

Study on the Relationship between Climate and National Frailty

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Abstract. In consequence of climate change, a country is faced with a series of economic, social and environmental problems. Which has affected the social and government stability in a country. First, in order to evaluate a country's fragility, we established a set of metrics including political economy, resources and society. Using space vector synthesis, we could calculate the score of vulnerability index. According to the principle of Natural fracture classification, finding that $(0,0.37]$, $(0.37,0.69]$, $(0.69,1)$ is divided to stable, fragile and extreme state. Next, we selected Somalia, analyzing its' climate characters: On the one hand, droughts lead to water resources reducing, on the other hand, floods lead to city submerging. Assumption that two situations, including "adequate water resources" and "well-organized government ",compared with the present situation ,we concluded that these effect contributes to less vulnerability. Finally, we studied the adaptability of the model. In terms of a city, our model only needs to be adjusted in certain aspects. For a continent, we use the weighted average of the proportions of the countries in the continents and their vulnerabilities as the state's vulnerability index to improve our model.

Keywords: National Frailty; Economic; Time series analysis; Climate.

1. Introduction

In recent years, the vulnerability of the country has become a research hotspot in western society. It refers to the state of the state or the legitimacy of the weakness, can not meet the basic needs and expectations of the national , unable to resist the internal and external risks in the natural, social, security and other fields. Reducing the vulnerability of a country is conducive to coping with risks, safeguarding economic security and enhancing the effectiveness of cooperation [1].

With the global climate changing steadily, scientists are aware of the notable impact of climatechange, changing human lifestyles, affecting the normal development of society and even leading to the collapse of government structures. For example, climate change leads to an increase in sea level, resulting in a reduction in the country's land area; climate change leads to land desertification, resulting in a reduction of the country's arable land area; climate change causes natural disasters that cause people to be displaced. In conclusion, climate change has a significant effect on the political, economic, social and ecological stability. If a country itself is in a "fragile" state, the impact of climate change on that country will inevitably be unimaginable [3]. Therefore, we will analyze the vulnerability of a country from the three levels of political economy, social status and resources, and then consider the impact of climate on all levels.

2. Evaluation Model of National Vulnerability Measures

2.1 National Vulnerability Measurement Index System

National fragility refers to the ability of the state to resist the interference of internal and external natural and human factors such as resources, politics, economy and social development in the development process. Therefore, this article establishes 17 corresponding indexes and constructs the comprehensive index system of national fragility [4-6].

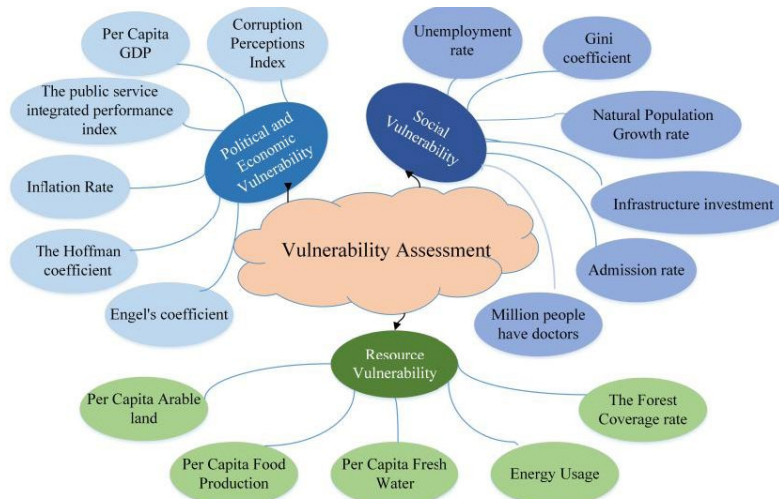


Fig. 1 Vulnerability evaluation index system

2.2 Entropy method to determine the index weight

Entropy is a measure used to describe the degree of systematic disorder[5]. If the degree of systematic order is higher, the smaller the entropy, the smaller its utility value, and vice versa. We define it m as country condition, the first j the entropy of the evaluation index is:

$$H_j = -\left(\sum_{i=1}^m f_{ij} \ln f_{ij}\right) / \ln m, \text{ among them } f_{ij} = \frac{b_{ij}}{\sum_{i=1}^m b_{ij}},$$

Calculate the entropy of evaluation index A:

$$:| A = (a_j)_{1 \times n},$$

$$\text{among them } a_j = \frac{1 - H_j}{n - \sum_{j=1}^n H_j}, \sum_{j=1}^n a_j = 1.$$

The entropy method is used to calculate the above 17 indicators and the weight of 3 indicator layers, and finally the index system of comprehensive urban national measurement is as shown in the following Table 1.

