Study on Regional Instability of Climate Change

Xuanyi Li [a, *]

School of Computer Science and Technology, North China Electric Power University, Baoding 071000, China;

[a]57436746@qq.com

Abstract

The problems caused by climate change are becoming increasingly important in the past few decades. As a result, the Fragile States Index(FSI) assessment model is established to incorporate the impacts of climate change to analyse the fragility of a country was established. Firstly, we establish a fragile evaluation system considering the availability of index of fragile countries. The first step in building the fragile state index is the solution of the qualitative issues of fragile states by means of quantitative. The second step is to select specific indicators under each macro-dimension that form the concept of national vulnerability in order to quantify the fragility. Choosing a secondary indicator should take into account not only the effectiveness of the diagnostic fragility, but also the availability of the data. In view of Carlton University CFIP evaluation system, principal component analysis is employed to obtain 16 second-level indicators and the entropy method and AHP method are utilized to determine the weight. The third stage is to calculate the fragility score of the country subject to measurement. Secondly, we synthesize the standardized data to form a comprehensive fragility index and build the gray prediction model and the regression analysis model to predict a country's fragile time in the FSI system. The correlation analysis can be employed to find the critical point of the environmental impacting vulnerability. The application of the FSI system shows that interventions can be taken to prevent a country from degenerating into a vulnerable country. Finally, some conclusions can be drawn by research. An analysis of the Sudan's vulnerability shows that climate change will make the country more vulnerable. In a study of India, it was discovered that India will become even more fragile by 2050 due to the gradual change in climate. According to the results in Africa and Taizhou, our model is suitable for both countries and cities. Furthermore, the model can be applied to study of the fragility of continents if some index parameters can be well adjusted.

Keywords

FSI AHP climate fragile.

1. Introduction

1.1 Background

Climate change is no longer just a possible future, there is enough evidence that the climate is changing[1]. The global climate is experiencing changes characterized by warming. In the past 50 years climate change is likely to be caused mainly by human activities. Since 1860, as the meteorological instruments have been recorded, the global average temperature rose 0.6 ± 0.2 ℃. Rainfall distribution also changed. Rainfall increased in the continental area, especially in the middle and high latitudes, and decreased in some areas such as Africa[2]. These climate changes have caused a series of irreversible impacts. The sea level is accelerating[3]. The storm has become more violent[4]. People who depend on snow melt have been facing a shortage of water resources during the dry season. 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[5].

The Fragile States Index is based on a conflict assessment framework – known as "CAST" – that was developed by FFP nearly a quarter-century ago for assessing the vulnerability of states to collapse. The Fragile States Index (FSI) is an annual ranking of 178 countries based on the different pressures they face that impact their levels of fragility. The Index is based on The Fund for Peace's proprietary Conflict Assessment System Tool (CAST) analytical approach. Based on comprehensive social science methodology, three primary streams of data — quantitative, qualitative, and expert validation — are triangulated and subjected to critical review to obtain final scores for the FSI[6].

As the concept of vulnerability captures the most prominent impacts of climate change more fully, it plays an irreplaceable role in explaining why the same disasters have very different outcomes in different social-economic contexts[7]. A new model has been established that incorporates the elements of climate change, drawing on the definition of Failed&Fragile states by the Country Indicators for Foreign Policy (CIFP)[8]. Scores are apportioned for every country based on 100 sub-indicators that are the result of years of expert social science research.

