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2018
MCM/ICM
Summary Sheet

The problem of climate change on our planet is getting increasingly serious. Climate change has threatened politics, economy, society and other fields of the countries. In other words, it has become a significant factor in affecting the state fragility. In order to measure the extent the climate change affect the fragility of a country, we proposed a metric model to identify the state fragility. Based on this, we introduced some indexes with regard to climate change and used them to establish a model to explain how climate change affect the state fragility.

First we developed the fundamental metric of state fragility and divided it into Cohesion Metric, Economic Metric, Political Metric, Social Metric and External Intervention Metric. The detailed factors were selected to make a difference. We then established our first model to get some knowledge about the state fragile level, namely the Fragility State Index. On this basis, the climate change factors are introduced and combined to measure the impact of it on state fragility. Then we used the data from 178 countries to verify our model and found that the graph rooted our models we drew had a high coincidence with the "Fragile State Index Table" of the Fund for Peace.

Then, according to these two models, we studied two cases. Firstly, we analyzed Syria. We briefly described the basic situation of Syria , and then inserted the required Syrian data into the second model and analyzed. We made it clear that how climate change worsen the fragility of Syria. What's more, we did an analysis of Nepal and discovered in what way and when climate change may push it to become more fragile.

Next, we devised a number of direct and indirect driving interventions to mitigate climate change and prevent a country from becoming a fragile state on the basis of our model, then forecasted the effect of our interventions under some hypothesized settings. Moreover, we calculated the total cost of interventions.

To better illustrate the impact of climate change, we carried out the research in a larger context. Through the analysis of Oceania, we further optimized the model for promoting its better adaptation to the various regions of the world.

Climate Change Effects on State Fragility

1. Introduction

1.1 Background

For five years, research on "fragile states" has become a major priority issue for the international development groups[1]. Fragile states mean that national governments are unable or unwilling to provide basic necessities for their people, entangled in various violent conflicts, or political, social and economic instability. State fragility ratings help to make political risk assessment and conflict early warning accessible to policymakers and the public at large.

In order to quantify the fragility of a country, many institutions and organizations have formulated various different indexes, such as CIFP index, Global Peace Index and Political Instability Index etc. The variables of these indices are mainly concentrated on the cohesion, economic, political and social dimensions.

However, with increased drought, shrinking glaciers, the range of changing animals and plants, rising sea levels, and so on, climate change has been increasingly influential in all fields, and there is evidence that combining with weak governance and social fragmentation can trigger violent conflict, improve the vicious spiral of violence, and thus increasing the fragility of a country. Consequently, when evaluating the fragility of a country, it is utterly important to take climate change into account, especially, to focus on the impact of climate on state fragility.

1.2 Restatement of problems

The International City Management Group (ICM) raised a series of tasks for our group to deal with. These problems and our work can be restated as the following lists:

Task1. Develop a model to determine the fragility of a country: whether the state is weak, the state is fragile, or the state is stable. On the basis of this model, we introduce climate change factors to develop another model to determine the impact of climate change on state fragility and how climate change increases state fragility through direct or indirect means.

Task2. Use the models in task 1, as well as the Fragile State Index tables, to determine how climate change increases Syria's fragility.

Task3. Utilize the models in task 1 to identify how and when climate change will contribute Nepal to a tipping point where the transition from fragile to a more fragile threshold take places.

Task4. Apply the two models established in identifying some country-driven interventions that mitigate climate change and prevent a country from becoming fragile, and then interpret the effect of the interventions and predict the total cost of the interventions.

Task5. Exploit the models to determine the impact of climate change on X. If it cannot effectively determine its impact, modify the models.

Through the above analysis, the flow chart of this paper is shown in **Fig.1** as follows.