Table 1. National Vulnerability Comprehensive Index System Table

Guidelines	Weights	Indicator layer	Weights
Political and Economic Vulnerability	0.36	Corruption Perceptions Index	0.021
		Per Capita GDP	0.038
		The public service integrated performance index	0.087
		Inflation rate	0.073
		The Hoffman coefficient	0.059
		Engel's coefficient	0.061
Social Vulnerability	0.23	Unemployment rate	0.023
		Gini coefficient	0.047
		Natural Population Growth rate	0.014
		Infrastructure investment	0.008
		Admission rate	0.065
Resource Vulnerability	0.41	Million people have doctors	0.073
		The Forest Coverage rate	0.041
		Energy Usage	0.119
		Per Capita Fresh Water	0.105
		Per Capita Food Production	0.078
		Per Capita Arable land	0.067

The problems in political operation will affect many aspects such as social stability, economic development and ecological balance in a country, which will eventually lead to the overall fragility of the country.

2.3 Calculation of National Vulnerability Index

The calculation of the national vulnerability index is divided into the following steps:

Step1:First of all, the data of the selected indicators are calculated[6]. The indicators are divided into the positive target and the negative target. The larger value of positive target is, the greater the fragility index is; the greater value of negative target is, the smaller the fragility index is.

Step2:The positive target is calculated as follows:

$$x_{ij} = \frac{S_{ij} - S_{i\min}}{S_{i\max} - S_{i\min}}$$

Negative target are calculated as follows:

$$x_{ij} = \frac{S_{i\max} - S_{ij}}{S_{i\max} - S_{i\min}}$$

Then, calculate the gray correlation coefficient:

$$\xi_{ij} = \frac{\Delta_{\min} + \rho\Delta_{\max}}{\Delta_{ij} + \rho\Delta_{\max}}$$

In the formula,

$$\Delta_{ij} = x_{ij} - x_{0j}, \Delta_{\min} = \min_i \min_j \Delta_{ij}, \Delta_{\max} = \max_i \max_j \Delta_{ij}, \text{ In addition, } \rho \in [0,1],$$

Distinguish coefficient takes 0.5 for analysis and calculation. Recalculate the weighted relevance

$$S_i = \sum_{k=1}^n w_k \xi_k$$

Step3: Where, S1 is political and economic instability, S2 is social instability, S3 is resource instability. Finally, calculate the unstable index. In the process of vector synthesis and calculation, the values of different axes are usually vector-combined to obtain the vector modulus. The principle is as follows

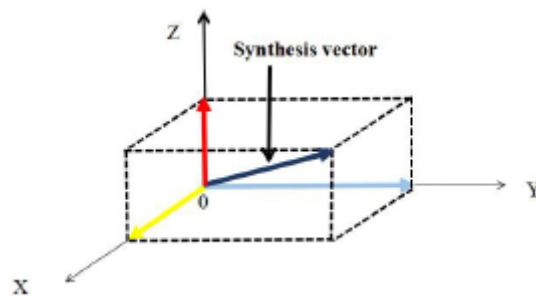


Fig. 2 Vector synthesis schematic diagram

Therefore, we draw lessons from this principle to carry on vector synthesis of economic and political instability S1 , social instability S2 and resource instability S3.

$$|\vec{x}| = \alpha_x S_1 \quad |\vec{y}| = \alpha_y S_2 \quad |\vec{z}| = \alpha_z S_3$$

$$\tilde{G} = \sqrt{(\vec{x})^2 + (\vec{y})^2 + (\vec{z})^2} = \sqrt{(\alpha_x S_1)^2 + (\alpha_y S_2)^2 + (\alpha_z S_3)^2}$$

Assume $S_1 = S_2 = S_3 = 1$, calculate $|G| = \sqrt{(\alpha_x \times 1)^2 + (\alpha_y \times 1)^2 + (\alpha_z \times 1)^2}$

Normalize the national fragility

$$G = \frac{\tilde{G}}{|G|} = \frac{\sqrt{(\alpha_x S_1)^2 + (\alpha_y S_2)^2 + (\alpha_z S_3)^2}}{\sqrt{(\alpha_x)^2 + (\alpha_y)^2 + (\alpha_z)^2}}$$

Where, $G \in [0,1]$. The value of G is the national vulnerability index.

3. Model Based on Automatic Control Theory

When studying a control system, scholars in the field of automatic control generally use control function and control block diagram to represent certain characteristics of the entire system. There is a second-order control system where a signal $R(s)$ is input to the input to react to the entire system and produce a relatively stable output $C(s)$ at the output that fluctuates around a certain value. When an interference signal $N(s)$ is input to the system, the system can constantly adjust the output by feedback to bring it to the initial stability value. However, when the system itself changes, the original output will change accordingly, eventually reaching a new stable value. Therefore, we draw on this principle to establish a systematic model, which shows that a country's vulnerability changes.