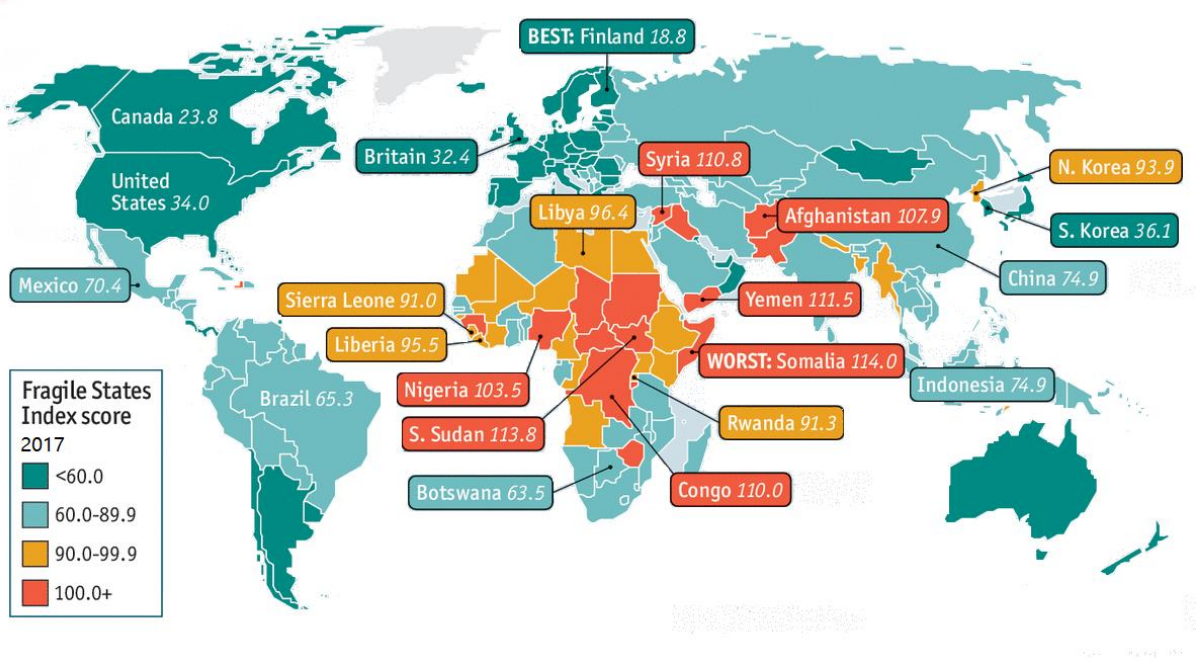

Figure 1. Failed States according to the "Failed States Index", 2017

1.2 Restatement of the Problem

In order to consider how climate change affects the index of weak countries directly or indirectly. We first measure the FSI without climate change and then add the factors of climate change to rebuild the model to get the FSI under this model. Based on this model to answer the following questions:

Build a model to determine whether a country's state is vulnerable, relatively fragile or stable. It also identifies how climate change can increase vulnerability through direct or indirect means.

Select one of the top 10 most fragile states to determine how climate change can increase the country's vulnerability. Use well-established models to show how to reduce the country's vulnerability.

Using models to measure the vulnerability of a country that is not in the top 10 lists how climate change can make it more vulnerable. Define a tipping point and predict when the country will reach the tipping point.

Use models to show which state of intervention prevents a country from becoming vulnerable. Explain the effect of human intervention and predict the total cost of intervention for this country.

Will your model work on smaller "states" (such as cities) or larger "states" (such as continents)? If not, how would you modify your model?

1.3 Overview of our work

In this paper, Principal component analysis (PCA)is employed to determine the main primary indicators, using entropy value method and hierarchical analysis method to determine the weights. Sudan is elected as a top 10 within the research object to research on the link of effects of climate change and the impact of the country's fragility.India is choosed as ten outside the research object, through the limit approximation method to find the tipping point, and using the interpolation method and grey forecasting method to predict the time that India starts to become fragile.

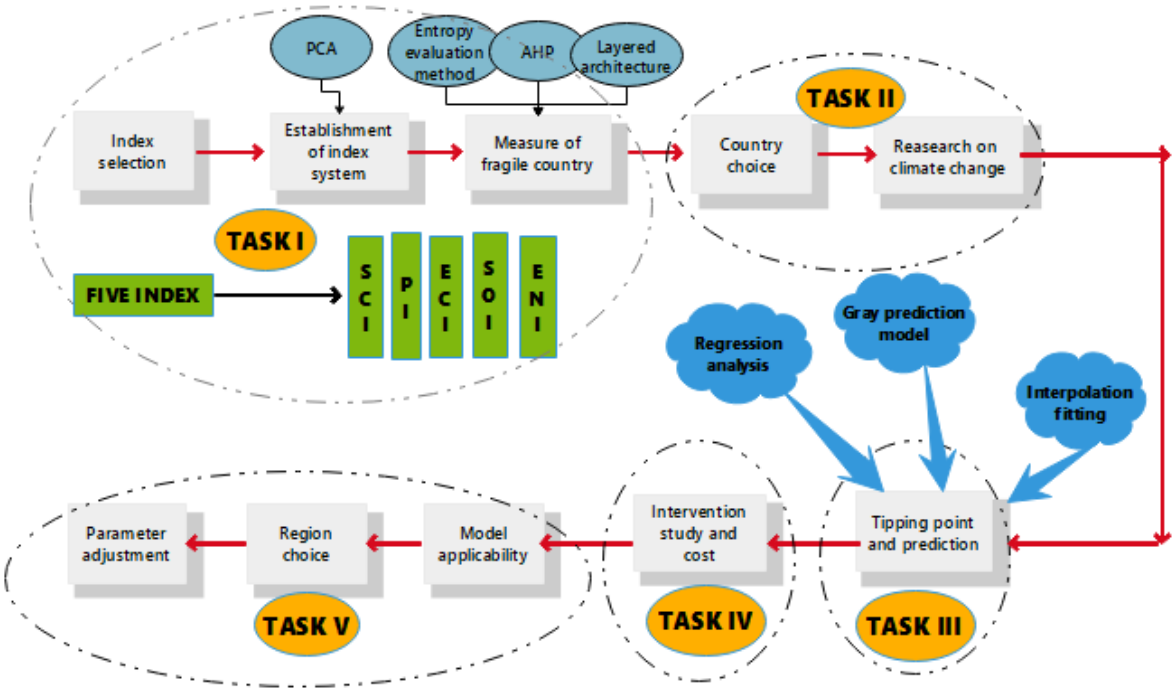

Figure 2. The flow chart in this paper

2. General Assumptions and Justifications

To simplify the problem, we have the following basic assumptions， which are properly justified.

