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T1 ________________	**73662**	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**E**	F4 ________________

2018
MCM/ICM
Summary Sheet

Fragile state index with climate change considered

First, we develop a model that can assess a country's vulnerability, and measure the impacts of climate change on vulnerability, which means that we have introduced a new variable called Adjusted Fragile States Index(AFSI). Based on the 12 factor factors, we consider the four factors of "Ratio of Forest Area(RFA)", "Carbon Dioxide Emissions Per Capita(CDEPC)", "Annual Mean Temperature(AMT)" and "Annual precipitation(AP)" as the main factors influencing the climate change. Through a large amount of data analysis, we draw a conclusion that RFA, CDEPC and AP are the direct impact factors and AP is the indirect impact factor. At the same time, we set the threshold to determine a country is fragile, vulnerable or stable.

Then, we use the model to analyze one of the top 10 fragile countries, Chad. Based on the data obtained, we find that when the RFA and the CDEPC decrease, the AP and the AMT increase, the Chad's AFSI increases. Moreover, we also use the model to analyze Brazil, which the fragile state index is not in the top 10. Through regression, we analyze four factors related to time and climate change, as well as twelve factors of fragile state index. Then, we use the coefficient of concordance in the goodness-of-fit test. When the statistic(R^2) is closer to 1, the goodness of fit of the model is higher, leading to a decisive variable. By the model calculation, we find the decisive variables that affect the AFSI in Brazil are CDEPC, RFA, External Disturbances(ED), and Human Flight and Brain drain(E_3). And we concluded that, in 2020, Brazil will enter a more stable state of vulnerability (Stable). In other words, Brazil is to enter another critical state.

Next, we put forward corresponding intervention measures from mitigation of climate change and adaptation to climate change, mitigating the country's risk of coping with climate change and preventing it from becoming a "fragile country". And we think that when the marginal cost of intervention is equal to the marginal benefit, the benefit of intervention is the largest, that is to say, it has the highest positive externalities. In countries with higher AFSI, the total cost of their interventions will be higher but not exceed their total cost of economic development.

What's more, we think our model can calculate the factor scores of the continents by a weighted average of sixteen factors in the country to get the AFSI of the continent. However, forecasting the small regions, we find that the sixteen factors at the national level are not well transformed into local indicators, leading to the model not working properly. Therefore, we propose to amend the proposal by transforming the national level factors into the more representative factors at the urban level, thus improving the application of our model.

Finally, we use the sensitivity analysis, finding that our model has a strong fault tolerance in the case of a small range of factors variation error. Simultaneously, we also suggest focusing on the stability of C_2(Factionalized Elites), P_1(State Legitimacy),P_3(Human Rights), S_2(Refugees and IDPs), because changes of these four factors will have a greater impact on the AFSI.

Keywords:
Adjusted Fragile States Index   Principal Component Analysis   Linear regression

Contents

1 Introduction

1.1 Background

Nowadays, the climate change in the world is aggravating day by day, global warming, sea level rise, drought increase and extreme weather increase. And climate change has profound and significant effects . These effects will change human lifestyles and potential lead to the breakdown and collapse of social and government structures. Consequently, destabilized governments could result in fragile states.

Recently, over 400 million people live in drier, subtropical, often densely populated and economically poor regions. As the glaciers melt, the sea level rises and the intensity of the waves increases as the sea level in winter declines, damaging the coastal cities. From 2007 to 2017, key agricultural areas throughout Europe and North America lasted a decade of droughts. With the persistent reduction of precipitation in these areas, lakes dry-up, river flow decreases, and fresh water supply is squeezed, overwhelming available conservation options and depleting fresh water reserves.Climate change has led to a shortage of resources. At the same time, exacerbating violent conflicts and resource competition among nations increase the vulnerability of nations.

1.2 Restatement of the Problem

We need to conduct a quantitative analysis of fragile states index in combination with climate change. Besides, we need to know whether climate change is an indirect or direct impact on national vulnerability. Moreover, we need to analyze the mechanism of climate change if it affects national vulnerability. Not only that, it is also necessary to select a country outside the top ten countries on the list to conduct an in-depth analysis.Then, identifying a new critical indicator to determine whether which level of vulnerability the country is and determine the determinants. Following this, we still need a proposal to reduce the country's vulnerability and analyze the forecast costs. Finally, applicability analysis of the model outside the country level is carried out.

In order to solve these problems, we will solve these problems like this:

- Establish a model to determine the relationship between relevant factors and time, the relationship between AFSI and time,the relationship betwee AFSI and factors.
- Give the corresponding strategy of intervention measures in different conditions,and analyse the cost.

