World Scientific Research Journal Volume 8 Issue 5, 2022
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0048

An Evaluation Model of State Fragility Based on Entropy Weight Method

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Abstract

In recent years, the definition of fragile states has become an issue of global significance. State fragility refers to a country with weak state capacity, unable to meet the basic needs and expectations of citizens, and unable to withstand internal and external risks. A scientific and objective system of evaluation, prediction and intervention measures is the key to the study of national vulnerability. First, establish a national fragility index assessment system that takes into account the impact of climate change on national fragility through the entropy weight method. We selected 20 indicators from four aspects, including cohesion, economy, politics, society, and cross-sector. Combined with the impact of climate on various aspects, we judged the national fragility index system by calculating the country's fragility index (FI).Second, through this model, the top ten "fragile countries" in the fragile country index system created by the Peace Fund were judged, and Chad, the "most vulnerable country in the world", was obtained, and how climate change changed the country's state of Chad. Vulnerability. Third, using Japan as an example, we analyze when and how climate change alters the country's vulnerability. At the same time, a "national vulnerability threshold" was established. When the fragility index (FI) revolves around this value, the country's vulnerability should be taken seriously. Then calculate the Japan Vulnerability Index from 2010 to 2020, and predict the natural development trend of Japan's National Vulnerability Index over the next 15 years.Fourth, based on the phenomenon of a sharp decline in Japan's fragility index, combined with Japan's climate change policy, we analyze the impact of some state interventions on the country's fragility index. Our paper may provide an assessment and forecast of national and regional vulnerability in the future. And the influence of climate on national vulnerability to provide reference value.

Keywords

Entropy weight method; State fragility; Interventions.

1. BACKGROUND

Global climate change has become a major challenge facing all mankind. Due to the rapid development of industry and rapid population growth, the global climate has undergone great changes, increasing droughts, shrinking glaciers, changes in the range of flora and fauna, and rising sea levels. These natural disasters affect people's way of life The impact cannot be underestimated. State fragility refers to a state in which a country is unable to resist natural disasters, cannot meet the needs of its citizens, and cannot guarantee social security. In addition to the influence of cohesion, economy, politics, society, etc., the environment also has a direct or

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indirect impact on the country's fragility. In a fragile state, these factors have little effect on their own, but in the event of poor governance or social division, these effects can be amplified, potentially triggering violent conflict. If effective solutions are not taken to solve these problems, there will be disasters for world peace and development. Therefore, judging and reducing a country's fragility is particularly important in today's world.

2. MODELING

In order to more scientifically measure the impact of climate change and characterize the country's fragility, we decided to establish a fragility evaluation system and use the Fragile index to judge whether a country is very fragile, fragile or stable.

2.1. Establish Indicators

In order to describe the fragility of a country more scientifically, we decided to measure the fragility of a country from four indicators: cohesion, economy, politics and society, and each of the four indicators is divided into climatic factors and non-climate factors. These indicators and factors work together to affect a country's Fragile index. The indicator structure diagram is shown in Figure 1:

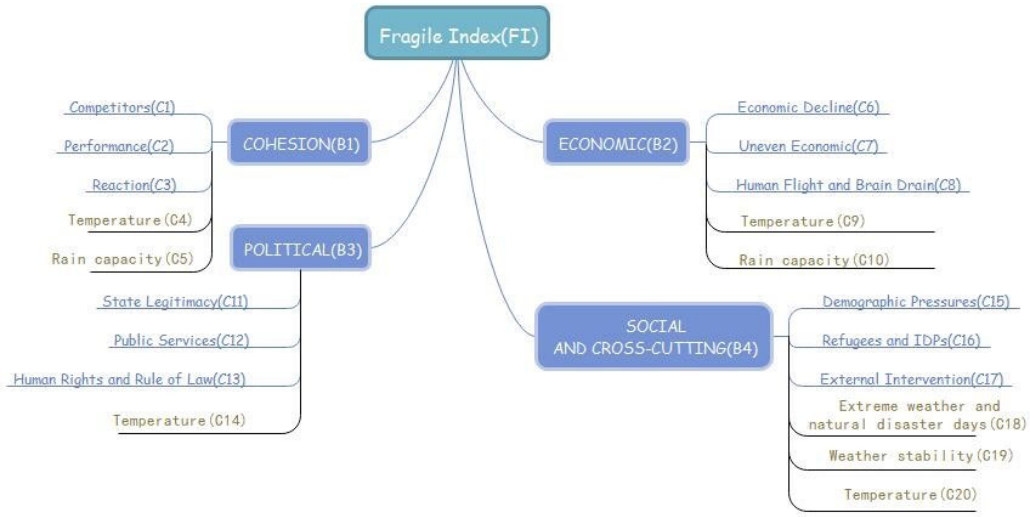

Figure 1. Fragile index

The Cohesion indicator (B1) is divided into 5 sub-indicators: Competitors (C1), Perfor- mance (C2), Reaction (C3), Temperature (C4), and Rain Capacity (C5). This indicator mainly considers the cohesion of the society, the credibility of the government, etc. Strong cohesion means the stronger the coercive power of the government of the country, there is no or very few:

2.1.1 Cohesion (B1)

A The Competitors Indicator (C1) considers security threats to the country, such as bombings, attacks, and war-related deaths, rebel movements, mutinies, coups, or terrorism;

B The Performance Indicator (C2) considers racial, class, clan, racial or religious lines, and brinkmanship and gridlock among ruling elites;

C The Reaction Indicator (C3) considers whether the military is under civilian control, whether there are private armed forces against the state, etc.

