A TVM-based Model for How Climate Change Influence Regional Instability

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Abstract

The effects of Climate Change, to include increased droughts, shrinking glaciers, changing animal and plant ranges, and sea level rise, are already being realized and vary from region to region. The Intergovernmental Panel on Climate Change suggests that the net damage costs of climate change are likely to be significant. Many of these effects will alter the way humans live,and may have the potential to cause the weakening and breakdown of social and governmental structures. Consequently, destabilized governments could result in fragile states.To solve this problems, a three-dimensional vector stratified model(TVM) is constructed based on the gray relational analysis to determine a country's fragility. Meanwhile, we classify the climate change. The level of grade affects the indicators of the three-dimensional vector stratified model. By this means, the impact of climate change on vulnerability can be measured. After that, it illustrates that climate change impacts the fragility in an indirect way.It is of great help in solving the problem.

Keywords

Climate change , Fragility of the state, Three-dimensional vector stratified model.

1. Introduction

Nowadays, research on fragile states has become a core issue for academics and policy makers, which is of vital significance for global security, development and poverty problems.

The effects of Climate Change, to include increased droughts, shrinking glaciers, changing animal and plant ranges, and sea level rise, are already being realized and vary from region to region. Many of these effects will alter the way humans live, and may have the potential to cause the weakening and breakdown of social and governmental structures. Consequently, destabilized governments could result in fragile states.

Being a fragile state increases the vulnerability of a country's population to the impact of such climate shocks as natural disasters, decreasing arable land, unpredictable weather, and increasing temperatures. Non-sustainable environmental practices, migration, and resource shortages, which are common in developing states, may further aggravate states with weak governance.

Therefore, the study of national vulnerability is of great significance to global sustainable development.

2. Assumption

the following basic assumptions are made to simplify the problems:

It is assumed that the data searched from the world bank and the peace fund are accurate and reliable.

The political and economic environment of the country choose is relatively stable.

Human factors cannot interfere with the occurrence and change of climate itself.

Assume that the state is a responsible and powerful sovereign state and the government is willing to provide the basic essentials to its people in the event of a serious climate disaster.

3. The TVM model

3.1 Indicator Selection

In this model, we construct a three-dimensional vector hierarchical model incorporating how to identify whether a state is fragile, vulnerable, or stable. It also measures the degree of deviation from the optimal development direction

To begin with, we logically classify the influence factor of fragility into three distinguishing categories, namely, economic index (EI), social index (SI) and environmental index(ENI) for quantitative analysis.

Economic Indexes (EI) It is consisted of total GDP, total social fixed assets investment, monetary aggregates and other second-class indicator layer factors, characterizing the quality of and the number of economic development in a country.

Social Indexes (SI) It considers medical level, the power consumption, urban population and the remaining four basic factors, mainly reflecting the social development status and predicting the future evolution. In general, it has the standardized data system with scientific quantitative function.

Environmental Indexes (ENI) The indicators are defined as adjustment in natural and human systems in response to actual or projected changes. The detailed vulnerability assessment system is shown in Figure.2