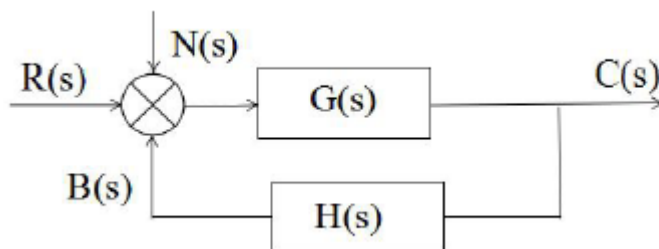


Fig. 3 Control system model

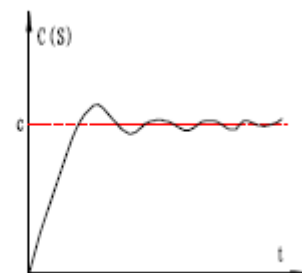


Fig. 4 output function diagram

Here, we learn from this idea, a country as a control system, the control system consists of political and economic functions, social functions, resource functions and the system's own regulatory function. The outside world has an input to it, and once it enters the system, it generates a response and then moves towards a stable near-state vulnerability index. When a country's system changes, its corresponding system function will change, at this time, the input response stability will be a new change.

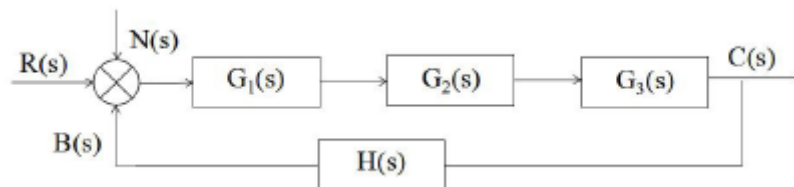


Fig. 5 National Vulnerability System Model Diagram

In Fig.5, $G_1(s)$:Political and Economic Function $G_2(s)$:Social Function $G_3(s)$:Resource Function. Interference from the outside world will produce two situations:

First, the output of the system fluctuates, and gradually returns to the initial stable value through the adjustment of the feedback function $H(s)$.

Second, the system internal function changes, that is, the country through the reform and other measures to change the original characteristics, resulting in a new system function, the output response in the volatility after reaching a new stable value nearby, resulting in a new country fragility index.

4. How Climate Change Can Increase National Vulnerability

4.1 Analysis of the process affected in Somalia

Somalia is among the ten most vulnerable countries. Due to its special geographical location and its vulnerability to climate change, Somalia, in order to more intuitively interpret the impact of the climate, draw the following sketch

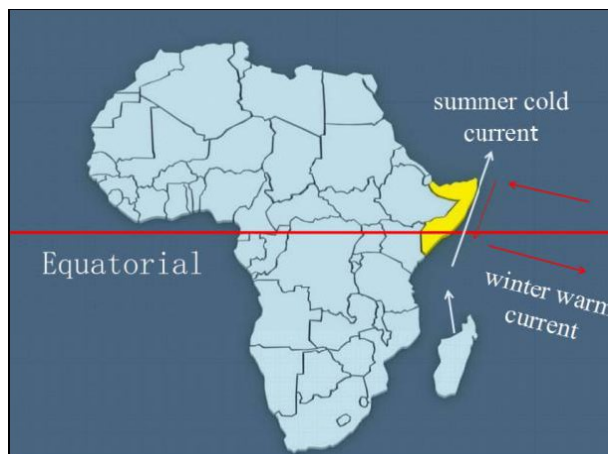


Fig. 6 Schematic diagram of climate change in Somalia

The climate in Somalia is mainly affected by the ocean currents, which under normal circumstances are affected by the cold in the summer and warm in the winter. The increasing La Niña caused by global climate change has changed the current features in the sea area off Somalia, which has changed the original climate of Somalia. Precipitation in some parts of Somalia has been unusually increased, leading to floods; while in other areas, precipitation has been continuously low for many years, causing a drought disaster that aggravates disasters such as land desertification and sandstorms. Then, based on the model established in Task 1, the data related to the indicators from 1989 to 2015 are checked and brought into the model to get the national fragility index of Somalia, and all the data are plotted as an intuitive line chart.