Taking into account the factors of Temperature (C4) and Rain Capacity (C5) at the same time, abnormal temperature and rain capacity will cause food production to decrease, leading to

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famine in some areas; rising temperature, melting glaciers, and rising sea levels will make the living environment in coastal areas suffer. Destruction, people's survival is threatened; and the occurrence of extreme climates and natural disasters will also make the living environment worse and increase the number of diseases. The deterioration of various conditions will inevitably lead to the weakening of the cohesion of the whole society, so it is inevitable and scientific to consider environmental factors such as temperature and rain capacity.

2.1.2 Economy (B2)

The Economic indicator (B2) is divided into 5 sub-indicators: Economic Decline (C6), Uneven Economic (C7), Human Flight and Brain Drain (C8), Temperature (C9), and Rain Capacity (C10). This indicator mainly considers economic factors. Generally speaking, countries with higher economic levels are more stable, and there are no or few:

A. The Economic Decline Indicator (C6) considers the pattern of gradual economic decline in society as a whole, as measured by per capita income, gross national product, unemployment, inflation, productivity, debt, poverty levels, or business failures. Sudden drops in commodity prices, trade receipts, or foreign investment, as well as a collapse or devaluation of a country's currency. Extreme social hardships caused by economic austerity programs, etc;

B. Indicators of Human Flight and Brain Drain (C7) consider structural inequalities by groups (eg, racial, ethical, religious, or other identity groups) or based on education, economic status, or regions (eg, urban-rural disparities); Uneven economic can exacerbate dissatisfaction, and may exacerbate community tensions or nationalist sentiment; and unequal opportunities for groups to improve their economic status, such as through access to employment, education or vocational training;

C. Uneven Economic indicator (C8). The economic situation in the country has deteriorated, and talents want better opportunities in other countries; professionals or intellectuals who have fled their country because of persecution or repression are forced to be displaced, especially displaced. There may be a loss of productive, skilled professional labor, with implications for the stability of the economy and the country; Taking into account the factors of temperature (C9) and rain capacity (C10) at the same time, abnormal temperature and rainfall will cause food production to decrease, hinder the economic development of agricultural countries, and increase the possibility of economic recession; food price fluctuations will also affect the world economy;

The temperature rises, the glaciers melt, the coastal erosion will be strengthened, the estuary delta will be submerged or eroded, the construction of coastal ports will be affected, foreign trade and economic and social development will be hindered, and social instability will be exacerbated.

2.1.3 Politics (B3)

The Political indicator (B3) is divided into four sub-indicators: State Legitimacy (C11), Public Service (C12), Human Rights and The Rule of Law (C13), and Temperature (C14). This indicator mainly considers political factors. The more stable the politics, the stronger the stability of the country, and the larger the indicator data of these aspects will be;

A. The State Legitimacy (C11) mainly considers representation and openness, and its relation- ship to citizens. The indicator looks at the level of public confidence in state institutions and processes and assesses the impact of a lack of this confidence through mass public demonstrations, persistent civil disobedience or armed insurgency.

B. The Public Service indicator (C12) serves people for the existence of the basic state. On the one hand, this may include the provision of basic services such as health care, education, water and sanitation, transport infrastructure, electricity and electricity, as well as internet and connectivity. On the other hand, it may include the ability of the state to protect its citizens.

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C. Human rights and rule of law indicators (C13) consider the relationship between the state and its population where fundamental human rights are protected, liberties are observed and respected. This indicator examines whether there is widespread abuse of legal, political and social rights, including those of individuals, groups and institutions.

At the same time, the impact of temperature (C14) on political indicators is considered. The increase in temperature is often accompanied by melting of glaciers, which leads to sea level rise, which leads to differences on the issue of marine boundaries and marine resource division, and causes certain unstable factors for political instability.

2.1.4 Society and Cross-Cutting (B4)

The social and cross-cutting indicator (B4) is divided into 4 sub-indicators: Demographic Pressures (C15), Refugees and IDPs (C16), External Interventions (C17), Temperature (C18), Rain Capacity (C19), Abnormal Climate Indicators (C20). This indicator mainly considers political factors. The more stable the politics, the stronger the stability of the country, and the larger the indicator data of these aspects will be;

A Demographic pressures indicator (C15) considers the pressure caused by the population itself or the surrounding environment. This indicator takes into account demographic characteris- tics, such as pressure from high population growth rates or uneven population distribution. These pressures can have far-reaching social, economic and political consequences.

B The Refugee and Internally Refugees and IDPs Indicator (C16) considers the massive forced displacement of refugees due to social, political, environmental or other reasons, and measures both internal displacement and the flow of refugees into other countries. These refugees reflect the great fragility of a country.

C External interventions (C17) takes into account the impact of external intervention. On the one hand, external interventions focus on the security aspects of participation from outsiders, where a country's internal affairs risk the balance of power that may be affectedby the government, military, intelligence services, identity goups or other entities. On the other hand, external intervention also focuses on the economic participation of external actors, including multilateral organizations, through large-scale loans, development projects or foreign aid, etc. These also affect the stability of a country in a sense.

At the same time, considering the impact of temperature (C18), precipitation (C19), and abnormal climate indicators (C20) on social and cross-domain indicators, rising temperatures, melting glaciers, rising sea levels, and inundation of coastal lowlands will also threaten low-lying The survival of people in the region; precipitation will affect agricultural production, affect food supply, reduce social carrying capacity, and increase population pressure; the occurrence of extreme climates and natural disasters will make the living environment worse; these factors will greatly affect the country's fragility.