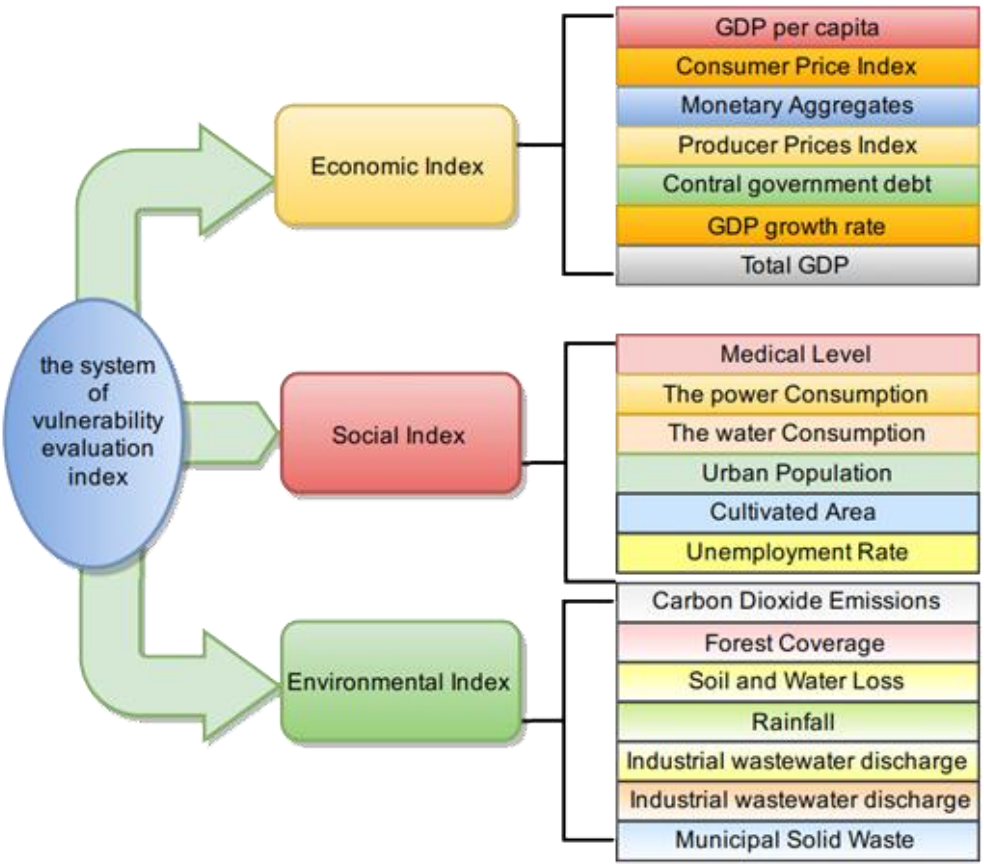

Figure 1National vulnerability index evaluation system

For simplify, we apply Grey Relational Analysis (GRA) to select 9 major indicators from 21 basic influences.

The steps of the grey relational analysis are as follows:

Determine reasonable weights. The corresponding weight of each indicator, defined through utilizing Analytic Hierarchy Process (AHP), is $w=[w_1, w_{2,} \cdots w_n]$,

where

$w_k (k=1,2,3,\cdots,n)$ is the weight of the k indicator;

Let $\xi_i(k)$ denote the gray correlation coefficient, it can be calculated by the following formula:

$$\xi_i(k)=\frac{\min_s \min_t |x_0(t)-x_s(t)|+\rho \max_s \max_t |x_0(t)-x_s(t)|}{|x_0(k)-x_i(k)|+\rho \max_s \max_t |x_0(t)-x_s(t)|} \quad (1)$$

Where

$\rho \in [0,1]$: denotes the identification coefficient, which is proportional to the resolution.

The gray weighted relevance is calculated as

$$r_i=\sum_{k=1}^{n} w_i \xi_i(k) \quad (2)$$

According to the degree of gray-weighted relevance, each evaluation object is sorted to establish the correlation order of evaluation objects. The larger the correlation, the better the evaluation result. After calculation, the correlation degree of each index is shown in the Figure 2,3,4.

