Research on the Impact of Climate Change on State Vulnerability

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Abstract: Climate change can influence regional instability, and the net damage costs of climate change are likely to be significant. Many of these effects will alter people's lifestyle, and may have the potential to cause the weakening and breakdown of social and governmental structures. Consequently, destabilized governments could result in fragile states. In this paper, a series of models are developed to help to solve climate change how influence regional instability.

1. Introduction

Global warming, shrinking glaciers and other global climate changes have happened to us. And these changes also have different local influences because of different regions. Its occurrence may result in natural disaster and deaths in the area. It may also result in the reduction of local grain output and the migration and extinction of plants and animals. The serious situation may lead to crowd riots or government unrest [1]. The combination of these factors will further lead to the country's fragility. Because the effects of climate change may lead to the instability of the country into a fragile country. The Organisation for Economic Cooperation and Development (OECD) defines fragile states as follows: "A state is fragile when it is unable or unwilling to perform the functions necessary for poverty reduction, the promotion of development, protection of the population and the observance of human rights". In other word the state is unable to perform basic functions in the areas of security, rule of law and basic social services.

So we set up a mathematical model to assess whether a country's climate change can remain stable. [2]We have established a mathematical model to measure the impact of climate change by representing indicators such as the annual global average temperature and the global annual average precipitation infiltration recharge volume. These impacts also affect the country's fragility as an influencing factor influencing the indicators of national fragility. In addition, models are used to illustrate which national interventions can mitigate the risk of climate change in order to prevent a country from becoming a "vulnerable country". Explain the effectiveness of human intervention and predict the total cost of intervention in the country.

2. Identify national fragility assessment models

First, we need to find out the determination of Indicators of national fragility. Index 4 based on national economic conditions. Index 1, 5, 6, 7 based on demographic changes and conflict violence [3] in the country. Index 2 and 3 based on country farming, and index 8 based on changes in national animal and plant cover. Define indicators that affect national fragility [4]: Positive factors are negative, negative factors are positive, the larger the assessment index, the greater the country's fragility, which means more fragile. Make the factors that are detrimental to the stability of the country take the positive values, the factors that are conducive to the stability of the country take the opposite value.

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1) The correlation coefficient of mortality take the positive value “+”;
2) Grain yield correlation coefficient take the reverse value “-”;
3) Arable land area correlation coefficient take the reverse value “-”;
4) Per capita GDP correlation coefficient take the reverse value “-”;
5) The average life expectancy correlation coefficient take the reverse value “-”;
6) Population Correlation Coefficient Take the reverse value “-”;
7) Population growth rate correlation coefficient take the reverse value “-”;
8) Forest area correlation coefficient take the reverse value “-”;

Using the global annual average temperature and global annual average rainfall infiltration recharge to express the fragility of climate change. [5]. Since climate change has different impacts on different countries, we should analyze the situation in each country. If the climate change and a factor correlation coefficient is not large, the absolute value of its correlation coefficient is relatively small. How to evaluate the comprehensive fragility index of a country or region caused by climate change?

The evaluation Model 1 is as follows:

$$I = \prod_{i=1}^{n} x_i \quad (1)$$

$$x_i = 1 \pm r_i \quad (2)$$

The parameters in the formulas: *I* indicates the state of the country; *n* indicates these 9 factors; *xi* indicates the value of the fragility affected by the factor *i*-th; *ri* indicates that the influencing factors of climate change and factor *i* , *ri* may be positive or negative.

When *xi* =1, and *ri* = 0, this situation shows that the factor has no effect on the country's fragility. The sign of 1±*ri* is given above. The greater the value of the final national fragility Index *I*, the greater the fragility due to climate change.

