{x}_l^0\right|+P\max\limits_j\max\limits_l\left|x_l^0-\hat{x}_l^0\right|}{\left|x_k^0-\hat{x}_k^0\right|+P\max\limits_j\max\limits_l\left|x_l^0-\hat{x}_l^0\right|}.$$

After that, we make use of posterior-variance-test for the statistical properties of the residual distribution, not only the average of the original sequence, but also mean square deviation of the original sequence and many other indicators. Calculating the probability of small residual error according to the indicators that obtained before:

Let $P=P\{\left|\Delta_i^0-\bar{\Delta}\right|<0.6745\mathrm{S}_1\}$, with $\mathrm{S}_0=0.6745\mathrm{S}_1$,

$\mathrm{e}_i=\left|\Delta_i^0-\bar{\Delta}\right|$, $P=P\{\mathrm{e}_i<S_0\}$

If for a given index $C_0>0$, when $C<C_0$, the mean variance of the model is better than the qualified model; If given $P_0>0$, the model is a qualified model of small residual probability.

Table 2. The Posterior difference Test Discriminant Parameter Table

P	C	The precision of the model
>0.95	<0.35	excellent
>0.80	<0.50	qualified
>0.70	<0.65	grudgingly qualified
<0.70	>0.65	unqualified

In the case of relative residuals, the correlation degree, the posterior difference test is allowed within the allowed range, can be used for prediction, otherwise the residual correction should be carried out. After simulating the model, we obtain few charts which embody the dynamics of the climate crisis. Taking this parameter to checking and obtain its weight for supplementing the evaluation index. As time goes by, it shows that the damage is spreading its wings quickly in the Sri Lanka and the analysis to obtain the mainly over-stretched regions has adverse effects due to the climate change, expected to be greater in the low country tea growing regions (<600 m above mean sea level) where the mean air temperatures are usually higher than 25°C and drought damages are greater. However, this is the region where the majority of tea production enters the market are concentrated in the low districts.

The effects of drought on tea plantations are well known. Increases in temperature, soil moisture deficit, and vapor pressure deficit create a plant water deficit, which belong to climate leads to growth retardation. Experimental results in the low country have shown that clonal tea yields could be adversely affected at temperatures higher than 26°C, soil moisture deficits surpassed 30-50 mm, and saturation vapor pressure deficits more than1.2 kPa .

Given these results, it could be assumed that the predicted climate change for Sri Lanka, higher temperatures and drier weather, will be unfavorable for tea production. A growing number of observational evidence that climate change will lead to an increased frequency of abnormal weather and climate, thereby deepening disaster risk, especially the occurrence of catastrophe risk, the effects of global warming on human society is not only widely, but also profound, produced by these effects, such as climate, frequent severe weather phenomena often, enough to economic sustainable development of human society, and the whole earth system poses a great risk of the regional instability.

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