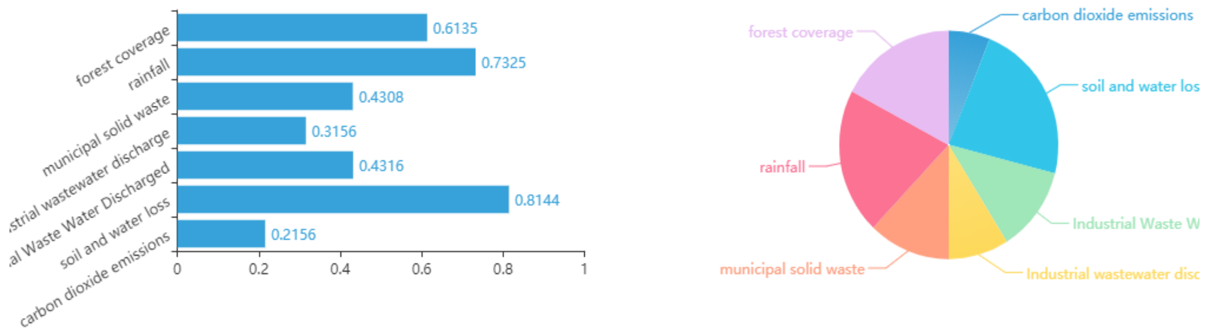

Figure 2 Grey weighted correlation of environmental indicators

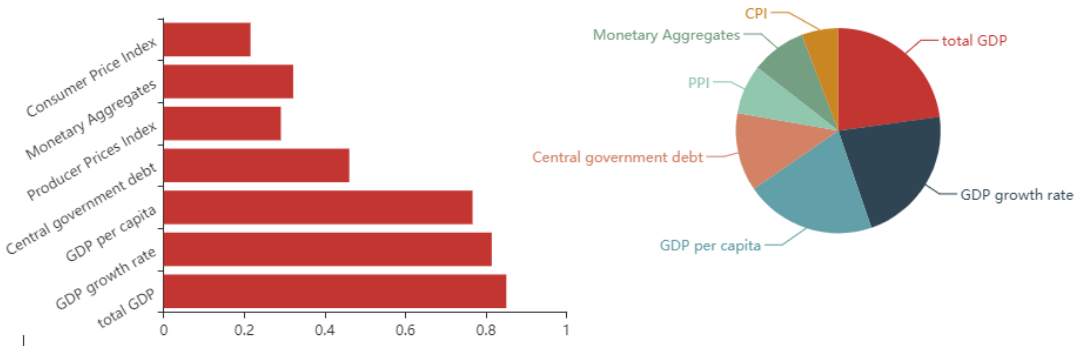

Figure 3 Grey weighted correlation of environmental indicators

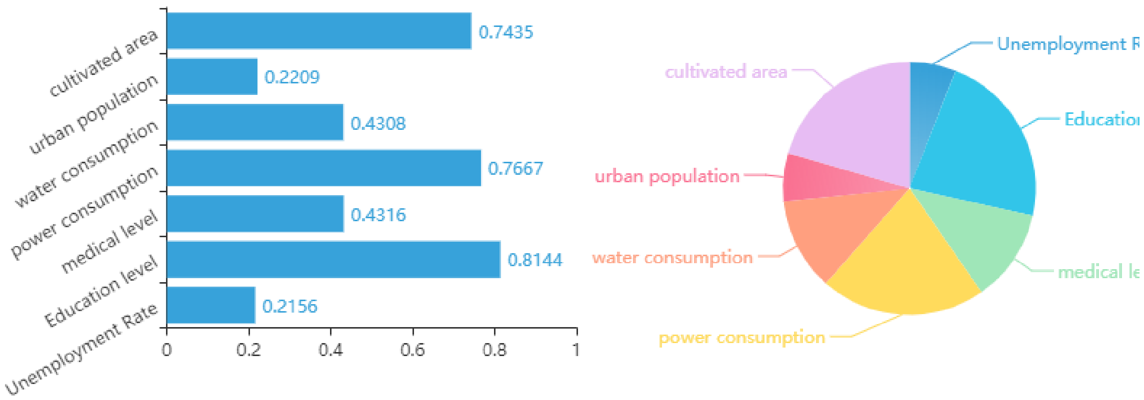

Figure 4 Grey weighted correlation of social indicators

Nine second-class indicators are identified after selecting a set of comprehensive and effective analysis. They are listed in Fig.5