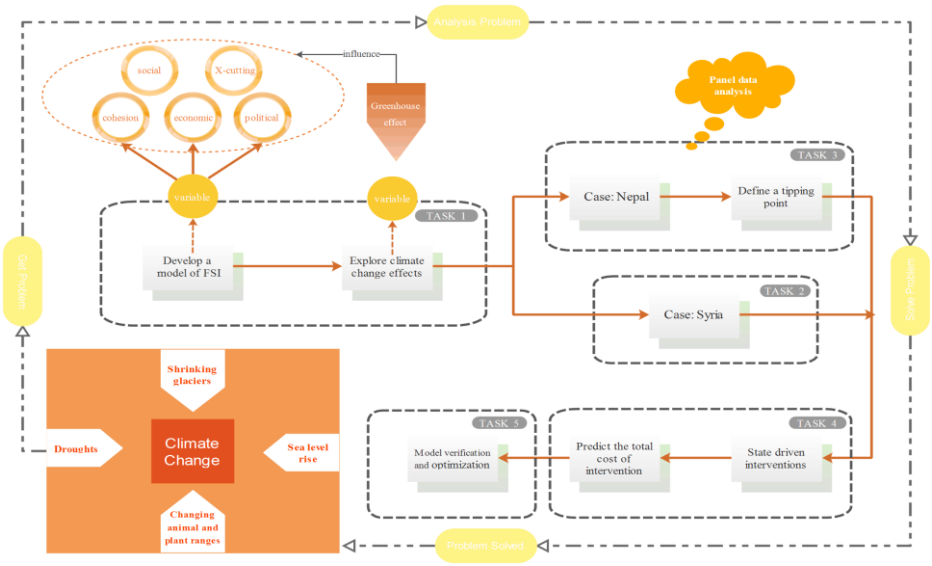

Figure.1 The flow chart in this paper

2. General assumptions

• The data collected from the online database is accurate, reliable and consistent, because our data sources are all websites of international organizations, so we can reasonably assume the high quality of their data.

• In model verification, the indicator data from countries that we neglect has little impact on the calculation of the weights and the results.

• The metric to measure the fragile state index is equally adaptable for different countries.

• For all our models, we don't consider time factor. Thus we can use the data available in the latest year to construct our model. But time is an important factor in our forecasting.

• Besides these general assumptions, there are also hypotheses we make for the specific models. We will present and discuss them in section 4 and 5.

3. Models

3.1 Model Of FSI

3.1.1 Variable descriptions

Above all, we define the abbreviation of Fragile States Index as FSI. The goal of the Fragile States Index is to measure trends in pressures within each individual state. To that end, the following section outlines what each indicator seeks to measure in the Index. To make them clearer, we classify them into five parts, cohesion, economic, political, social and cross-cutting indicators, which practically contains all the factors we want.

First of all, There are three cohesion indicators.

a) The Security Apparatus indicator considers the security threats to a state, such as bombings, attacks and battle-related deaths, rebel movements, mutinies, coups, or terrorism. It also takes into account serious criminal factors, such as organized crime and homicides, and perceived trust of citizens in domestic security.
b) The Factionalized Elites indicator considers the fragmentation of state institutions along ethnic, class, clan, racial or religious lines, as well as and brinksmanship and gridlock between ruling elites. It measures power struggles, political competition, political transitions, and where elections occur will factor in the credibility of electoral processes.
c) The Group Grievance Indicator focuses on divisions and schisms between different groups in society and their role in access to services or resources, and inclusion in the political process. Group Grievance may also have a historical component, where aggrieved communal groups cite injustices of the past, that influence and shape that group's role in society and relationships with other groups.

Meanwhile, there are three economic indicators:

a) The Economic Decline Indicator considers factors related to economic decline within a country. It is measured by per capita income, Gross National Product, unemployment rates, inflation, productivity, debt, poverty levels, or business failures. It also takes into account sudden drops in commodity prices, trade revenue, or foreign investment, and any collapse or devaluation of the national currency.
b) The Uneven Economic Development Indicator considers inequality within the economy, irrespective of the actual performance of an economy. The Indicator considers not only actual inequality, but also perceptions of inequality, recognizing that perceptions of economic inequality can fuel grievance as much as real inequality, and can reinforce communal tensions or nationalistic rhetoric.
c) The Human Immigrant and Brain Drain Indicator considers the economic impact of human displacement and the consequences this may have on a country's development. On the one hand, this may involve the voluntary emigration of the middle class. On the other hand, it may involve the forced displacement of professionals or intellectuals who are fleeing their country due to actual or feared persecution or repression.