Determination of correlation coefficient r is:

$$r = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}} = \frac{l_{XY}}{\sqrt{l_{XX} l_{YY}}} \quad (3)$$

$$l_{XX} = \sum (X - \bar{X})^2 = \sum X^2 - \frac{(\sum X)^2}{n} \quad (4)$$

$$l_{YY} = \sum (Y - \bar{Y})^2 = \sum Y^2 - \frac{(\sum Y)^2}{n} \quad (5)$$

$$l_{XY} = \sum (X - \bar{X})(Y - \bar{Y}) = \sum XY - \frac{(\sum X)(\sum Y)}{n} \quad (6)$$

Since the resulting r values are between (-1,1). In order to prevent the evaluation index after takeover is too small, and does not change the size of the evaluation index, the revised evaluation model is:

$$I = -\log(\prod_{i=1}^{n} x_i) \quad (7)$$

Randomly extrat 10 countries, respectively, Afghanistan, Central African Republic, Democratic Republic of the Congo, Iraq, Sudan, Somalia, China, United States, Australia and India. Bring their respective nine national fragility index data into the optimized model. Taking the global average annual temperature and the global average precipitation infiltration into expression (3) yields can get the results. [6]The state values of 10 countries are directly visualized as shown in Figure1. Combined with the complete Fragile Country Index data for 2006-2017 [6], it is judged that the

country is very fragile, fragile and stable. We propose that the state value is stable between [0,2), [2,4) is weak and [4,6) is very weak. Draw conclusions from the country status value I obtained, it is concluded that AFG,COD and SOM are very fragile. CAF, IRQ, SDN, CHN and IND are fragile, and USA and AUS are stable.

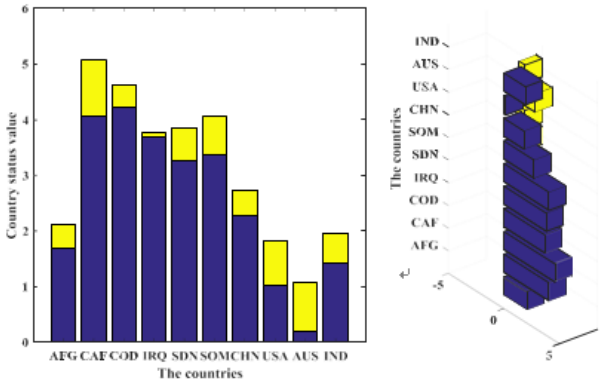
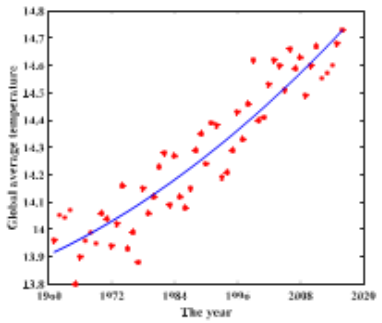
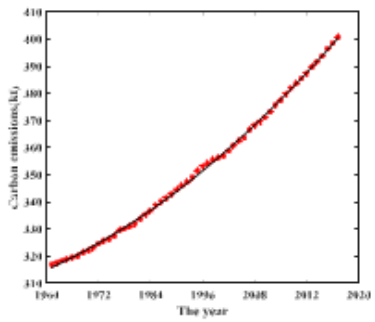


Figure 1: National Vulnerability Assessment Indicators by Climate Change

3. Model of GDP from unit carbon emissions

The most important reason for the change in temperature is the emissions of CO2 [7], whereby the country takes interventions. Using the formula (3) to calculate correlation coefficient of global average GDP, annual temperature, and the emissions of CO2. The result shows r is 0.9387 so the relevance of them is very obvious. Fitting the curves of global temperature change, global GDP change and global emissions of CO2 separately as Figure 2,3,4.





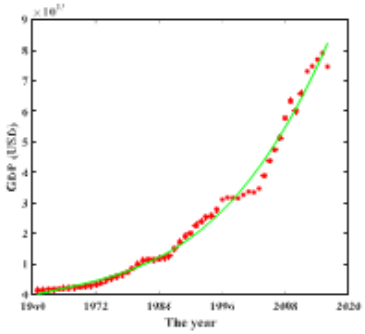
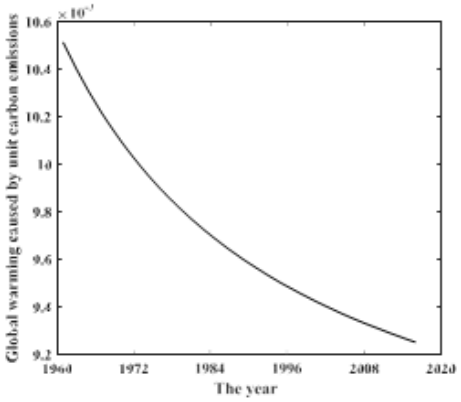