In our model, we first make a linear regression model and use principal component analysis to determine the linear equation of the fragile states index and each factor. Not only that, we distinguish the direct and indirect factors of climate change to analyze changes in fragile states index.

After confirming the above relationships, we use Brazil as an example to analyze the decisive variables of fragile states index and the future vulnerability of Brazil with the goodness-of-fit test, and quantify the exact time point for Brazil to enter the next level of stability(stable). In addition, we use some restrictions to determine the cost of interventions. In order to expand the scope of the model, the optimization and design ideas for the model are proposed.

2 Assumptions and Justifications

- **The specific climate indicators on the continent are only determined by the national area of the country and the climatic index of the country made up** Because taking all the factors concering to the relationship between country to continent into consideration is not practical at all.
- **We can completely replace the benefits of 16 elements by two sets of substitution variables out of Principal Component Analysis(PCA).** As a matter of fact, each factor has a direct and indirect effect on vulnerability, and when we judge indirect or direct indicators, we distinguish the concept of relative size.
- **All costs need to be considered the marginal effect.** Because when the marginal cost equals the marginal revenue, the positive externalities of the interventions are the largest.
- **It is assumed that the national annual average climatic factor can be used to represent the country's climate conditions for that year.**Based on reliable data, we calculated the average of the country's 10-year climatic factors to represent the country's climatic conditions.
- **Climate change is totally determined by four factors, including RFA, CDEPC, AP and AMT.** Because of the many factors influencing the climate change, we can not analyze all of them. Therefore, we select four typical variables.

3 Notation

Abbreviation	Description
AFSI	Adjusted Fragile States Index
C_1	security Apparatus
C_2	Factionalized Elites
C_3	Group Grievance
E_1	Economy
E_2	Economic Inequality
E_3	Human Flight and Brain drain
P_1	State Legitimacy
P_2	Public Services
P_3	Human Rights
S_1	Demographic Pressures
S_2	Refugees and IDPs
X_1	External Intervention
RFA	Ratio of Forest Area
CDEPC	Carbon Dioxide Emissions Per Capita
AP	Annual precipitation
AMT	Annual Mean Temperature
DVi	The decisive indicator of AFSI after the ith factor is added to the time parameter
K_i	regression coefficient corresponding to the ith factor

4 Mode

4.1 Establishment of Fragile States Index Model

Using the historical data at http://fundforpeace.org/fsi/data/, we can see that the original fragile states Indexs explained by twelve factors, without taking climate change considerated. We use the principal component analysis in determining the indirect or direct effects of climate change on the country's vulnerability.

First of all, we have carried on the principal component analysis to the original 12 indexes. It can be seen from the principal component relation matrix that without any other factors, the main component is one and is highly interpreted by twelve factors, which can be understood as the principal component, which is another representative of Vulnerability, concluding that Y_{11} is the only component that directly affects the fragile states index.Y_{ij} means i_{th} main component in the j_{th} principal component analysis.

The second part of our thinking is to divide the environmental climate difference into four factors, RFA, CDEPC, AP and AMT. Then it is analyzed whether the four factors are direct or indirect influences factors . According to the principal component relation matrix, we can see that under the four factors of environmental climate, the cumulative variance contribution rate reaches 88.696 when the main component is two. As a result, the two main components are practical to explain the AFSI. Analysis is shown in the tables below:

Table 1:Explanations of variance

element	Initial eigenvalue			Capture square and load		
	total	mutated %	accumulated%	total	mutated %	accumulated %
1	12.776	79.850	79.850	12.776	79.850	79.850
2	1.415	8.846	**88.696**	1.415	8.846	88.696
3	.971	6.072	94.767			
4	.482	3.011	97.779			
5	.184	1.148	98.927			
6	.149	.934	99.861			
7	.014	.088	99.949			
8	.008	.047	99.996			
9	.001	.004	100.000			
10	6.024E-16	3.765E-15	100.000			
11	4.895E-16	3.059E-15	100.000			
12	2.101E-16	1.313E-15	100.000			
13	1.243E-16	7.770E-16	100.000			
14	-1.096E-16	-6.853E-16	100.000			
15	-3.838E-16	-2.399E-15	100.000			
16	-5.692E-16	-3.557E-15	100.000			