It is assumed that all the analysis factors in the model are comprehensive;

It is assumed that the main contributor to climate change is CO2 emissions, the cost of intervention in climate change is largely borne by GDP.

It is assumed that the proximity setting is based on the adjacent vulnerability status.

It is assumed that the hierarchy of evaluation system is well structured and each weight is set reasonably, it can be applied to most countries.

It is assumed that the statistics we collected from the website are reliable and accurate.The data utilized in our models is mainly collected from valid statistics websites, such as the Word Bank[9], Global Fire Power[10], Global Terrorism Database[11]. Thus, this assumption is reasonable.

3. Variable Description

Variables	Descriptions
RP	Refugees Produced
TNI	Terrorism – Number of Incidents
MS	Military Strength
GE	Government Effectiveness
CPI	Level of Corruption
CPIA	Country Policy and Institutional Assessment
GPC	Economic Size – Relative – GDP per capita
EDPG	External Debt – Percentage of GNI
GDP	Economic Size – Total – GDP
GINI	Gender Inequality
UE	Unemployment – Total
EPEI	Education – Primary Enrolment – Total
ISFP	Improved Sanitation Facilities
PCE	Pollution – CO2 Emissions per capita
FAL	Forest area (% of land area)
CRI	Climate Risk Index
SCI	Security Index
PI	Politics Index
ECI	Economy Index
SOI	Society Index
ENI	Environment Index
FSI	Fragile State Index

4. The Establishment Of Model

In this chapter, we developed a model to determine the Fragile state index of a country, after which we updated this model to measure FSI without climate change.[13] Observe how climate change affects FSI. The data obtained from the model is compared with the data of THE FUND FOR PEACE to verify whether the model is reasonable.

4.1 The FSI System

Formulating a national vulnerability concept is the so-called "use components of necessary and as little as possible to describe the concept, determine the concept of logic,and avoid excess concept or merged".The first involves what is fragile states the basic concept, vulnerability is an abstract concept, the concept of vulnerability must be divided into two categories of specific .Dimensions - functional

dimensions and structural dimension. Fragile states is validity and legitimacy in both that fragile countries are all at risk of failure. The most systems based on vulnerable countries (such as the CFIP of carleton university,the FSI of Fund for peace) based on the structural dimension, the measurement of fragility from five aspects: security, politics, economy, society and environment.Based on carleton university CFIP assessment system[14], Considering the effects of climate change, the following model is built, as the figure 3:

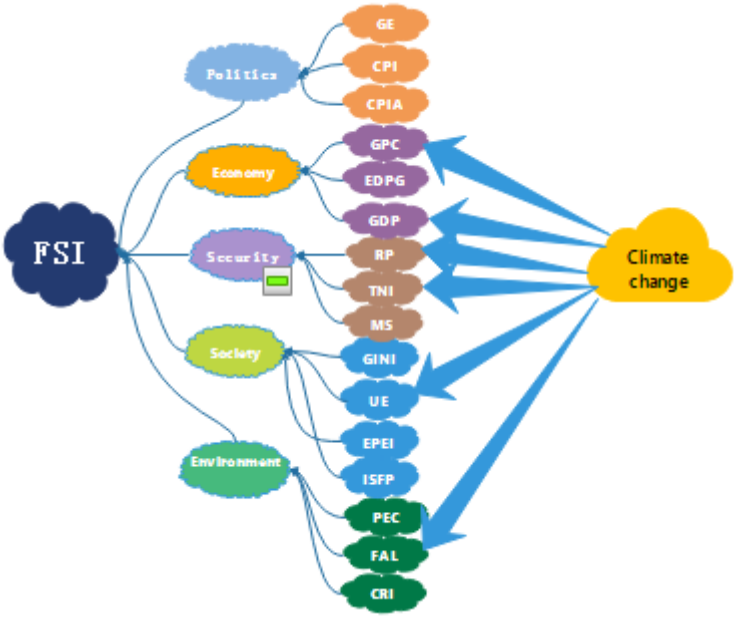

Figure 3. The structure FSI system

4.2 The set of weight

4.2.1 Weighting model based on AHP

To determine the weight of the first-level indicator, we used the Analytic Hierarchy Process (AHP) for weighting.According to data, expert opinion, system analyst's experience and other indicators, it will generate a judgment matrix as the following

$$\begin{array}{c} \\ C1 \\ C2 \\ C3 \\ C4 \\ C5 \end{array} \begin{array}{c} \begin{array}{ccccc} C1 & C2 & C3 & C4 & C5 \end{array} \\ \begin{pmatrix} 1 & 1 & 1/2 & 2 & 2 \\ 1 & 1 & 1/2 & 2 & 2 \\ 2 & 2 & 1 & 3 & 3 \\ 1/2 & 1/2 & 1/3 & 1 & 1 \\ 1/2 & 1/2 & 1/3 & 1 & 1 \end{pmatrix} \end{array}$$