Figure 2: Global temperature trends Figure 3: Global trends in carbon emissions Figure 4: Global GDP trends

Using annual temperature increment and annual increment of carbon emissions to obtain the tendency of global temperature rise caused by the change of unit carbon emissions over time. Fitting out the unit of carbon emissions caused by temperature rise over time as Figure 5.



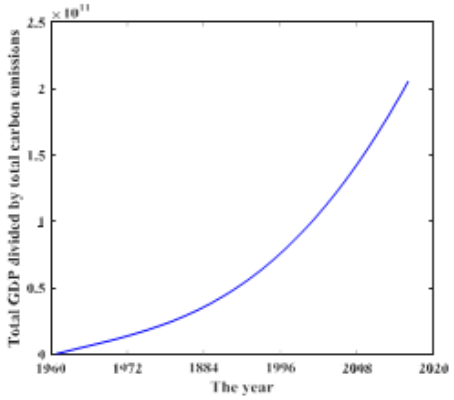


Figure 5: Global warming caused by unit carbon emissions over time

Figure 6: Unit carbon emissions generated GDP trends over time

Using annual carbon emissions and annual GDP increments to calculate GDP over time and fitthe curve of total GDP divided by total carbon emissions over time as Figure 6. From this we can see that GDP has a tendency of growth, which is related to carbon emissions. Ifcarbon emissions cease, the tendency of GDP growth will change.

Assuming no interventions to control carbon emissions, GDP will continue to increase in accordance with the original tendency. Assuming GDP growth is G_1 in the years of ΔN. Assuming that intervention measures are taken to control carbon emissions so that make carbon emissions will stop at the level of 2017. Due to the development of industrial technologies, the GDP will continue to rise produced by unit carbon emissions over time. Similarly, GDP growth is G_2.

Getting the ΔG is:

$$\Delta G = G_2 - G_1 \tag{8}$$

At this point ΔG is equivalent economic cost (non-actual cost) of taking an intervention to control carbon emissions.

Among them, the calculation of G_1 is based on the prediction of GDP over the years, using quadratic polynomial to fit:

$$G(t) = P_1 t^2 + P_2 t + P_3 \tag{9}$$

$$G_1 = G(t_2) - G(t_1) \tag{10}$$

$$\Delta N = t_2 - t_1 \tag{11}$$

Calculating the G2 as follows:

The expression of global carbon emissions change is:

$$f_c(t) = P_{c1} t^2 + P_2 t + P_3 \tag{12}$$

The expression of global GDP growth is:

$$G(t) = P_1 t^2 + P_2 t + P_3 \tag{13}$$

Establish the Model of GDP from unit carbon emissions is:

$$mgc(t) = \frac{G(t)}{f_c(t)} \tag{14}$$

$$G_2 = [mgc(t_2) - mgc(t_1)] \cdot f_c(t_1) \tag{15}$$

$$\Delta G = G_1 - G_2 \tag{16}$$

Selected Sudan as a research object, we bring its data of GDP and CO2 emissions from 1960 to 2017 in Sudan into the Model. Finally, we can get equivalent economic costs (the reduction in Sudan's GDP) from 2018 to 2020 respectively. ΔG=6.416×10^8,1.388×10^9,2.2476×10^9.

4. Conclusion

Based on the analysis of regional stability caused by climate change, a series of models are obtained through mathematical modeling. Select design variables and corresponding optimization algorithms, and use known data to get the factors and indicators affecting national vulnerability and the state of the country. By controlling carbon emissions, countries can mitigate the risk of climate change and predict the total cost of their intervention through models.

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