Table 2:Explanations of the main components of the factor

Factor	Y1	Y2
C1: Security Apparatus	0.959	0.085
C2: Factionalizd Elites	0.975	0.070
C3: Group Grievance	0.942	0.073
E1: Economy	0.948	-0.006
E2: Economic Inequality	0.906	0.150
E3: Human Flight and Brain Drain	0.965	0.099
P1: State Legitimacy	0.986	0.048
P2: Public Services	0.952	0.142
P3: Human Rights	0.983	0.013
S1: Demographic Pressures	0.943	0.166
S2: Refugees and IDPs	0.988	0.075
X1: External Intervention	0.959	0.121
RFA: Ratio of Forest Area	**-0.664**	0.576
CDEPC: Carbon Dioxide Emissions Per Capita	**-0.709**	0.436
AP: Annual precipitation	0.053	**0.795**
AMT: Annual Mean Temperature	**0.891**	-0.377

Therefore, we think that these two principal components are highly explained by sixteen factors, and the first component Y_{21} is highly explained by fifteen factors. The second component Y_{22} is highly explained by one factor-AP.Y_{21} is the component of the original impact componentY_{11} after considering the climatic factors. Therefore, we think the influence of RFA, CDEPC and AMTon the vulnerability index indirectly. Owing to this, we think these three indicators (RFA, CDEPC and AMT) indirectly affect the vulnerability index, and $Y_{22}(AP)$is directly understood as the influence of temperature on the vulnerability index. Therefore, AP is considered to have a direct impact on the Vulnerability Index.

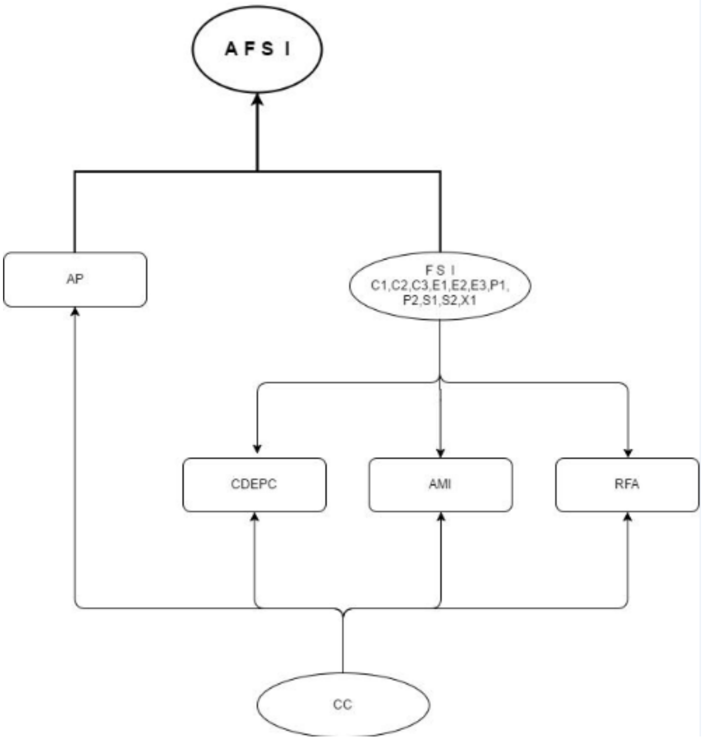
The principal component analysis is performed using 16 influencing factors. The main components of the relationship between the 16 factors are listed as follows:

$$AFSI = \sum_{i=1}^{N} \frac{\alpha_i(x_i - \bar{x}_i)}{\sqrt{\frac{1}{N}\sum_{j=1}^{N}(x_{ij} - \mu)^2}}$$

Where, n is the number of factors, is equal to 16,$x_i$is the i_{th} of 16 factors, N is number of country that we have selected, is equal to 50,x_{ij} is the i_{th} factor of the j_{th} country.

Because of the different dimensions of the data indicators we obtained, we select data including 50 countries in the same year.Consequently,we first standardize the 16 indicator with Z standardization method before calculating them.We get $Z_i(i = 1, 2, 3, 4, ..., 16)$, where $a_{1i}, a_{2i}, ..., a_{pi}(i = 1, ..., m)$ are the The corresponding feature vectors of covariance X matrix. Next, we begin to judge the correlation between the indicators.

From the cumulative variance contribution of the components, we replace the original 16 indicators with two principal components.$C_1, C_2, C_3, E_1, E_2, E_3, P_1, P_2, P_3, S_1, S_2, X_1$,and RFA,CEDPC,AP and AMT explain the changes of the first principal component, while AP explains the second principal component.