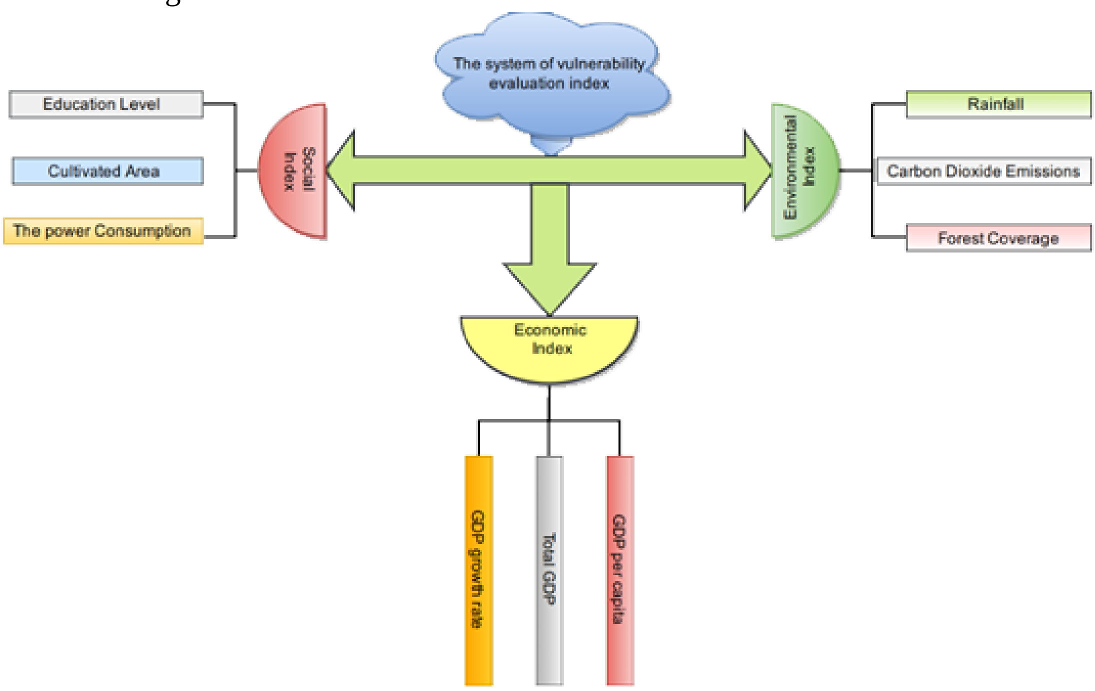

Figure 5Improved national vulnerability index evaluation system

3.2 Quantification of qualitative indicators

3.2.1 Data normalization

Since the dimensions of the 9 indicators are different, the data can't be directly compared. To normalized the data, all the data is converted to number between 0 and 1.

positive indexes:

$$R_{ij} = \frac{x_{ij} - x_{\min}}{x_{\max} - x_{\min}} \tag{3}$$

Negative indicators:

$$R_{ij} = -\frac{(x_{ij} - x_{\max})}{x_{\max} - x_{\min}} \tag{4}$$

where

R_{ij} represents the variable value of x_j after standard treatment,

x_{max} is the maximum value of the j index

$x_{\min}$ is the smallest of the j index

$R_{ij} \in [0,1]$

3.2.2 The mean variance weighting method

$$D_i = \frac{1}{n}\sum_{j=1}^{n} R_{ij} \tag{5}$$

$$\sigma = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(R_{ij} - D_i)^2} \tag{6}$$

$$\omega_i = \sigma_i / \frac{\sigma_i}{\sum_{i=1}^{n}\sigma_i} \tag{7}$$

Where

D_i is the mean of the variable;

σ_i is the mean square deviation of the variable;

ω_i is the weight coefficient.

3.2.3 Determination of index weight

Table 1 Determination of index weight

First-class index	Second-class Index	Weight
Economical	GDP per capita	0.214
	Total GDP	0.254
	GDP growth rate	0.532
Social	Education Level	0.36
	Cultivated Area	0.51
	The power Consumption	0.13
Environmental	Rainfall	0.24
	Carbon Dioxide Emissions	0.46
	Forest Coverage	0.30

3.3 Space Vectorization.

In Model 1, the three aspects mentioned before correspond to each coordinate axis of space rectangular coordinate system respectively from an innovative point of view, which serves as a basis for the total analysis of the vulnerability. To be precise, x-axis represents the EI while y-axis is a symbol of SI and z-axis stands for ENI in a coordinate system.