Thirdly, the following three are political indicators.

a) The State Legitimacy Indicator considers the representativeness and openness of government and its relationship with its citizenry. The Indicator takes into account openness of government and considers the ability of a state to exercise basic functions that infer a population's confidence in its government and institutions, such as through the ability to collect taxes.
b) The Public Services Indicator refers to the presence of basic state functions that serve the people. On the one hand, this may include the provision of essential services, such as health, education, water and sanitation, transport infrastructure, electricity and power, and internet and connectivity. On the other hand, it may

include the state's ability to protect its citizens, such as from terrorism and violence, through perceived effective policing.

c) The Human Rights and Rule of Law Indicator considers the relationship between the state and its population insofar as fundamental human rights are protected and freedoms are observed and respected. The Indicator looks at whether there is widespread abuse of legal, political and social rights, including those of individuals, groups and institutions.

Fourthly, the following three are political indicators.

a) The Demographic Pressures Indicator considers pressures upon the state deriving from the population itself or the environment around it. The Indicator considers demographic characteristics, also takes into account pressures stemming from natural disasters and pressures upon the population from environmental hazards.

b) The Refugees and Internally Displaced Persons Indicator measures the pressure upon states caused by the forced displacement of large communities as a result of social, political, environmental or other causes, measuring displacement within countries, as well as refugee flows into others.

Last but not least, there is also a cross-cutting indicators which is an external intervention. The External Intervention Indicator considers the influence and impact of external actors in the functioning –particularly security and economic – of a state.

3.1.2 The Foundation of model

For the 12 indicators we presented in the previous section, we first analyze whether there is a correlation between them by drawing a chart and stepwise regression. It is shown as fellows in **Fig.2**.

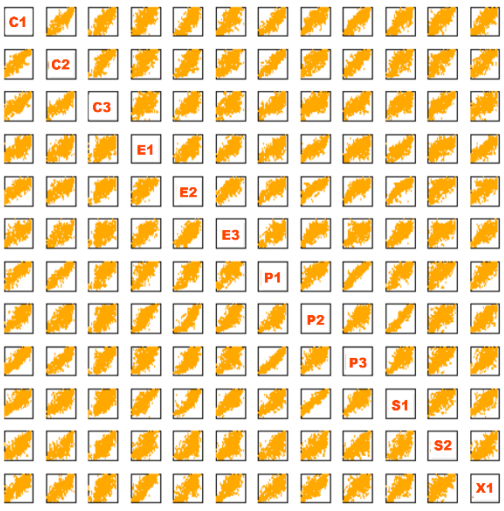

Figure 2 correlation between the indicators

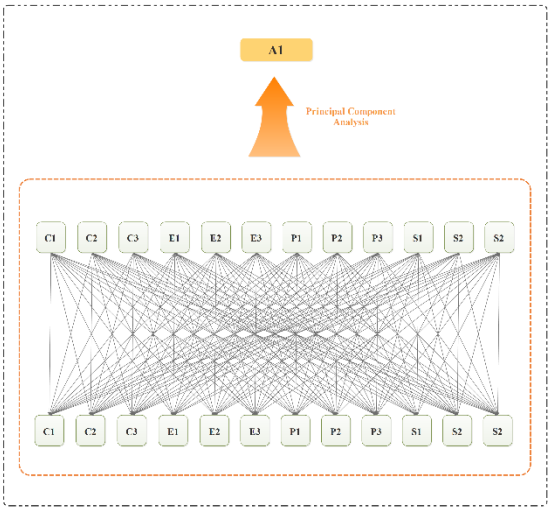

Figure 3 schematic diagram of indicators

As we can see in the picture, Obviously, there's a strong relationship between them. Therefore, we will carry out a Principal Component Analysis of them, aiming at eliminating the correlation between the indicators[2,3]. After analyzing by R, we can draw the conclusion that all the indicators can be summarized as one variable which

we entitle it as A_1 .