The contribution of RFA, CDEPC and AMT have the impact of the original twelve factors, namely, RFA, CDEPC and AMT are the Indirect Influence Factor(IIF), other factor(AP) is the Direct Impact Factor (DIF)

The equation can be used to calculate the AFSI index of the target country we are facing against the model and divide it by three with the AFSI threshold that we set out by the FSI. The specific boundaries and ranges are as follows:

Table 3:Classification of AFSI

Category	score	Brackets	color
Fragile	80.0-120.0	High：105+ Middle：90-104.9 Low：80-89.9	Red
Vulnerable	40.0-79.9	High：69.9-79.9 Middle:60-69.9 Low：40-59.9	Yellow-Orange
Stable	0.0-39.9	Stable：30-39.9 Sustainable：20-29.9 Very sustainable:：0-19.9	Green
Not assessed	N/A	-	Light gray

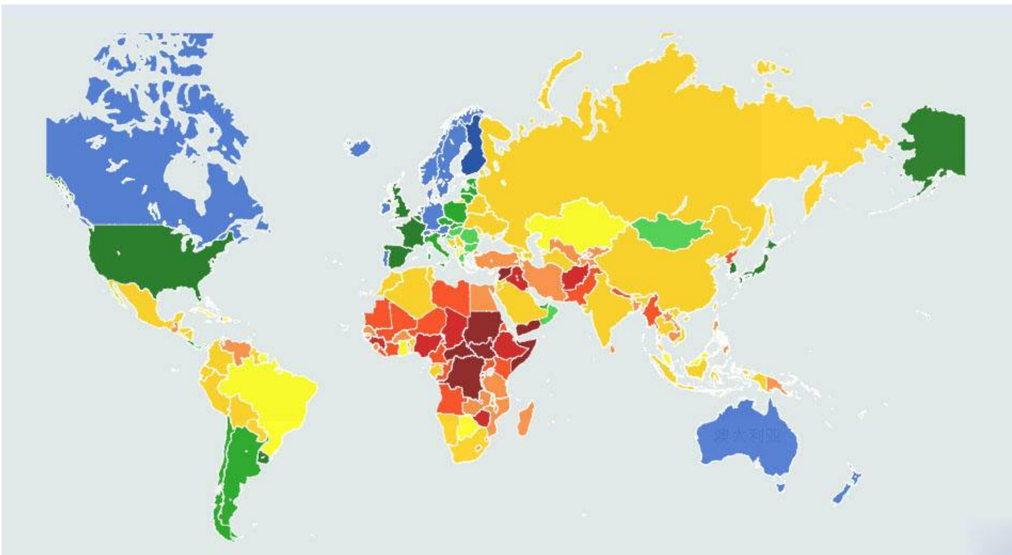
- Countries that score between 80.0 and 120.0 are listed in the red "Fragile" category;
- Countries with scores between 40.0 and 80.0 fall into the yellow-orange "Vulnerable" category;

- Countries scoring 0.0 to 40.0 are included in the green "Stable" category;
- Countries that have not been assessed are classified as not applicable and light gray.

Tips

- These ratings do not necessarily predict that the country may experience violence or collapse. Instead, they measure the collapse or conflict of vulnerabilities. All countries in the red, orange or yellow categories have shown the characteristics that make it easy to fail a significant part of their society and institutions. The speed and direction of change (positive or negative) vary. Some in the yellow area may fail faster than those in the more dangerous orange or red areas, and may therefore experience violence more quickly. Conversely, some red areas, though critical, may show some signs of positive recovery or slow deterioration, giving them time to adopt mitigation strategies.
- In addition, color gradation and classification are a vague guide, but should not be overly dependent. In essence, it is a way of decomposing an index into digestible parts, providing a way to understand a broad range of concepts at a glance. One country scored 40.0 and the other scored 40.1, classified as "stable" and "Vulerable" respectively, but in fact the overall pressure difference between the two is negligible. Any serious analysis of stress and instability should go deep into sub-index measures and long-term trends - simply relying on the map's color coding is not sufficient for a substantive analysis.

Figure 2: AFSI of the world



4.2 Implementation of Fragile States Index Model

4.2.1 Mechanism of action of climate change on AFSI - Chad

We selected Chad to analyze the impacts of climate change on fragile states index. Among the four factors of climate change, ratio of forest area and per capita emissions of carbon dioxide have contributed to the reduction of fragile states index. The remaining two ,AP and AMT, have a positive correlation with the fragile states index. Among them, AP plays a direct role in the calculation. From the model we can find that from 2006 to 2014, RFA in Chad is reduced by about 1,300 square kilometers per year and the amount of carbon dioxide emission is increasing year by year. In addition, The numerical standard deviation of average temperature is relatively large, supported by the example of climate change from 2006 to 2007. Between the two years, all the factors of climate change are moving towards the increase of national vulnerability, namely, RFA, CDEPA,AP and AMT increase. The change of vulnerability indicators from$AFSI_{Chad} = 109.2863189$ in 2006 to $AFSI_{Chad} = 112.3373269$ in 2007 also testifies to the fact. If there is no such effect, Chad will not be so vulnerable.