Then we calculate the weight and conduct consistency test. As shown in the formula (1) ~(3)

$$CI = \frac{\lambda_{\max - n}}{n-1} \tag{1}$$

Through the consistency test, the consistency index value which should tend to zero.

$$RI = \frac{\sum_{i=1}^{m} C_i}{m} \tag{2}$$

Where RI is Average random consistency index, its value is usually determined by the order of the comparison matrix.

$$CR = \frac{CI}{RI} \tag{3}$$

We calculated the consistency ratio , When n=1,...,20 ,the value of RI is given as 0(1), 0(2), 0.52(3), 0.89(4), 1.12(5).... 1.63(19),1.64(20) ,where the numbers in brackets indicate n .

4.2.2 The entropy evaluation method

This formula is used to non-negate the data. Avoid making logarithmically meaningless when seeking entropy, Data needs to be panned:

$$r_{ij} = \frac{x_{ij} - x_i^{\min}}{x_i^{\max} - x_i^{\min}} + 1 \tag{4}$$

The formula is to deal with the bigger the better indicator.

$$r_{ij} = \frac{x_i^{\max} - x_{ij}}{x_i^{\max} - x_i^{\min}} + 1 \tag{5}$$

The formula is to deal with the smaller the better indicator.

$$k = (\ln n)^{-1},\ f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} \tag{6}$$

$$H_i = -k \sum_{j=1}^{n} f_{ij} \ln f_{ij} \tag{7}$$

$$w_i = \frac{1 - H_i}{m - \sum_{i=1}^{m} H_i} \tag{8}$$

Where:

R_{ij} is the non-negative processed data.

X_i is the first to have the most data in the evaluation index.

$X_i(\min)$ is the last to have the most data in the evaluation index.

F_{ij} is the i-th indicator accounts for the proportion of the indicator in j programs.

H_i is the entropy of the i-th evaluation index output.

W_i is the proportion of the i-th indicator in all the indicators.

Second-class indicator(weight)	Primary indicator (weight)
SCI (20. 62%)	RP (29. 66%) TNI (34. 56%) MS (35. 78%)
PI (20. 63%)	GE (39. 24%) CPI (32. 32%) CPIA (28. 44%)
ECI (36. 89%)	GPC (32. 62%) EDPG (29. 58%) GDP (37. 8%)
SOI (10. 93%)	GINI (24. 37%) UE (32. 88%) EPEI (21. 82%) ISFP (20. 93%)
ENI (10. 93%)	PCE (35. 64%) FAL (32. 77%) CRI (31. 59%)

Figure 4. The ultimate weight of all indicators

4.3 The assessment system of FSI

We determine each of the FSI indicators to determine their best state and the worst state, and then use the five-point method to score the indicators, and finally based on the FSI model to get the final FSI score, the same five-point method FSI for the visual description, as shown below:

Figure 5. The same five-point method FSI

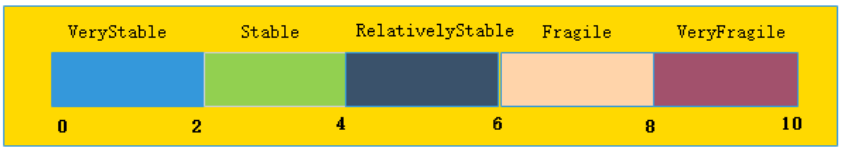

Figure 6. The Standard of Fragile State Index

5. The Application Of Model

5.1 Example of Sudan

5.1.1 The national conditions of Sudan

Sudan is located in the northeast of Africa, along the red sea coast and the eastern end of the Sahara desert. With an area of 1886,068 square kilometers, it is the third largest country in Africa and the 15th largest country in the world. Sudan lies between 9 degrees north latitude and the tropic of cancer. The whole country is directly exposed to the sun. It is one of the hottest countries in the world, and the drought and heat are the basic features of the climate in this country. Sudan is vast, and the temperature varies widely between north and south. The country can be divided into two climate zones: southern hot rainy in summer and winter warm, dry savannah climate zone, the north is the high temperature and less rain tropical desert climate zone, the climate is dry, more than the sand. Sudan is one of the least developed countries in the world declared by the United Nations. Sudan has a single economic structure, mainly agricultural and animal husbandry, backward industry, weak foundation and strong dependence on nature and foreign aid.