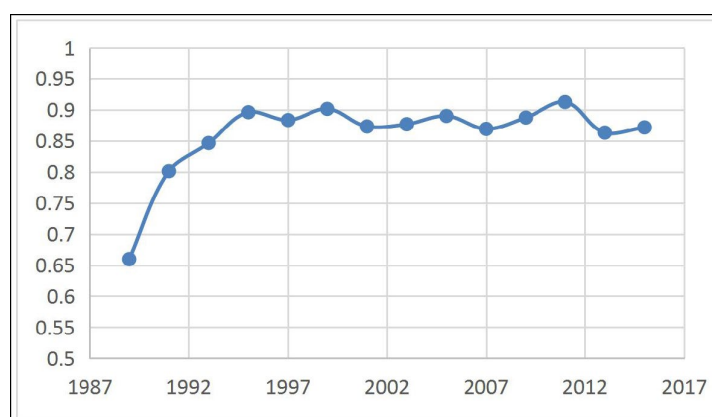


Fig. 7 Somali Vulnerability Index Change Chart

As can be seen from the Figure 7, in 1989, the national fragility of Somalia only belonged to the fragile level, and after 1991, the national fragility index of Somalia rose to above 0.8, and Somalia's country was vulnerable for more than 20 years. The index is fluctuating around 0.85 and is extremely vulnerable. Inquiries: According to the analysis of data, in 1986 civil war broke out in Somalia and the social order gradually began to chaos. In 1991, the Somali presidential regime was overthrown, the civil war continued and social order collapsed, leading to a gradual rise of the National Vulnerability Index.

4.2 The total amount of water resources is declining

Due to the drought in most areas, the most direct impact of climate change on Somalia is the reduction of water resources. The linear relationship between per capita water resources and years can be obtained through multiple regression. As shown below, the impact of water resources on a country is multifaceted, affecting people's basic life and affecting the country's agricultural production and industrial progress. It can be said that the impact is everywhere. All of these aspects

will jointly output an indicator of CO₂ \ emissions. Therefore, we use annual CO₂ \ emissions from Somalia as a measure.

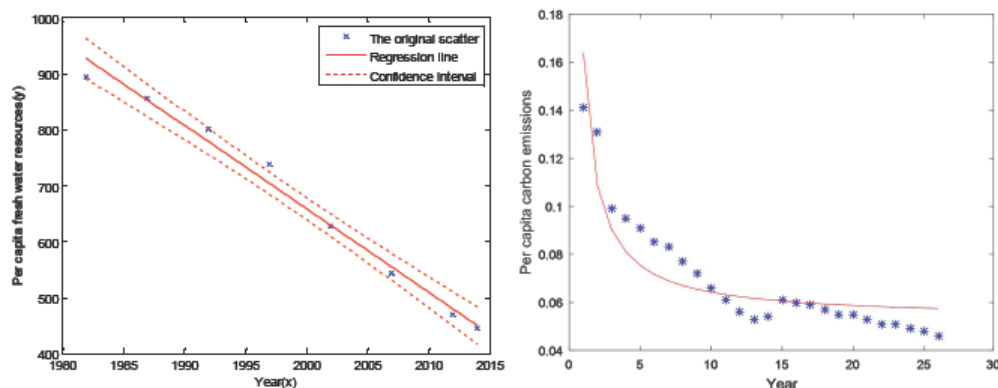


Fig. 8 Per capita water resource change and Per capita carbon dioxide change

As shown in Figure 8, fitting out the average water resource equation:

$$y = -14.901x + 30461$$

Goodness of fit

$$R^2 = 0.926, p = 9.3 \times 10^{-3} < 0.05.$$

The effect of linear fitting is good, and the change of water resources with year is significant. The fitted curve shows that according to this trend, annual per capita water resources in Somalia will be reduced by 14.901 cubic meters. Per capita carbon dioxide emissions curve:

$$y = \frac{0.1106}{x} + 0.0532$$

Carbon dioxide emissions can reflect a country's industrial development and economic level. The emission of carbon dioxide in a developing country under normal circumstances is gradually increasing while that of carbon dioxide emission curve is approximately inversely proportional to the curve, indicating that social development in Somalia has been going backwards in recent decades. It also shows that climate change is significant to the changes of the entire country's vulnerability.

5. Conclusion

Vulnerability index is measured by our model. When the vulnerability index (0,0.37], (0.37,0.69],(0.69,1), respectively, corresponds to three levels of stability, fragility and extreme vulnerability,when climate changes occurring, directly affects the total amount of resources in a country, such as reduced water resources, reduced arable land, etc., indirectly affect social stability, economic development, political stability, the country becomes vulnerable.

For a long time, Somalia was in anarchy. In addition to the total amount of domestic water resources affected by climate change and its total amount of food, the national vulnerability index reached as high as 0.8 and will continue to rise. However, assuming the existence of a government, or assuming no climate change exists, the vulnerability index will be greatly reduced. Singapore is obviously affected by climate change. It not only promotes domestic tourism development and green economy, but also exposes the country to the risk of being inundated. Using the Chow principle of time series, Singapore has its eruption point of 2062.

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