4.2.2 Analysis of the relationship between time and AFSI - Brazil

We analyze the four factors related to climate change and the twelve factors of AFSI through linear regression, obtaining the linear regression equations between time and sixteen factors respectively. In measuring the credibility of the regression equation, we use the determinable coefficients of the goodness of fit test. The closer the statistic is to 1, the higher the goodness of fit of the model is. If the $R^2 >= 80\%$, we can conclude that the factor corresponding to this equation is the decisive variable:

$$R^2 = \frac{\sum(\hat{y}_i - \bar{y})^2}{\sum(y_i - \bar{y})^2}$$

The Constraint

$$R^2 \geqslant 80\%$$

The regression equation for some factors versus time is as follows:

$$\begin{aligned} E3 &= -0.342t + 1.710, R^2 = 0.878 \\ X1 &= -0.356t + 1.779, R^2 = 0.949 \\ RFA &= -0.632t + 1.779, R^2 = 0.984 \\ AECD &= 0.355t - 1.774, R^2 = 0.944 \end{aligned}$$

t means in the process of linear regression, the data we use in 2006 is defined as the year of 0, which is used in linear regression equation.

T means the actual year of the letter contrasting t

Therefore, T=t+2006

Through the linear regression relationship between AFSI and sixteen factors, we can get the equation of AFSI and time :

$$AFSI_{Brazil} = Y_1 + Y_2$$

Table 4: Regression relationship between of time and factors

Factor	R^2	constant	Coefficient of the year
C1	0.208	0.833	-0.167
C2	0.361	-1.097	0.219
C3	0.011	0.195	-0.039
E1	0.131	-0.66	0.132
E2	0.524	1.322	-0.264
E3	0.878	1.71	-0.342
P1	0.282	0.969	-0.194
P2	0.86	1.693	-0.339
P3	0.011	0.191	-0.038
S1	0.205	-0.826	0.165
S2	0.099	-0.575	0.115
X1	0.949	1.779	-0.356
RFA	0.984	1.811	-0.362
CDEPC	0.944	-1.774	0.355
AP	0.142	0.689	-0.138
AMT	0.276	-0.959	0.192

The Results

According to the year coefficient and R^2 of 16 factors, we get a set of equations that can describe the vulnerability wave of Brazil. Then we get them with two groups of one-dimensional matrix $Y_1$and Y_2 adaptation and integration, and we get a linear equation that we consider it fitting in the short term (20 years) to predict the national vulnerability index in Brazil as follows

$$AFSI_{Brazil} = -2.410865874t + 72$$

It can be calculated that when $t = 14, AFSI = 38.24787776$ and $T = t + 2006 = 2020$. In other words, in 2020, Brazil will enter a more stable state of vulnerability (stable), that is, enter another critical state. Table 5 shows that in this model, the importance of variables is ranked in turn as CDEPA, RFA, X1, and human flight and loss. The tipping point of Brazil is that when the model calculates AFSI at 80 and 120. The description of how to difine the tipping point is showed on the Section 4, Table 3.

4.3 Interventions

Based on our analysis, we put forward intervention measures which consist of mitigating climate change measures and adapting to climate change measures,in order to mitigate the risk of climate change and prevent a country from becoming a fragile state

Intervention measures

1. **Mitigating Climate Change**

   - **Adjusting the industrial structure.** States optimize the industrial structure and explore new paths and patterns in green and low-carbon transformation by speeding up elimination of backward production capacity, promoting transformation and upgrading of traditional industries, and supporting the development of strategic emerging industries.

- **Optimizing the energy structure.**Coal Resource Tax can be calculated ad valorem in order to imposing strict control over coal consumption. The scale and level of natural gas utilization need to be promoted to enhance the intensive use of resources and environment protection.

- **Controlling GHG Emissions from Non-Energy Activities.** Key actions on Hydro Fluorocarbons (HFCs) control can be carried out to strengthen the management of non-carbon-greenhouse gas GHGs. The use of more advanced waste incineration technologies can be promoted, and the incentive policy of promoting the recycling of landfill gas can be formulated to controlle GHG emissions from waste disposal.

- **Increasing Carbon Sinks.**We can strengthen the construction of the key protection forest system and the protection of natural forest resources to increase the area of the National Forest and the carbon sequestration of the forest.

2. **Adapting to Climate Change**

    - Agricultural Sector. National Agricultural Administration can carry out farmland infrastructure, improve soil fertility, pest control , vigorously promote water-saving irrigation, dry farming and other work.