Instruction:

The abnormal climate indicator (C20) shows the fragility of the country by counting the duration of the unbearable living environment for the human body in a year. The unbearable living conditions here are as follows:

1 The monthly average temperature is higher than 25 °C or lower than minus 10 °C;

2 Precipitation belongs to arid areas according to the national classification.

2.2. Entropy Weight Method to Determine Index Weight

2.2.1 Reasons for choosing entropy weight method

Typical methods for determining weights include: Analytic Hierarchy Process (AHP), factor analysis weight method, entropy weight method, etc. The AHP method is too subjective; the factor analysis weight method cannot guarantee the irrelevance between the various common

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factors in the data, the irrelevance between the special factors and the irrelevance between the common factors and the special factors, and the entropy weight method is a It is an objective weighting method, which corresponds to the corresponding weight through the degree of variation of the indicator, and the fragility of different countries is reflected by the degree of variation of the indicator. In addition, the application of the entropy weight method is limited, so we choose the entropy weight method.

2.2.2 Application of entropy weight method

First, find the sub-indicator data, that is, the data of the C-level indicators, and apply the entropy weight method to determine the sub-indicator weight; then, the existing data is subjected to dimension division processing, and the data of the main indicator is calculated in combination with the obtained weight, that is The data of the B-level indicators; then the weight of the main indicator is determined according to the data of the main indicator, and finally the fragility index can be calculated. Here we select the 2010 data of 10 representative countries from the Fragile Countries Index System established by the Peace Fund as an example. Figure 2 is a flow chart of the entropy weight method.

2.3. Determination of the Weight of the Cohesion Sub-indicator

2.3.1 Forward processing

We perform forward processing on the data, as shown in the Table2:

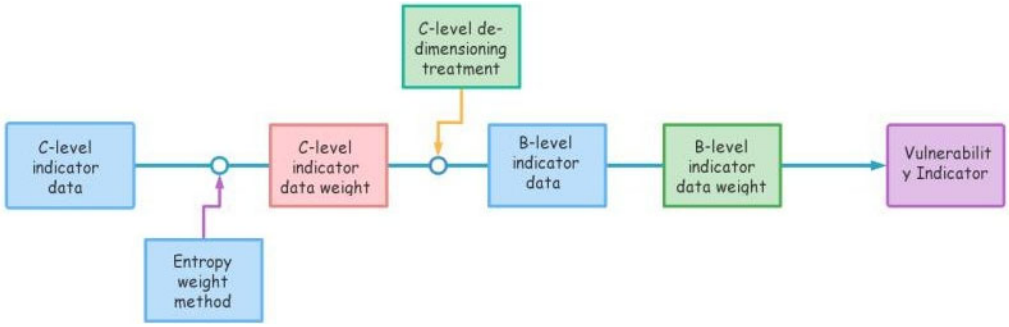

Figure 2. Fragile index system

The cohesion indicator includes 5 sub-indicators: Competitors (C1), Performance (C2), Reaction (C3), Temperature (C4), and Rain Capacity (C5). Among them, it can be seen from the analysis in 4.1 that when the rain capacity (C5) increases, the fragility index decreases, which is a very small index, which needs to be forwarded, which can be realized by MATLAB code, see the appendix for details.

Table 1. C-level indicator data

Country	C1	C2	C3	C4	C5
Somalia	10.000	10.000	9.700	27.500	282.000
Chad	9.900	9.800	9.800	28.400	744.000
Sudan	9.800	9.900	9.900	29.200	692.000
Tanzania	5.600	6.000	6.400	23.500	1071.000
Fiji	6.800	8.200	7.400	24.600	2592.000
Gambia	5.800	6.200	4.600	28.800	836.000
Honduras	7.000	6.800	5.000	24.200	1976.000
Sweden	1.300	1.300	1.300	1.100	624.000
Finland	1.000	1.000	1.200	1.300	536.000
Norway	1.200	1.100	1.300	0.900	1414.000

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2.3.2. Standardized processing

There are a total of 10 objects to be evaluated and 5 evaluation indicators. The data formed after the normalization process is as shown in Table 3:

Importing its data into the matrix we get the following n ∗ m order matrix

$$X = \begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{pmatrix} \tag{1}$$

xnm represents the nth evaluation object, the data of the mth index. The normalized matrix is denoted as Z, and each element in X is processed as follows to Z:

$$z_{nm} = \frac{x_{nm}}{\sqrt{\sum_{n=1}^{10} x_{nm}^2}} \tag{2}$$

Table 2. Data x

Country	C1	C2	C3	C4	C5
Somalia	10.000	10.000	9.700	27.500	0.9408
Chad	9.900	9.800	9.800	28.400	0.9277
Sudan	9.800	9.900	9.900	29.200	0.9538
Tanzania	5.600	6.000	6.400	23.500	0.7636
Fiji	6.800	8.200	7.400	24.600	0
Gambia	5.800	6.200	4.600	28.800	0.8815
Honduras	7.000	6.800	5.000	24.200	0.3092
Sweden	1.300	1.300	1.300	1.100	0.9880
Finland	1.000	1.000	1.200	1.300	1
Norway	1.200	1.100	1.300	0.900	0.5914