$$A_1 = -0.306C_1 - 0.298C_2 - 0.262C_3 - 0.275E_1 - 0.288E_2 - 0.269E_3$$

$$-0.304P_1 - 0.303P_2 - 0.294P_3 - 0.3S_1 - 0.274S_2 - 0.287X_1$$

After defining A_1 , we have a regression analysis of it and Y .

$$Y = -7.636A_1 + 71.172$$

$$Y = 2.337C_1 + 2.276C_2 + 2C_3 + 2.1E_1 + 2.2E_2 + 2.254E_3$$

$$+2.321P_1 + 2.314P_2 + 2.245P_3 + 2.29S_1 + 2.09S_2 + 2.192X_1$$

According to the software running results, we can see that the t value is very small, which means that the regression coefficient is significant. At the same time, the R-Squared value is close to the Adjusted R-Square value approaching to 1, therefore, the high goodness of fit is extremely high.

To further verify the accuracy of our model, we conduct a residual normality test next, its results are shown in **Fig.4**. On the basis of it, the residuals do not have the heteroscedasticity and strictly obeys the normality. Multiple results show that the model is very reliable. By the way, the graph rooted our models we drew had a high coincidence with the "Fragile State Index Table" of the Fund for Peace.

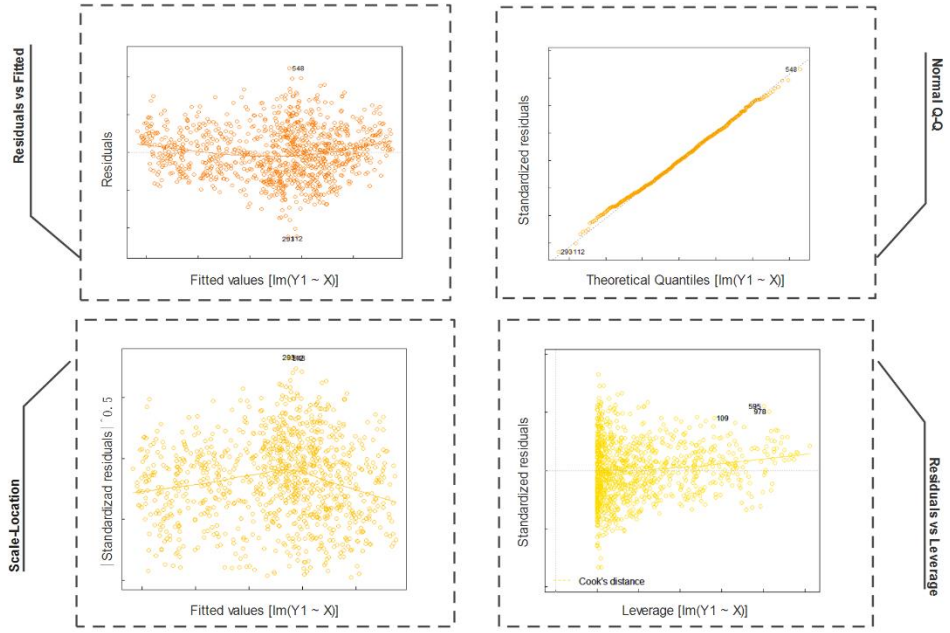

Figure 4 residual test result diagram

3.2 Model Of Climate Change Effect

3.2.1 Variable Descriptions

In this part, we will identify how climate change increases fragility through direct means or indirectly. There are two dimensions of time series and cross section. In order to analyze this, we selected ten climate-related variables from publicly-available datasets together with time series. An overview of these variables and our justification for their selection is presented in **Tab.1** below.

Table 1 Example of the table

Variable	Units	Justification
Cereal yield	kg per hectare	Bad weather affects grain production.
Energy use per units of GDP	kg oil eq./ US $	The reduction in energy savings limits our use of energy.
CO2 emissions per capita	metric tons	CO2 emissions promote the greenhouse effect.
GHG net emissions	metric tons	GHG net emissions promote the greenhouse effect.
Nationally terrestrial protected areas	% of total land area	Increasing the protection zone can ease the vulnerability.
Forest area percentage	% of total land area	Climate change affects the growth of trees.
Population growth	annual % increase	Population growth will accelerate greenhouse gas emissions.
Urban population growth	annual % increase	Agriculture affects by the climate, so that the rural population move to the city.
Sea level height	mm	The melting of glaciers makes the sea level rise.
Annual precipitation	mm	Precipitation affects the growth of plants and animals.