    - Water Resources. National Water Resources Administrationcan actively promote rivers and lakes reservoir connectivity to improve the ecological environment of rivers and lakes. The construction of key river management projects can be enhanced, simultaneously, the flood control and disaster reduction system for major rivers can be improved.

    - Marine Sector. National Oceanic Administration can establish the system for monitoring carbon dioxide exchange in offshore sea-air surfaces, and enhance the marine disaster observation, warnings and prevention and reduction.

    - Meteorology Sector. National Weather Administration can strengthen the monitoring and early warning for extreme weather and climate events and the management of meteorological disaster risks, and achieve automatic matching of state-level early warning information.

Effect of interventions

- Adjusting the industrial structure, optimizing the energy structure can reduce the country's pollution and reduce greenhouse gas emissions.Moreover, it has an important impact on the status quo in mitigating global warming.
- It can improve the local climate conditions, increase local humidity and precipitation through afforestation, conservation of natural forest resources and vigorously stepping up the grassland ecological protection measures.

- For the elevation lower than sea level countries,it is important to reduce the risk of sea level rise and other marine disasters by enhance the marine disaster observation, warnings and prevention and reduction.
- Strengthening the monitoring and early warning of extreme weather and climate events and meteorological disaster risk management, will enable the country to make disaster prevention measures in advance and reduce the risk of sudden meteorological disasters to the country.

Predict the total cost

Assumptions and Justifications

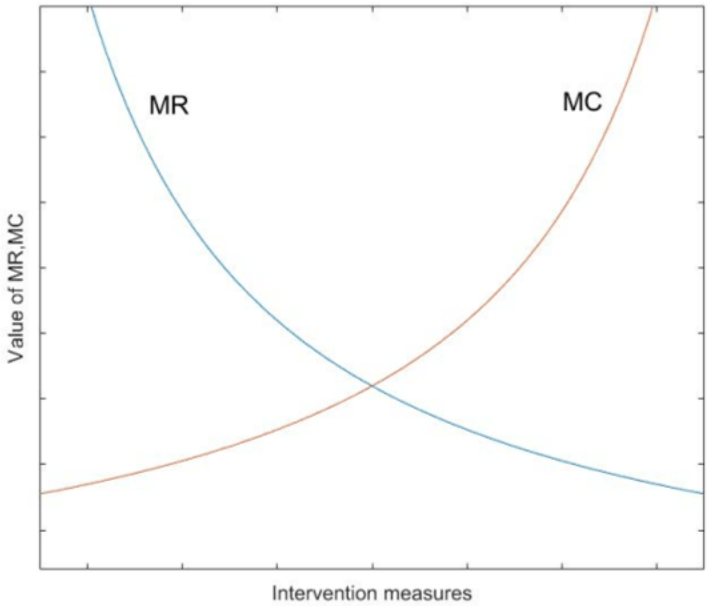
- Total Cost of interventions(TC_E): technical costs(C_t), labor costs(C_l), construction costs(C_c), other costs(C_x)
- Scope of interventions: agriculture, water resources, forestry, oceanography, meteorology
- Taking interventions can give the local environment a positive externalities. When the marginal cost is equal to the marginal benefit, the benefit is the largest, that is, the positive externalities are the largest.
- The higher the national vulnerability index, the total cost of intervention should be higher. However, the cost of interventions should be less than the cost of the country for economic development(C_e). Because countries with higher vulnerability indicators tend to be those developing countries that are economically backward and harsh. It is because of the economic backwardness that these countries do not have enough capacity to take the appropriate interventions. Only if the country's economy continues to evolve will it be able to afford sufficient economic capacity to take interventions to improve the natural environment, increase environmental carrying capacity and combat the risks posed by climate change.
- Countries with low AFSI should also take interventions to maintain or enhance their national capacity to deal with climate change.

Model of the cost of interventions

$$TC_E = C_t + C_l + C_c + C_x$$
$$TC_E = \sum(C_{ti}) + \sum(C_{li}) + \sum(C_{ci}) + \sum(C_{xi})$$

$$TC_E < TC_e$$
$$R = MAX\ R, MC = MR$$

Figure 3:the marginal cost is equal to the marginal benefit



Through the analysis of a large number of relevant data in Brazil, we predict that the estimated cost of Brazil will reach 2 billion 565 million 890 thousand dollars from the fragile state to the stable state.