The Z matrix is as follows:

$$\widetilde{Z} = \begin{bmatrix} \widetilde{z}_{11} & \widetilde{z}_{12} & \text{B} & \widetilde{z}_{1m} \\ \widetilde{z}_{21} & \widetilde{z}_{22} & \text{B} & \widetilde{z}_{2m} \\ \text{C} & \text{C} & \text{E} & \text{C} \\ \widetilde{z}_{n1} & \widetilde{z}_{n2} & \text{B} & \widetilde{z}_{nm} \end{bmatrix} \tag{3}$$

Substitute the data of data z into a few, and get the following Table 4

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Table 3. Insert z data

Country	C1	C2	C3	C4	C5
Somalia	0.4671	0.4537	0.4652	0.3892	0.3708
Chad	0.4624	0.4446	0.4700	0.4020	0.3657
Sudan	0.4577	0.4491	0.4748	0.4133	0.3759
Tanzania	0.2616	0.2722	0.3069	0.3326	0.3010
Fiji	0.3176	0.3720	0.3549	0.3482	0
Gambia	0.2709	0.2813	0.2206	0.4076	0.3475
Honduras	0.3269	0.3085	0.2398	0.3425	0.1219
Sweden	0.0607	0.0590	0.0623	0.0156	0.3894
Finland	0.0467	0.0454	0.0575	0.0184	0.3941
Norway	0.0560	0.0499	0.0623	0.0127	0.2331

The probability matrix P is calculated by the following formula

$$p_{ij} = \frac{\widetilde{z}_{ij}}{\sqrt{\sum_{i=1}^{n} \widetilde{z}_{ij}^{2}}} \tag{4}$$

The obtained data P and e are as shown in Table 5: Normalize the information entropy by formula

Table 4. Data P and e

Country	C1	C2	C3	C4	C5
Somalia	0.171	0.165	0.171	0.145	0.026
Chad	0.169	0.162	0.173	0.149	0.069
Sudan	0.167	0.164	0.174	0.154	0.064
Tanzania	0.095	0.099	0.113	0.124	0.099
Fiji	0.116	0.135	0.130	0.129	0.240
Gambia	0.099	0.102	0.081	0.151	0.077
Honduras	0.119	0.112	0.088	0.127	0.183
Sweden	0.022	0.021	0.022	0.005	0.057
Finland	0.017	0.016	0.023	0.006	0.049
Norway	0.021	0.018	0.022	0.004	0.131
e	0.910	0.9096	0.910	0.875	0.920

$$W_j = d_j / \sum_{j=1}^{m} d_j (j = 1, 2, ..., m) \tag{5}$$

Finally, the weights of each C-level indicator are obtained as follows:

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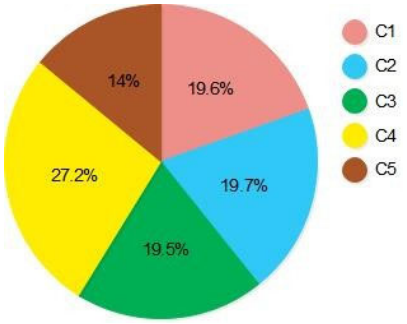

Figure 3. The weight of the cohesion sub-indicator

Divide the data into dimensions and multiply the corresponding weights to obtain the final cohesion (B1) data.

2.3.3 Economic sub-indicator weights

The economic indicator (B2) includes 5 sub-indicators: economic recession (C6), unbalanced economic development (C7), personnel outflow and brain drain (C8), temperature (C9), and pre- cipitation (C10). According to the analysis of the above five sub-indicators in 4.2, it can be seen that when the precipitation (C10) is suitable and meets the needs of crop growth, the fragility index shows a downward trend, so it is an interval index and needs to be processed positively. Repeat the cohesion factor weight calculation process, and finally get the weight shown in the following figure:

Table 5. Data P and e

Country	C6	C7	C8	C9	C10
Somalia	9.600	8.000	8.300	27.500	282.000
Chad	8.500	9.300	8.300	28.400	744.000
Sudan	6.700	9.500	8.700	29.200	692.000
Tanzania	7.200	6.700	6.100	23.500	1071.000
Fiji	6.700	7.500	6.600	24.600	2592.000
Gambia	7.500	6.800	6.200	28.800	836.000
Honduras	7.500	8.300	6.500	24.200	1976.000
Sweden	2.200	2.100	1.800	1.100	624.000
Finland	3.000	1.700	2.200	1.300	536.000
Norway	2.600	2.400	1.200	0.900	1414.000

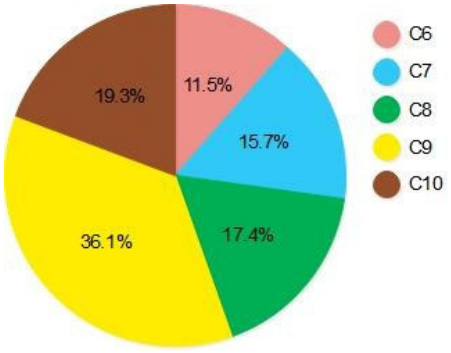

Figure 4. Economic sub-indicator weights

So the final economic (B2) data

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2.3.4 Political sub-indicator weights

The political indicator (B3) is divided into four sub-indicators: C11, C12, (C13), (C14).