3.2.2 The Construction of Model

Different countries in the world contain different variables, which are cross section data. At the same time, we have to analyze the correlations between them and time.

Due to we need to take multiple sections on the time series and select sample dat a from the sample observations at the same time, we analyze the data by Panel data an alysis. We choose 30 major countries' data from 2006 to 2017, as well as each country has 10 indicators.

Above all, we use unit root test to analyze the stability of each variable to preven t it from false regressions and spurious regression. As a result, all of the p-value are u nder 0.05, which means that they pass the test. Then, we run the EVIEWS software to make Panel data analysis and the coefficients and p-values for each variable in this m odified model are presented in **Tab.2**. From them, we can learn that how the direct or indirect indicators increase fragility and the model fits well.

Table 2 Correlation coefficient of variable

Variable	Coefficient	Prob.
Cereal yield	-0.003750	0.0030
Energy use per units of GDP	0.049064	0.0000
CO_2 emissions per capita	1.978964	0.0019
GHG net emissions	0.034520	0.0221
Nationally terrestrial protected areas	0.047789	0.0568
Forest area percentage	-3.702194	0.0049
Population growth	1.978961	0.0605
Urban population growth	0.141421	0.0847
Sea level height	69.01521	0.0000
Annual precipitation	-0.234409	0.0200

3.3 Evaluation of the model

Strengths:

a) Our metric for the ability to manage state fragility, cohesion, economic, political, social, and external interventions are easily calculable and encompass nearly all drivers. Besides, the data required in the model can be obtained in the database of international organizations. Thus, it can be easily applied to identify state fragility level for most countries.

b) We apply Principal Component Analysis to cut off the correlation between the indexes. Thus, the model is objective and convincing.

c) The model is easy to understand, and easy to use, as long as the input of the country's data, we can know the fragility of the country.

Weakness:

a) After the Principal Component Analysis is done and the independent variables are decomposed and integrated, our final model is a unitary equation. But in the wider field of knowledge, the model is likely to be more complex and accurate.

b) When we determine whether a country is weak, fragile or stable based on the results of the model, there is a certain degree of subjectivity. They are highly dependent on our subjective judgment and are somewhat undesirable.

4.Cases Study

According to the above analysis, we divided all the countries into three sections by fragile, vulnerable, or stable**(Fig.5)**. Then we choose two countries, Syria and Nepal, discussing in depth that how climate change affect fragility through direct means or indirectly.