5.1.2 The data of Sudan

The data of Sudan with the help of the world bank,some data about Sudan the research needs can be used,as the Tab1:

Table 1. The data of India the FSI requires

RP	TNI	MS	GE	CPI	CPIA	GPC	EDPG
197823	1018	0.1593	57.21	36	3.5	6583.4	20.4

GDP	GINI	UE	EPEI	ISFP	PCE	FAL	CRI
2264000	35.2	3.6	108.6	39.6	1.73	23.77	18.33

5.1.3 The effect of climate change on the FSI system

To research on the effect of climate change on the model,firstly, the FSI system was established with the influence of climate change factors (direct and indirect impacts) and then the FSI system without climate change factors was finished.so as to obtain the following figure.

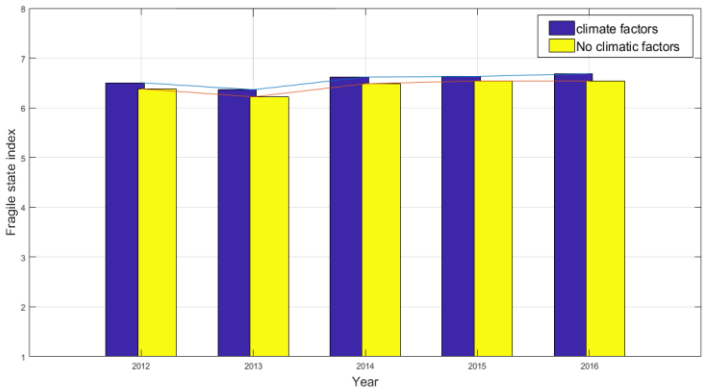

Figure 7. The Impact of Climate Change on FSI

5.1.4 The intervetions to avoid fragility

Since the conditions in each country and the dominant factors affecting each country are different,It is necessary to be made aware of the situation it faces to intervene appropriately,Taking Sudan as an instance, the following picture[14] shows some of the main causes of fragility in Sudan.

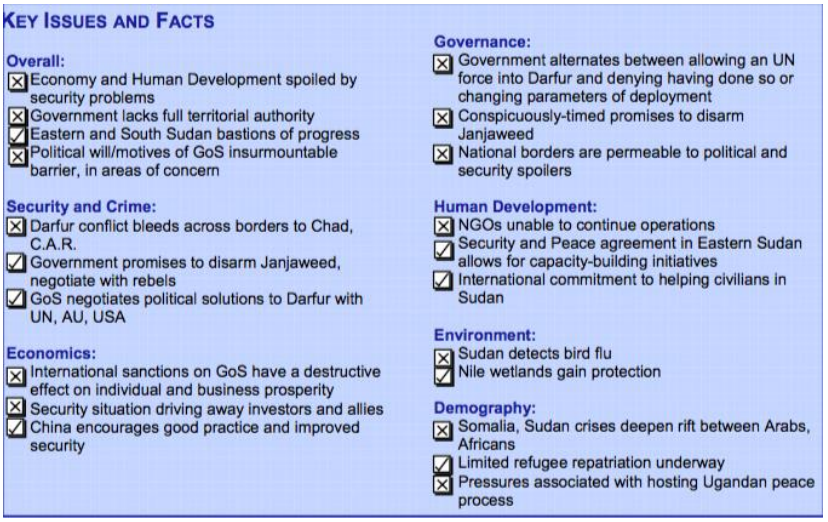

Figure 8. The major indicators result in fragility in Sudan

In response to the status quo in Sudan, intervention is carried out targetedly from five aspects of Sudan so as to improve its fragility.

Security & Crime	Border support in coordination with Chad, C.A.R. or Uganda would enhance regional security DDR programs for ex-fighters in the East and near Eritrea and Ethiopia Programs focused on children affected by conflict
Economics	Community-based poverty reduction in rural areas and urban slums, with attention to women and girls
Governmance	Strengthening local level government by providing resources and training
Society	Basic education and literacy can help rehabilitate children affected by conflict and serve to support Sudan's MDGs
Demography	Job-training for new urban arrivals to reduce unemployment in slums 6. Support to indigenous peacebuilding and diversity programming

Figure 9. Intervetions in Sudan

5.2 Example Of India

5.2.1 The national conditions of India

India is located in South Asia and is the largest country in the subcontinent. India is the second most populous country in the world and one of the brics countries. India is one of the fastest growing countries in the world, with impressive economic growth. Measured by the same purchasing power, India's GDP in 2011 was $4.457 trillion, ranking third in the world with Japan, behind only the United States and China. India's economy is diversified, covering agriculture, handicrafts, textiles and services. Two-thirds of India's population, still directly or indirectly dependent on agriculture, has grown rapidly in recent years and has become the world's leading exporter of software, finance and other services. India is a developing country with extremely unbalanced social wealth distribution,

and the caste system is more acute. Military power ranks fourth in the world. In 2007, India's literacy rate reached 75 percent, but adult illiteracy still topped 300 million, the highest in the world.