Repeat the above steps, and finally obtain the weight of the political sub-indicator as shown in the figure below:

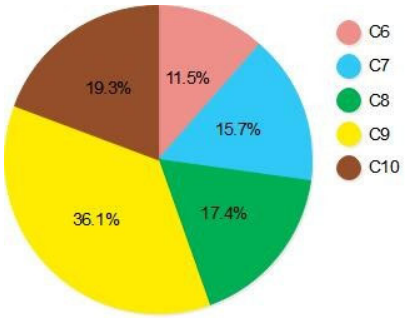

Figure 5. Political sub-indicator weights Take the final political (B3) data

Table 6. Political Data

Country	C11	C12	C13	C14
Somalia	10.000	9.600	9.900	27.500
Chad	9.900	9.600	9.600	28.400
Sudan	9.900	9.300	9.900	29.200
Tanzania	6.500	8.300	5.900	23.500
Fiji	8.900	5.500	6.700	24.600
Gambia	7.600	7.200	7.400	28.800
Honduras	7.500	6.900	6.300	24.200
Sweden	0.800	1.300	1.800	1.100
Finland	0.700	1.200	1.500	1.300
Norway	0.800	1.100	1.600	0.900

2.3.5 Social sub-indicator weights

The social and cross-cutting indicator (B4) is divided into 4 sub-indicators: population pressure (C15), refugees and internally displaced persons (C16), external interventions (C17), temperature (C18), precipitation (C19), abnormal climate indicators (C20). Based on the analysis in 3.2, when the precipitation (C10) meets the needs of crop growth, the fragility index decreases, so it is an interval index and needs to be positively processed.

Table 7. Social sub-indicato r data

Country	C15	C16	C17	C18	C19	C20
Somalia	9.600	10.000	9.600	27.500	282.000	14.000
Chad	9.400	9.500	9.700	28.400	744.000	14.000
Sudan	8.800	9.800	9.600	29.200	692.000	12.000
Tanzania	8.200	7.300	7.000	23.500	1071.000	20.000
Fiji	5.900	4.200	6.100	24.600	2592.000	22.000
Gambia	7.600	6.000	7.300	28.800	836.000	16.000
Honduras	7.600	4.100	6.500	24.200	1976.000	21.000
Sweden	2.700	2.700	1.600	1.100	624.000	16.000
Finland	2.300	1.700	1.800	1.300	536.000	15.000
Norway	1.700	1.600	2.100	0.900	1414.000	20.000

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Repeat the above steps, and finally get Figure 6

So the data for social and cross-cutting indicators (B4) are getted.

2.3.6 Establishment of main indicator weights

The fragility index includes four indicators of cohesion, economy, politics, and society, all of which are data after positive processing.

Finally, the cohesion, economic, political and social weights are obtained as shown in the figure below:

Comparing the ranking order of the Fragile index of 10 representative countries judged by our National Fragile index System with the ranking order of the Fragile Countries Index System established by the Peace Fund, It can be seen that after the factors of climate change are taken into account, there is a slight change in the ranking order, but the overall change is not large, which is consistent with the actual situation. Climate change will affect a country's Fragile index through its impact sub-indicator (C-type indicator). Therefore, our National Fragile index System can reflect the impact of climate change on national fragility.

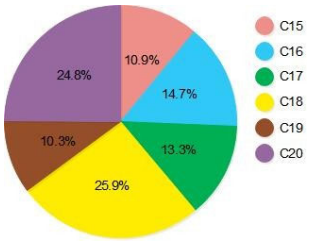

Figure 6. Social sub-indicator weights

Table 8. Establishment of main indicator data

Country	B1	B2	B3	B4
Somalia	7.219	5.664	9.209	6.551
Chad	7.423	6.075	9.106	6.657
Sudan	7.457	5.987	9.130	6.434
Tanzania	5.084	5.031	6.528	6.351
Fiji	6.662	6.170	6.660	6.267
Gambia	4.954	5.282	7.095	5.880
Honduras	5.670	5.975	6.541	6.173
Sweden	1.088	1.340	1.183	2.808
Finland	0.921	1.398	1.037	2.521
Norway	1.364	1.793	1.059	3.261

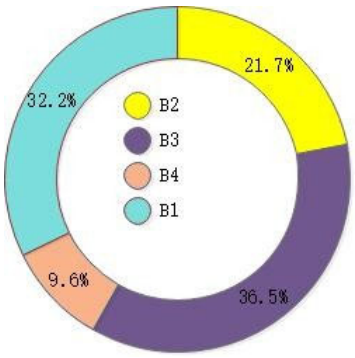

Figure 7. Establishment of main indicator weights

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0048

3. HOW CLIMATE CHANGE IS INCREASING THE COUNTRY'S FRAGILITY

We select the top ten countries from the Fragile State Index System established by the Peace Fund, collect relevant data, and then insert these data into our National Fragile Index System to judge the fragility of these countries. Fragile index, with three decimal places after the decimal point and sorted in descending order, as shown in the following table:

Table 9. Social sub-indicato r data

Country	Ranking	FSI	score
Somalia	1st	114.3	7.544
Chad	2nd	113.3	7.672
Sudan	3rd	111.8	7.651
Tanzania	72nd	81.2	5.722
Fiji	74th	80.5	6.517
Gambia	75th	80.2	5.896
Honduras	76th	80.0	6.103
Sweden	175th	20.9	1.343
Finland	176th	19.3	1.221
Norway	177th	18.7	1.528