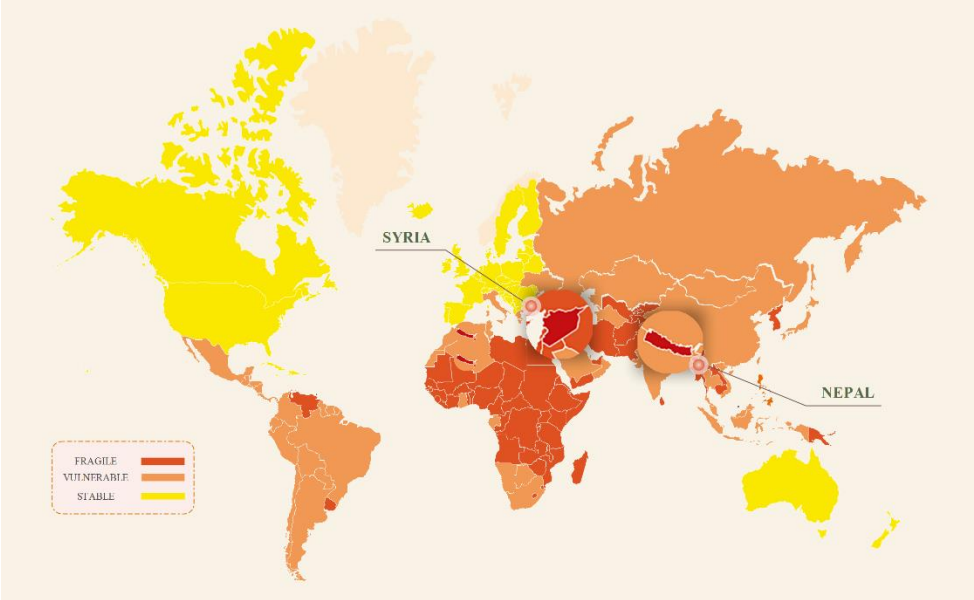

Figure 5 national fragility map

4.1 Syria

4.1.1 Country Profile

The Syrian Arab Republic, or Syria, which is well-known for its continuous chaos caused by war, is located in the west of Asia, on the eastern shore of the Mediterranean Sea, with a total area of 185180 square kilometers. It is a middle-income country, which located in the center of Middle East with the most abundant oil and natural gas. Its main sources of economy are agriculture, petroleum, processing industry and tourism.

The fertile crescent zone of agriculture has been born 12 thousand years ago, and it has experienced the worst drought recorded since 2006. At the same time, the rainfall has been reduced in the region for a long time, and Global warming has led to a global increase of temperature. With the unsustainable agricultural policies, that drought has led to a general collapse of agriculture in the northeastern part of Syria. According to a report by the International Institute for Sustainable Development, between 160 and 220 villages were abandoned due to drought[4]. And after 2006, a million Iraqi refugees entered Syria, and then lots of rural families came to the city. Many displaced people live on the edge of the city, and the lack of electricity has made this difficult living condition worse.

To make matters worse, the state institutions are fragmented along ethnic, class, clan, racial or religious lines, as well as the brinksmanship and gridlock between ruling elites. Not to mention the security threats in this country, such as bombings, attacks and battle-related deaths, rebel movements, mutinies, coups, or terrorism.

Syria as one of the top 10 most fragile states as determined by the Fragile State Index, we will discuss how climate change influence the fragility of it in the following

section.

4.1.2 Application of the model to Syria

Our goal in this section is to apply our Refined Model to the country of Syria, using it to determine how climate change may have increased fragility of that country. According to the result of last section, by determine the coefficients of variables are positive or negative, we can learn how these indicators affect fragility of a country. That is to say, there is a positive correlation between the independent variable and the dependent variable if the coefficient is positive and vice versa. As a result, animal growth as well as forest area percentage going down, the increasing of sea level height and the reduction of annual precipitation, The rise in greenhouse gas emissions and energy use are all the reason on deteriorating the fragility of state.

Next, let's see how climate changes affect Syria specifically.

Population growth, poor agricultural policies, aggressive economic liberalization policies and the influx of Iraqi refugees had all placed an unsustainable burden on water resources, including rainfall and groundwater resources. The severe drought triggered an agricultural collapse and an internal displacement of entire rural farm families, it utterly unlike the usual seasonal labor migrations or the rural-to-urban migration from prior years[5].

Climatic change was a contributory factor in the extreme drought experienced within Syria prior to its civil war; this drought in turn led to large-scale migration; and this migration in turn exacerbated the socio-economic stresses that underpinned Syria's descent into war[6]. Simultaneously, as Oil has faced a drying up situation, Syrian has sunk into the plight of economic, politics, society and so forth.

Apparently, be plagued by non-sustainable environmental practices, migration, and resource shortages, and as a fragile state, Syria is more vulnerable to the impact of such climate shocks as natural disasters, decreasing arable land, unpredictable weather, and increasing temperatures.

The Syrian case has potentially important policy implications, especially about the way that political, military and development institutions accommodating changing global climate.

4.2 Nepal

4.2.1 Country Profile

Federal Democratic Republic of Nepal, abbreviated to Nepal. It is a landlocked country of South Mountain, located in the southern Himalaya. North meets China, the remaining three are adjacent to India. The total area of the country is 147 thousand square kilometers, with a total population of about 28 million 500 thousand. Nepal is an agricultural country. 80% of the population is engaged in agricultural production. It is one of the most underdeveloped poor countries in the world[6].