Next, we define a standard vector delegating when a country is the least fragile and optimal. It points to (1,1,1) from the coordinate origin. Since the projection of standard vector on each axe is 1, we can assume that the state it represents is experiencing the most balanced direction and velocity of development.

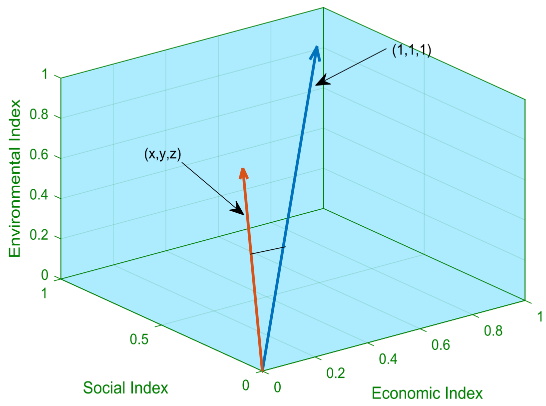

Figure 6 Improved national vulnerability index evaluation system

Then we obtain an arbitrary vector, which coordinate is (x, y, z). By comparing this vector with the standard one, the fragility can be described through two variables.

The angle difference θ :denotes the degree of deviation from the optimal direction.

$|\overrightarrow{OP_i}|$: denotes the rate of decay along the fragile direction.

Emphatically, the less fragile the country is. The greater the modulus value is, the faster the decay towards fragility. The function that measuring the fragility can then be presented by

$$F = 1 - \frac{\alpha \frac{45-\theta}{45} + \frac{|\overrightarrow{OP_i}|}{\sqrt{3}}}{1+\alpha} \tag{8}$$

It should be noted that α is a parameter who depends on the overall power of a particular country.

As for developed nation, 0 < α < 1, because we attach more importance to the decline speed along fragility direction.

As for developing nation , α > 1 , because the direction matters more.

In short， we can adjust the weight according to the actual situation in order to adapt to the different countries. A larger vulnerability index implies a weaker ability for a country to handle the balance between different indicators and external influence, and a harder work for it to solve its safety problem.

3.4 The Interval of The Fragile

Putting a lot of data into our model, we accurately quantified a country's vulnerability, as shown in the figure 7.

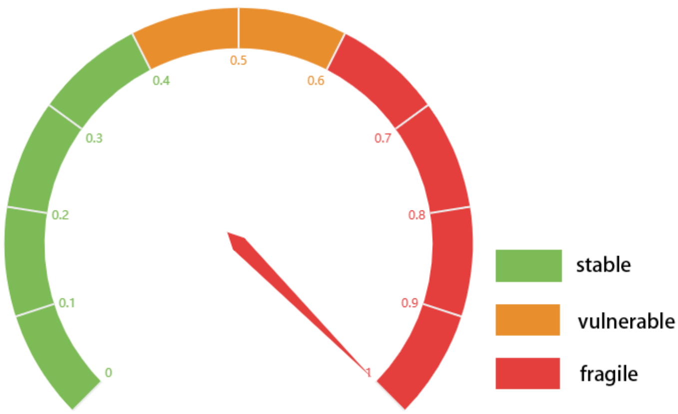

Figure 7 General Metric

4. Conclusion

The level of grade affects the indicators of the three-dimensional vector stratified model. By this means, the impact of climate change on vulnerability can be measured. Furthermore, we select Democratic Republic of the Congo and plug its data into the model. After that, it illustrates that climate change impacts the fragility in an indirect way.

According to this model, the vulnerability of a country can be derived, and the impact of climate change can be measured.It is of great help in solving the problem.

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