Table 10. Fragility Index of Top 10 Countries

Country	B1	B2	B3	B4	C1	C2	C3	C4	FI	Rank
Chad	7.423	6.075	9.106	6.946	0.322	0.217	0.365	0.096	7.699	1
Sudan	7.457	5.987	9.130	6.930	0.322	0.217	0.365	0.096	7.698	2
Iraq	7.282	6.589	8.861	6.915	0.322	0.217	0.365	0.096	7.673	3
Somalia	7.188	6.357	8.497	7.498	0.322	0.217	0.365	0.096	7.516	4
CDR	7.219	5.664	9.209	5.600	0.322	0.217	0.365	0.096	7.453	5
Zimbabwe	7.225	5.886	8.443	7.209	0.322	0.217	0.365	0.096	7.378	6
CAR	6.697	6.015	8.802	6.087	0.322	0.217	0.365	0.096	7.259	7
Guinea	6.749	4.983	8.516	6.664	0.322	0.217	0.365	0.096	7.003	8
Afghanistan	6.764	5.466	8.259	5.091	0.322	0.217	0.365	0.096	6.868	9
Pakistan	6.823	5.031	7.806	5.786	0.322	0.217	0.365	0.096	6.694	10

As can be seen from the table, after the evaluation of the National Fragile Index System (National Fragile index System), we found that Chad is the most fragile country in the world, so we selected it as our case.

Chad has an area of 1,284,000 square kilometers. It is the 21st largest country in the world, located in north-central Africa, between 8 and 24 degrees north latitude and 14 and 24 degrees east longitude. Chad is far from the ocean and has a mostly desert climate.

Chad is divided into three main geographical areas: the northern part is the Sahara desert or semi-desert, accounting for 1/3 of the country's area, the eastern part is the plateau area; the arid Sahel area in the middle and the more fertile grassland area in the south. Tibes in the northwest raises the original average altitude by 2,000 meters. Mount Kuxi is 3,415 meters above sea level and is the highest peak in the country and Central Africa.

Chad takes its name from Lake Chad, which had an area of 330,000 square kilometers 7,000 years ago, but has shrunk to 17,806 square kilometers in the 21st century. Seasonal factors have a great impact on its area. Lake Chad is the second largest wetland in Africa.

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We substitute all the indicator data of Chad in 2010, we can get the FI is 7.699.

We reflect the impact of climate change on the country's fragility by changing the country's average temperature, precipitation, and number of days of abnormal weather in a year, resulting in the following table:

Table 11. State Fragility Analysis of Chad

T	Rain	Abnormal	B1	B2	B3	B4	FI
28.4	744.000	7.000	7.423	6.075	9.106	6.946	7.699
33.4	894.000	7.000	7.720	6.473	9.209	7.215	7.945
33.4	644.000	7.000	7.611	6.322	9.209	7.135	7.869
18.4	1344.000	7.000	7.222	5.823	8.900	6.697	7.481
18.4	1344.000	2.000	7.222	5.823	8.900	5.457	7.361

Analyzing the table of impacts of climate change on national fragility, we learn that: When the average temperature of the year increases by 5 degrees Celsius and the average annual precipitation increases by 150mm, because the country is too hot, the fragility index will increase from 7.699 to 7.945, and the country will become more vulnerable;

When the average temperature of the year increases by 5 degrees Celsius and the average annual precipitation decreases by 100mm, the fragility index will increase from 7.699 to 7.869 due to the country's excessive heat and insufficient precipitation, and the country will become more fragile;

When the average temperature of the year decreases by 10 degrees Celsius and the average annual precipitation increases by 500mm, the country will become livable after cooling down and become less water-deficient after the increase in precipitation. The fragility index will drop from 7.699 to 7.481, and the country will change. More stable;

When the country's abnormal weather conditions improve, the abnormal weather index will drop from 7 to 2, the country's weather will stabilize as a whole, and the fragility index will drop from 7.699 to 7.361, and the country will become more stable.

In general, climate change has an impact on country fragility, and when the climate changes, the country's fragility index changes with the climate.

4. OUR CASE - JAPAN

Climate change will have a major impact on the world, most notably global warming, rising sea levels and the accelerated melting of icebergs in the Arctic and Antarctic. As an iconic island country, Japan will be impacted to varying degrees on four levels as sea levels rise.

A. Cohesion

Climate change has no impact on faction elites (C2) and group appeals (C3), so the main analysis is that security institutions (C1) are affected by climate change, that is, by temperature (C4) and precipitation (C5).

It can be seen from Figure 8 that the indicators of Japanese security institutions show an upward trend as a whole, that is, the security threats faced by the country gradually increase, which means that the fragility index is positively affected by the security institutions (C1). Gradually increase, the country's fragility increases. This is also in line with the impact of climate change on Japan. The specific analysis is as follows:

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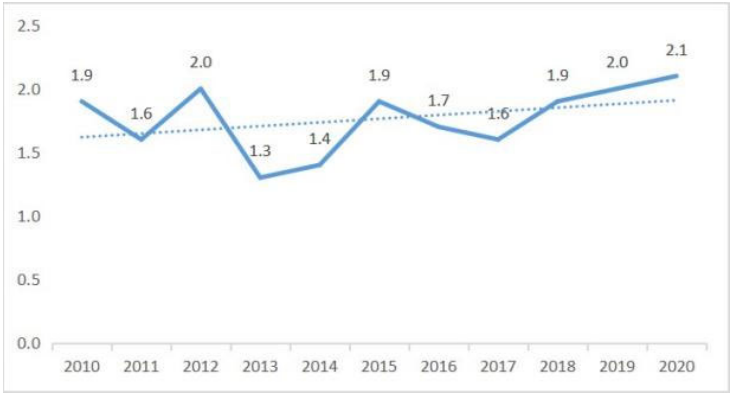

Figure 8. Security Agency Indicators

First of all, there is a lot of evidence that since Japan is in the sea, the geological structure is not as solid as the land due to the long-term immersion of the sea water, and the land subsidence is likely to be caused by the extrusion of the plate. As icebergs melt and sea levels rise dramatically due to global warming, Japan's low-elevation areas will also be threatened, and the national security agency index will increase, and the fragility will increase.