Including Mount Everest, the world's ten largest peak of eight in Nepal border. Therefore, In recent years, Nepal is facing many environmental problems, such as melting glaciers. Besides, the Blue Lake is likely to burst and cause floods, flood

accidents are more frequent, debris flows often happen and rain patterns change. It has great influence on Nepal's agricultural system. When the tide is rising, the tide will rise especially high, drowning their coastline, and the problem is getting worse and worse. In some parts of the country, the whole village was forced to migrate. With the invasion of the sea water, the crops were destroyed and the fresh water was polluted.

Nepal is located at the junction of India plate and Eurasian plate. The earthquake in the area of Himalaya is related to global warming. The major earthquakes in history occurred in the middle and late stage of global warming. The melting of glaciers caused by global warming and the rising of sea level in India ocean exacerbated the speed and intensity of the northward movement of India continent[8]. Himalaya Range and the world ice melting led to the sea-level rise, destroyed the original crust, then crustal movement formed the continental crust and oceanic crust rise decline. The Tibetan Plateau is the roof of the world, as nearly 30 years of ice melting significantly, apparently is the most serious area of isostasy issue. Nepal, located around the Himalaya Range, is also greatly affected by it.

4.2.2 Estimate the Tipping Point

In this subsection, we forecast when climate change may push it to become more fragile in Nepal based on the theory stated in section 3. The key of our forecast model is how to deal with the uncertainty of environmental and fragile factors. Due to the complexity of the uncertainty, we apply Grey Forecasting Model(GFM) to solve this problem.

If a set of time series data has obvious trend, Grey Forecasting Model in the Grey System Theory can give a precise prediction. Based on the result of above regression, we apply GM(1,1) model, the most widely used Grey Forecasting Model, to forecast the value of 10 factors in ESM model. For each factor, we use the data from 2006 to 2017, which is sufficient for GM(1,1) model. It can be calculated by the DPS data processing system. To get the tipping point, we calculate and summary the variables change data since 2018 and stop when we get a rising phenomenon in the vulnerability. By analyzing, the predicted value of fragility of Nepal is turning to ascend in 2030.

To make the result clearer, we have only selected integer time points to present. The rows in **Tab.3** shows the predicted value in 2020,2025 and 2030 using GM(1,1) model, together with the respective value in 2017 and the forecast error. As a comparison, we also show the change data of Fragility State Index as an indicator in the table.

From the table, the forecast error is quite small, implying the good performance of the model. According to the results, more and more rural people will move to the downtown, the greenhouse gas emissions will increase, sea level height is rising apparently, which has a great impact on the country of Nepal. Although at the same time, it can be clearly seen that the national intervention policy is playing a role. As a result of the blending of two kinds of counterforces, we can predict in 2030, Nepal will reach the tipping point of more fragile.

Table 3 Factor Prediction Results in ESM Model

	2017	2020	2025	2030	Error [%]
Cereal yield	2210.13	2218	2361.1	2373.9	0.018
Energy use per units of GDP	333.54	334.02	325.23	323.23	0.058
CO2 emissions per capita	0.11	0.12	0.12	0.12	0.01
GHG net emissions	8.02	8.11	8.32	8.53	0.4
Nationally terrestrial	5.22	5.34	5.65	5.78	3.646
Forest area percentage	25.36	25.36	25.22	25.12	4.47
Population growth	1.65	1.5	1.44	1.32	0.58
Urban population growth	4.32	4.47	5.11	5.63	1.85
Sea level height change	0	6	20	33	4.09
Annual precipitation change	0	-1	-2.3	-2.4	1.122
Fragility State Index	93.4	91.8	90.5	92.2	/

5. Interventions

5.1 interventions Statement

Based on our analysis, we put forward some driven interventions to mitigate the risk of climate change and prevent a country from becoming a fragile state, consisting of direct and indirect interventions.