5.2.2 The data of India

with the help of the world bank,some data related with India the research needs can be used,as the Tab.2:

Table 2. The data of India the FSI requires

RP	TNI	MS	GE	CPI	CPIA	GPC	EDPG
421454	168	3.6761	7.21	11	2.5	4730.3	24.3

GDP	GINI	UE	EPEI	ISFP	PCE	FAL	CRI
95584.38	35.4	13.3	66.6	23.6	0.309	8.08	38.5

5.2.3 The determination of the tipping point in the FSI

First of all, the relationship between climate change and FSI indicators is looked for by gray relational degree, and the index with larger correlation degree is selected for regression fitting, and the correlation coefficient of each index is obtained. The determination of the threshold of fragility translates into the search for the critical point of climate change. This gives the following plot,as the fig.10:

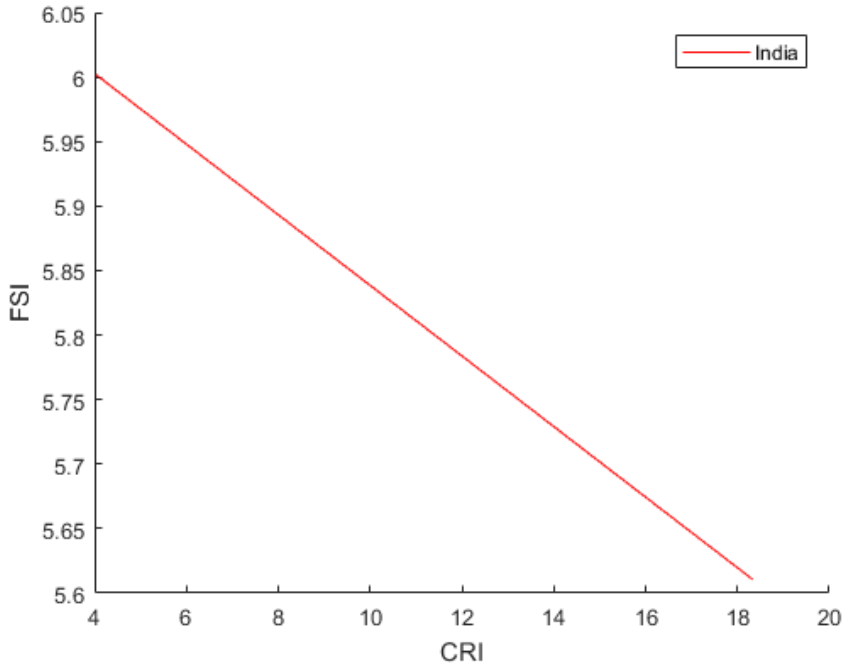

Figure 10. Impact of Climate Change on FSI in India

5.2.4 The forecast of India becoming fragile in the FSI

The first data interpolation, the use of gray predictive model of climate over time changes in the value of forecasting, resulting in the following climate change prediction chart：