Secondly, affected by the large annual precipitation, the number of natural disasters in Japan has increased, such as floods, landslides, and mudslides. This also makes Japan face more security threats, and the security agency index (C1) increases accordingly. The fragility index gradually increased.

Finally, based on the above analysis and the trend change in the security agency indicator (C1), Japan will reach its maximum fragility indicator in 2020 or 2012.

B. Economy

Climate change has no impact on the unbalanced economic development (C7), human flight and brain drain (C8), so the main analysis is that economic recession (C6) is affected by climate change, that is, temperature (C9), precipitation (C10).

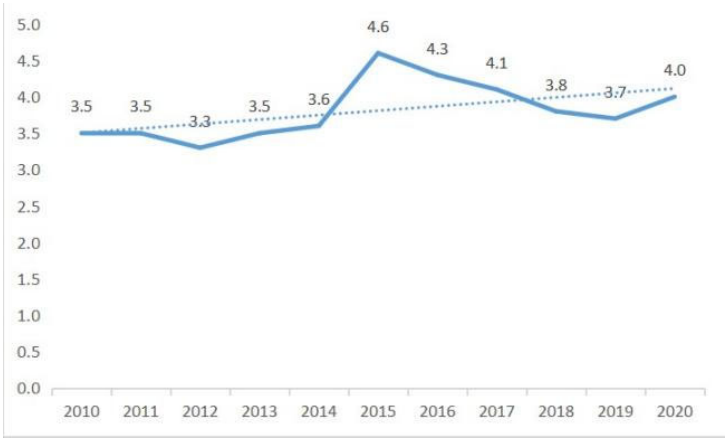

Figure 9. Recession indicator

It can be seen from the figure that Japan's economic recession (C6) indicator is on the rise as a whole, that is, the overall economy of the society is gradually declining, which means that the fragility index is positively affected by the economic recession (C6), that is, as the year increases,

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the fragility index gradually increases. increase, and the country's fragility increases. This is not only in line with the impact of climate change on Japan, but also reflects the development of Japan's current pillar economic industries. The specific analysis is as follows:

The melting of icebergs and the massive rise in sea levels caused by global warming have resulted in the gradual reduction of only 12% of arable land in Japan, limiting agricultural development and the overall economy. The overall economy is gradually declining.

Therefore, based on the analysis and the recession indicator chart, it is known that Japan will reach the maximum fragility indicator in 2016.

C. Politics

Climate change has no impact on public services (C12), human rights and the rule of law (C13). Therefore, it is mainly analyzed that the national legitimacy (C11) is affected by climate change, that is, affected by temperature (C4) and precipitation (C5).

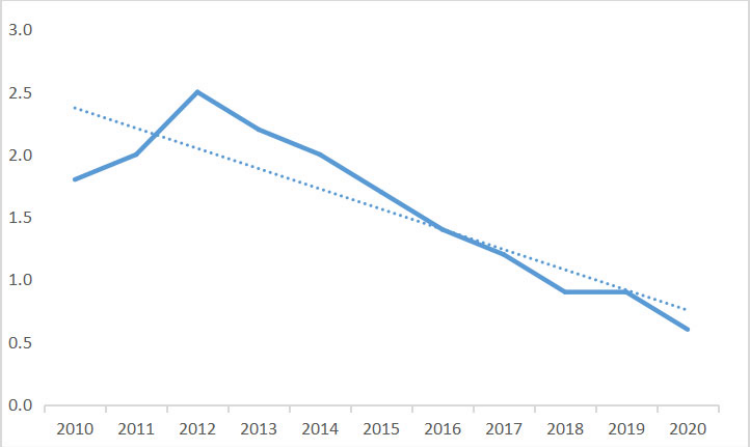

Figure 10. National Legitimacy Indicators

It can be seen from the figure that the overall national legitimacy (C11) is on a downward trend, that is, Japan's openness and its relationship with citizens gradually increase and improve over the years, which means that the fragility index is affected by the economic recession (C6) as a reverse trend. , that is, as the year increases, the fragility index gradually decreases. This is inseparable from Japan's strict laws, the specific analysis is as follows:

The rise in temperature is accompanied by the melting of glaciers, which leads to the rise of sea level, which leads to differences on the issues of marine boundaries and marine resource division. Especially for Japan, where fishing is the mainstay of the economy, strict division is required. However, Japanese servility is deeply rooted, and It will not affect the Japanese people's doubts about state institutions and processes, so it will only have an impact in a short period of time and will not affect the overall trend.

Therefore, based on the above analysis and the trend of the national legitimacy (C11) indicator, Japan will reach the maximum fragility indicator in 2012.