5 Further discussion

In discussing whether the model is applicable to smaller geographies(eg: city) and larger geographies(eg: continent), we put forward the first idea concerning to the extreme value of local vulnerability compared to the vulnerability we receive from that country. Assuming that in country at a certain level of AFSI, in which all regions' AFSI is the same. However, even in the same country, the vulnerability of each small area is different. At this time, the concept of relative error has appeared, we employ the concept of introducing error percentage, and when the actual vulnerability in a region differs from the national vulnerability by 20%, then we can define that the model is not working properly. However, in a study of Australia, a country of high vulnerability, we can also find some areas with high vulnerability, which overtakes that in Australia by 20%. Not only that, we also find that in countries with low AFSI such as Germany, France and Canada, this phenomenon of low AFSI of the local area still happens all the time. That is, we get the conclusion that our models do not work properly in most countries. This is contrary to the conclusion that our model is used to assess the overall vulnerability of a country as normal work. **Therefore, this judgment of model is not correct. The AFSI reflects the overall level, which is similar to the concept of "average". However, local vulnerability shows individual differences, similar to the concept of "range".** It is obviously wrong to measure "average" work properly with "range".Not only that, among the twelve factors we adopted, some factors, such as E_1,P_1also adjust and consider this range.

After studying a large number of papers, starting from the availability of data, we think our model can play a predictive role in larger "nations," such as the continents. The organism is to transform the power from the country's 16 factors to the weight of the continent. When we are able to get 16 factors of the continent, we can calculate the AFSI of the continent.

- CA: Continent Area
- NLA: National Land Area
- $W_{continent,i}$: the ith factor's weight of Continent
- $W_{continent,i} = NLA/CA$
- Resident life satisfaction: CLS: Citizens' Life Satisfaction

As the prediction of the city, we find that the 16 factors are not easy to translated into local indicators and therefore the model does not work properly. Suggestions for modification of the model are as follows.

Establish a functional relationship with a series of 12 factors, including urban GDP, elite proportions in the region, local human rights and the rule of law, and life satisfaction of their citizens, and add this relationship to the model The vulnerability index of some areas.

6 Sensitivity Analysis

Sensitivity analysis, when a single factor has +4% floating range, the influence degree of the sixteen factors on the whole is 3.84% , 3.90% , 3.77% , 3.79% , 3.62% , 3.86% , 3.94% , 3.81% , 3.93% , 3.77% , 3.95% , 3.84% , 2.66% , 2.84% , 3.18% , 3.56%. When all the factors are floating within 4% together, the maximum impact on the model is only 5.83%, so we think our model is very strong in the range of factor variation error. We also recommend focusing on the stability of C_2,P_1, P_3, P_2, because the changes of these four will have a global impact on the degree of the factor itself.

7 Strengths and weaknesses

7.1 Strengths

- Climatic conditions and vulnerability established a clear functional relationship.
- The function identifies the level of national vulnerability (stable, vulnerable,fragile)
- The model can accurately explain the specific causes of changes in the level of national vulnerability.
- Our model is able to predict the vulnerability index of a given country after several years.
- Under the support of enough data, the supplementary function can be extended to a large area and a small area of vulnerability prediction.
- After the data is normalized, the data is entered into the model so that the effects of the dimension on the AFSI are smoothed out.

- We use the data of 16 factors from 50 countries that is form credible websites such as the World Bank, which is of great guiding significance for practical application.

7.2 weaknesses

- The samples of countries we draw are less than the total number of countries in the world. When applied to the prediction of some special countries, we may find that the error is relatively large. However, this problem can be solved by establishing other factors connected the sixteen factors with functional relationship, the prediction accuracy will be further improved.
- Linear regression models may not be able to better predict countries with high or weak national vulnerabilities, with a low level of interpretation (R-squared) but apply to most of the country's projections on Earth.
- When predicting the continent, simply taking the ratio of land area to continent area as the weight is not entirely applicable to all situations, but this method of calculation can be adjusted according to different situations in the predicted area, and the framework of the model as a whole will not Have a great impact.
- When analyzing the degree of temperature on the degree of national vulnerability, the annual average temperature is used, ignoring the seasonal changes.

8 Conclusion

Through the four models we established, we set up a model judging direct factor or indirect factor of AFSI, a regression model of time and factor, a regression model of time and AFSI, and intervention cost and intervention benefit compare models. First, we use four sub-factors to analyze the impact of climate change on AFSI, namely RFA, CDEPC, AP and AMT. Then, through principal component analysis, we come to the conclusion that AP is a direct factor, RFA, CDEPC, and AMT are indirect influencing factors, which play a role in the correction of the other 12 factors.