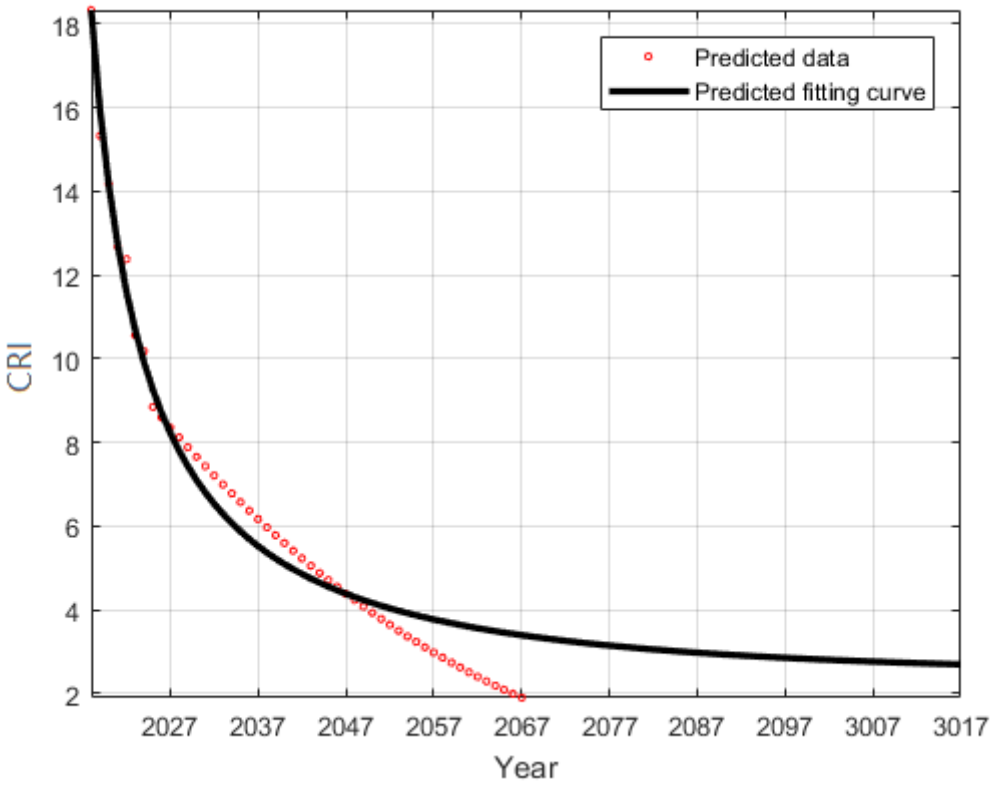

Figure 11. Climate Risk Index forecast trend chart

Based on the analysis of the above two figures, we can get that India's critical point of over-vulnerability is when the climate change risk index is 4.037 and India will become vulnerable around 2050.

6. Model development

We selected the more developed Taizhou in Africa with more countries and the northeastern China coast to test the applicability of our FSI model. Since the criteria we used to construct the model are judged on the basis of the country's information, this assessment is for larger continents and smaller cities than the country. We adjusted the FSI model after adjusting for GDP, GDP per capita and other factors. FSI judgments were made to Africa and Taizhou using the two models, respectively, and the data as shown in the following figure was obtained.

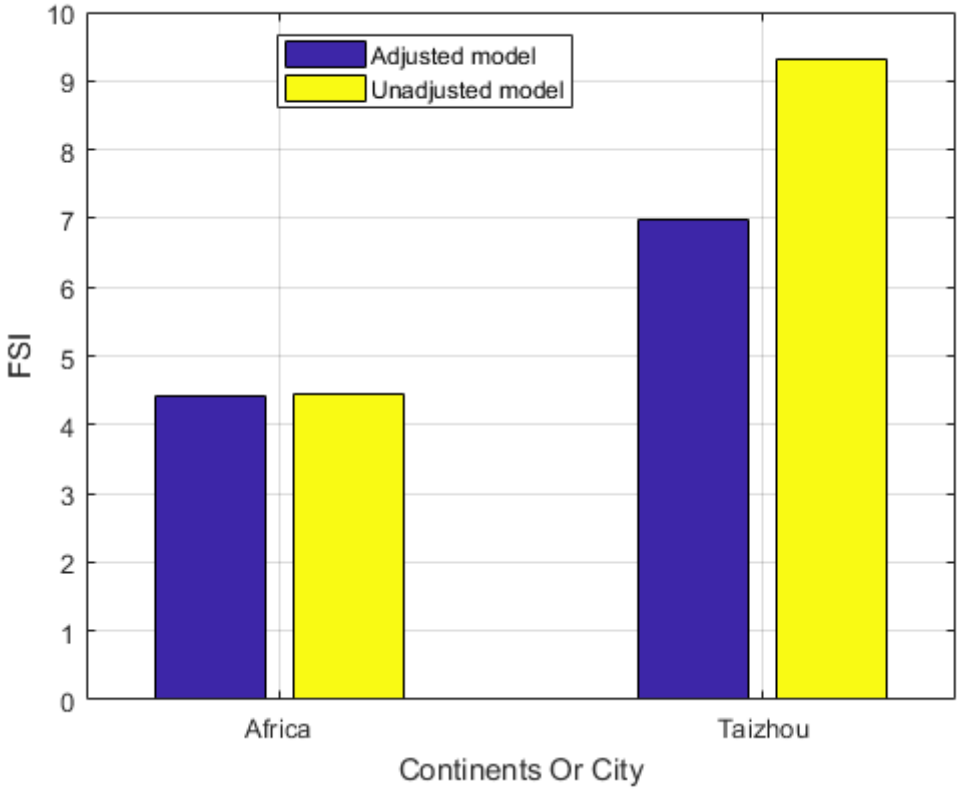

Figure 12. Model Adaptability Verification

As can be seen from the data in the figure, the original FSI model has a good adaptability to the country and the city, but the FSI assessment on the continent is ineffective. The new model obtained by adjusting the indicators such as the GDP, GDP per capita and the number of refugees in the original model is very good Good adaptability.

7. Sensitivity analysis

In this section, we make the sensitivity analysis about the weight , which is based on our model. The sensitivity analysis of five country is shown as fellows in fig.10. It can be seen from the figure that the change of weight has a greater impact on the FSI in various countries, but we can see that our model is more stable.