D. Society

Climate change has a greater impact on population pressure (C15), refugees and internally displaced persons (C16), so the analysis of temperature (C18), precipitation (C19), and abnormal climate indicators (C20) on C15, C16 Impact.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0048

Figure 11. Population pressure and internally displaced persons

It can be seen from Figure 11 that the indicators of population pressure (C15) and internally displaced persons (C16) in Japan are on the rise as a whole, that is, the fragility index gradually increases as the years increase. This is caused by climate change, and the specific analysis is as follows:

Rising temperatures, along with melting glaciers, lead to rising sea levels, resulting in a reduction in habitable land area, a surge in population pressure, and an increase in the number of displaced people, especially given the lack of habitable land in Japan and the intensification of abnormal climate indicators, exacerbated this trend. However, Japan's reclamation measures slowed down the above trend, so it showed ups and downs in some parts but an upward trend as a whole.

Therefore, based on the above analysis, Japan will reach its maximum fragility index in 2012.

4.1. Definition of Critical Point

The average of the highest fragility index and the lowest fragility index determined by all countries is taken as the critical value of the fragility index, specifically:

$$(7.675 + 1.221)/2 = 4.443$$

For the convenience of description, we set 4.5 as the critical value of the fragility index.

4.2. Japan Reaches Tipping Point Forecast

With grey forecasts, we predict future data based on 10 years of existing data to see when a critical value is reached.

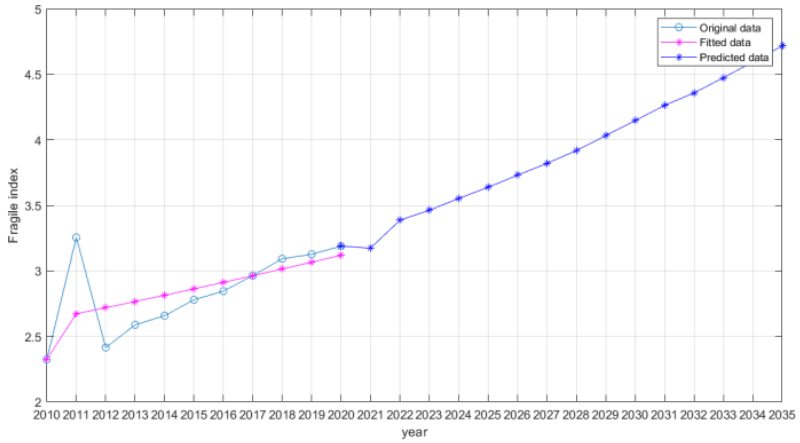

Figure 12. Grey forecast graph

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0048

It can be seen from the figure that when it reaches 2035, Japan will reach a tipping point, that is, from a low-fragility country to a medium-fragility country.

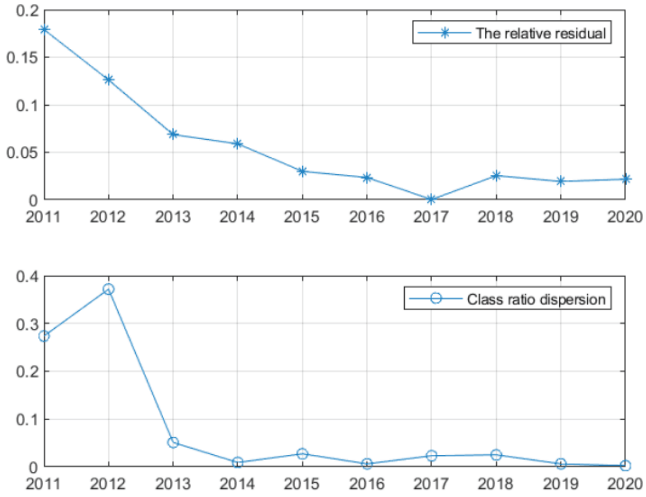

Figure 13. Residual Plot vs Mean Level Ratio Residual Plot

The average relative residual is 0.055258. The results of the residual test show that the model fits the original data very well.

5. SUMMARIZE

We use the entropy weight method, consider the climate, and combine the four aspects of cohe- sion, economy, politics, society and cross-domain to establish a national fragility index evaluation system, and obtain the final weight of each index as shown in the figure.

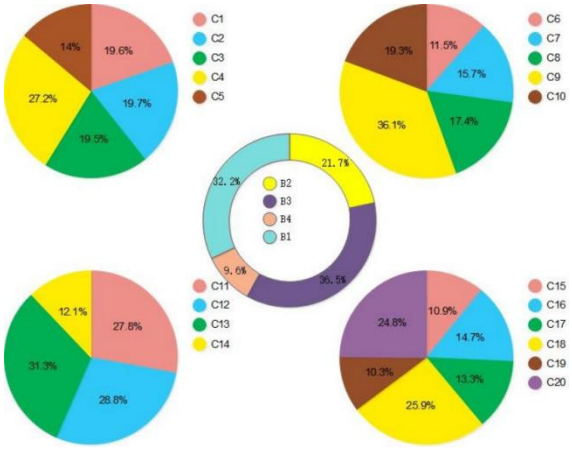

Figure 14. Weight of each indicator

Bringing the top ten fragile states of the Fragile State Index System created by the Peace Fund into our model, we conclude that Chad is the most fragile state, and the model concludes that if Chads climate improves, its fragility will be appropriately reduced.

By calculating all national fragility indicators, and establishing 4.5 as the "national fragility critical point", and using the grey forecast method, it is concluded that when 2035, the Japanese fragility indicator will reach the critical point.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202205_8(5).0048

Our paper may provide an assessment and forecast of national and regional vulnerability in the future. And the influence of climate on national vulnerability to provide reference value.

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