Then, we set up a linear regression model to analyze the relationship between the sixteen factors and the AFSI respectively. We let the factors be the dependent variable and the AFSI as the independent variable. The model is assumed to be a monadic linear regression model. Through analyzing the algorithm principle in SPSS analysis software, it analyzes the positive or negative correlation between the factors and the AFSI respectively. Through the principal component analysis, the RFA and CDEPC show a negative correlation with AFSI while the other 14 factors showed a positive correlation.

Not only that, the linear regression model is used to establish the relationship between time and sixteen factors. This model allowed us to relate time to AFSI in the end. A study in Brazil finds that Brazil will enter a more stable state (AFSI is less than 40) in the 14 years after 2006, then we use the goodness of fit test to determine the decisive variables: E_3,X_1, RFA, CDEPC.

After all the functional relationships are identified, the cost of interventions is analyzed to describe the changes in intervention costs through technology costs, labor costs, construction costs and other costs. When the marginal cost is equal to the marginal benefit, the interventions are obtained the biggest gains.

Finally, we make an objective analysis of the advantages and disadvantages of the model and make an attempt to further expand the model in order to make our model and method more successful.

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9 Appendix

Table 5The matrix of factor score coefficient

factor	1	2
Zscore: C1	.075	.060
Zscore: C2	.076	.050
Zscore: C3	.074	.051
Zscore: E1	.074	-.004
Zscore: E2	.071	.106
Zscore: E3:	.076	.070
Zscore: P1	.077	.034
Zscore: P2	.075	.100
Zscore: P3	.077	.009
Zscore: S1	.074	.117
Zscore: S2	.077	.053
Zscore: X1	.075	.085
Zscore: RFA	-.052	.407
Zscore: CDEPC	-.055	.308
Zscore: AP	.004	.561
Zscore: AMT	.070	-.266

Figure 4:The climate of Brazil

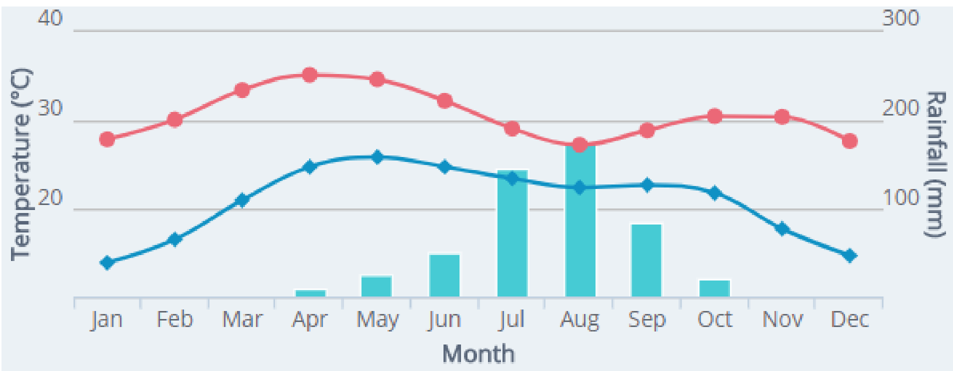

Table 6:The climate of Brazil

Year	c1	c2	c3	e1	e2	e3	p1	p2	p3	s1	s2	x1	RFA	CDEPC	AP	AMT
2006	5.7	3.2	5.7	2.7	8.5	5.0	5.5	6.7	5.3	6.5	3.6	4.7	5050788	347668.27	1848	25.6
2007	6.9	4.5	6.1	3.2	8.8	5.0	6.2	6.3	5.3	6.6	3.4	4.6	5034236	363212.683	1688	25.6
2008	7.1	4.9	6.1	3.7	8.8	5.0	6.2	6.0	5.6	6.3	3.3	4.6	5017684	387631.236	1903	25.3
2009	6.9	5.1	6.4	4.1	8.9	5.0	6.4	6.0	5.6	6.4	3.9	4.4	5001132	367147.374	1931	25.6
2010	6.7	5.1	6.2	4.0	8.8	4.8	6.2	6.0	5.4	6.3	3.7	4.2	4984580	419754.156	1759	25.8
2011	6.5	4.9	6.5	3.9	8.5	4.5	5.9	5.8	5.1	6.1	3.5	3.9	4974740	439412.943	1832	25.5
2012	6.2	4.9	6.2	3.6	8.4	4.2	5.6	5.5	5	7	3.9	3.6	4964900	470028.726	1653	25.7
2013	5.9	4.9	5.9	3.3	8.3	3.9	5.3	5.4	5.3	7.0	3.6	3.3	4955060	503677.118	1765	25.7
2014	5.6	4.9	5.6	3.6	8.0	3.8	5.4	5.6	5.6	6.7	3.6	3.0	4945220	529808.16	1746	25.8