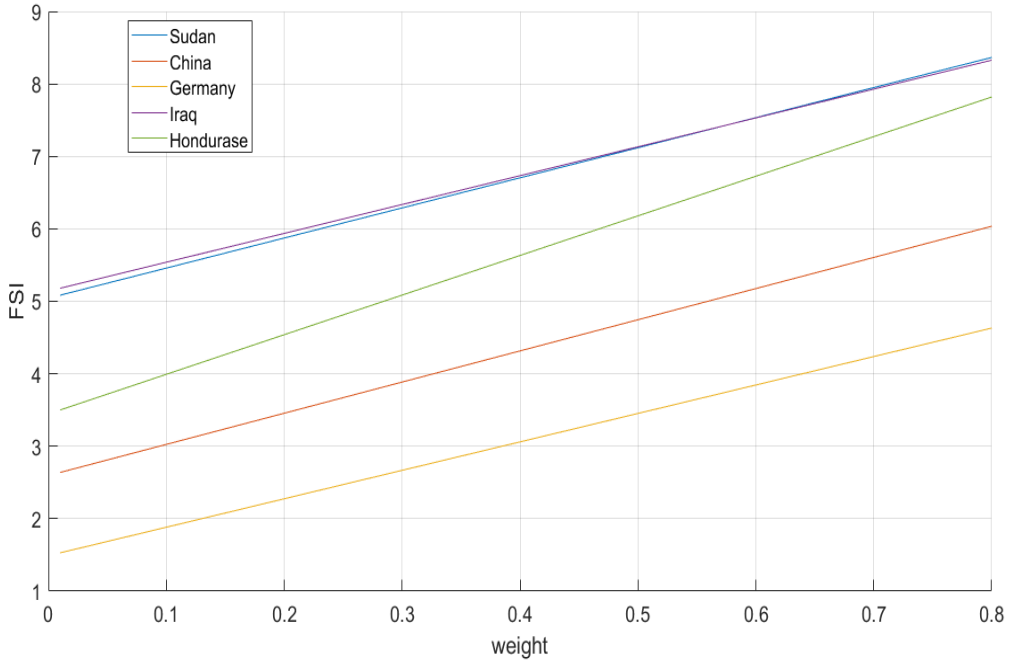

Figure 13. Influence of Weight Setting on Evaluation System

8. Evaluation of the model

8.1 Strengths

Adopt objective weighting method (entropy weight method) and the subjective (group decision making method). More effective weights are obtained.

This paper uses a better five-segment scoring model to make the assessment of vulnerability more reasonable.

8.2 Weaknesses

Although we have try our best. Time is finite, and some data are missed. As a result, the missing data can still bring the errors in evaluation.

Some of the parameters are based on common sense because few data are available.

9. Conclusion

The assessment of Sudan and India by the FSI model shows that:

Climate changes will make a country more vulnerable

If there is no interference with climate change, it may make the country more vulnerable

Appropriate interventions on climate change can effectively reduce the impact of climate change on vulnerability.

References

[1] Marcia McNutt, Climate intervention: The possible impact on global security and resilience.
[2] Qin Daohe, Climate change sciences into the 21st century: Facts, impact and strategies addressing climate change.
[3] Hay CC, Morrow E, Kopp RE, Mitrovica JX. Probabilistic reanalysis of twentieth- century sea-level rise. Nature 2015;517(7535):481-4.
[4] Marvel K, Bonfils C. Identifying external influences on global precipitation. Proc Nat Acad Sci 2013;110(48):19301-6.
[5] 2018_ICM_Problem_E.pdf Retrieved from: http://www.comap.com/undergraduate/contests/mcm/contests/2018/problems/

[6] Fragile States Index and CAST Framework Methodology. Retrieved from: http://f undforpeace. org/fsi/2017/05/13/fragile-states-index-and-cast-framework-methodology/
[7] Zhangqian, Social Vulnerability and Poverty under the Impact of Climate Change: Review of Foreign Studies, Vol.31,NO.2,2014.
[8] Country Indicators for Foreign Policy (CIFP) Retrieved from: https://carleton. ca/cifp/failed-fragile-states/indicator-descriptions/
[9] World Bank Open Data. Retrieved from: https://data.worldbank.org/
[10] 2017 Military Strength Ranking. Retrieved from:https:// www.global firepower. com/ countries-listing.asp
[11] Global Terrorism Database (GTD). Retrieved from: http://www. start.umd. edu/data-tools/global- terrorism-database-gtd
[12] Zhang Lingying. A Fuzzy Evaluation method for Subjective Index Appraisal[J]. Systems Engineering Theory & Practice.
[13] Liu Tianxu and Wu Tao，Evaluation criteria for vulnerable countries, Theoretical discussion 2016.04
[14] Country Indicators for Foreign Policy (CIFP),Fragile state policy report 4:Sudan,2017 Retrieved from: https://carleton.ca/cifp/failed-fragile-states/indicator-descriptions/