Direct Interventions:

a) The construction of water conservancy facilities. The government should lay more emphasis on the west water transmission project, and increase the reservoir construction, promote water - saving irrigation methods such as drip irrigation, so as to alleviate the problem of drought[9].
b) Reduction of fluorocarbons. The government should attach more attention on the development of decomposition techniques for CFCs or searching alternatives to CFCs.
c) Increase connectivity to facilitate species migration. One is to increase connectivity between protected areas, that is, to expand the area of protected areas, while increasing the protection of shelters and migration corridors that are least affected by climate change.
d) Carry out afforestation. Actively implement the protection of natural forests, returning farmland to forests and grass, artificial afforestation, grassland construction and forest management, so that protecting ecological diversity.
e) Strengthen the restoration and reconstruction of coastal wetlands, mangroves, coral reefs and other ecological system. Besides, Control the groundwater exploitation and effectively control the ground subsidence.

Indirect Interventions:

a) Carbon tax and carbon trading combination: carbon trading is aimed at a fixed

number of large emission sources, carbon tax is used to cover carbon dioxide emissions trading industries, the two functions complement each other to reduce greenhouse gas emissions.

a) Adopt a series of financial support measures for the use of low carbon and renewable energy as well as for the production and consumption of energy efficiency. Demonstration projects and R&D activities of various renewable energy sources, such as offshore wind energy, biomass and solar energy, and related technology, including fuel cells, micro-power generation [10]. And significantly increase the proportion of "green" electricity, for instance, encouraging the purchase of "green" vehicles using biofuels or ethanol, and granting tax incentives.
b) Control the population growth to control of greenhouse gas emissions. China is a good reference, where the "One-Child" policy was implemented for several decades and made some progress in controlling population.
c) Seek international cooperation. Introduce international advanced climate friendly technology and share experience and lessons, meanwhile, provide financial, technical and product support for developing countries.

In short, according to our model, some interventions to mitigate climate change are shown. However, the implementation of our interventions may lead to large expenses, diplomatic disputes and other adverse effects. There are also some interventions that may take a long time to work, or to accelerate economic development and technological progress, which may not be easy to implement.

5.2 The effect of human intervention

We assume that the trend of the countrys' development remain unchanged and that the above interventions can be effectively implemented. Based on these hypothesis, we can forecast the effect of human intervention as follows.

Through a series of direct interventions in 5.1, the state could promote water recycling, conservation, wider play a role, but also could slow down the rate of melting of glaciers, as well as a whole string of effects it causes, including rising sea level、water shortages and polar species extinction, in addition, these interventions expand the scope of animal activities, vegetation coverage , thereby protecting biodiversity.

At the same time, the policy of combining carbon tax with carbon trading enforced by laws and regulations, as well as financial support for low-carbon energy and renewable energy, Policy enforcement and market freedom complement each other and are implemented to citizens and enterprises, directly related to their vital interests, and given a certain freedom of choice[11]. In both active and passive aspects, they are urged to reduce greenhouse gas emissions[12]. Also, controlling the size of the population is of great significance for reducing carbon emissions. In a sense, the family planning policy is one of the most cost-effective ways to reduce carbon emissions, for instance, China, with 400 million fewer births over the past 30 years, is now reducing its carbon dioxide emissions by 1.83 billion tons a year, based on current per capita carbon dioxide emissions of 4.57 tons. As far as the world is

concerned, controlling the size of the population brings about even more climate change[13,14]. Furthermore, the states actively needs international cooperation, strengthened exchanges and mutual supervision and encouragement. It is estimated that if the Paris climate agreement is fully implemented, it is expected that the gas emission by 2030 will still maintain the trend of rising temperatures, which could rise 2.9 to 3.4 degrees by the end of the century.

If these interventions can be implemented well, they will largely alleviate climate change, thereby preventing a country from becoming a fragile state and promoting a country's economic vitality, political stability, social stability and people's happiness.

5.3 The Estimated Total Cost of Intervention

To estimated total cost of interventions taken by the state, we first classify it into two parts: The Cost of Environment Control and The Environment Opportunity Cost. The formal one consists of the cost of direct elimination of pollutants and the reduction of the residual amount of pollution, as well as costs paid to eliminate the harmful environmental effects caused by pollutants[15]. Meanwhile a variety of direct and indirect costs or losses paid to eliminate the effect of pollution together with the loss of other investment opportunities because of the investment on eliminating the pollutants[16]. Their relationship is reflected in **Fig.6**.

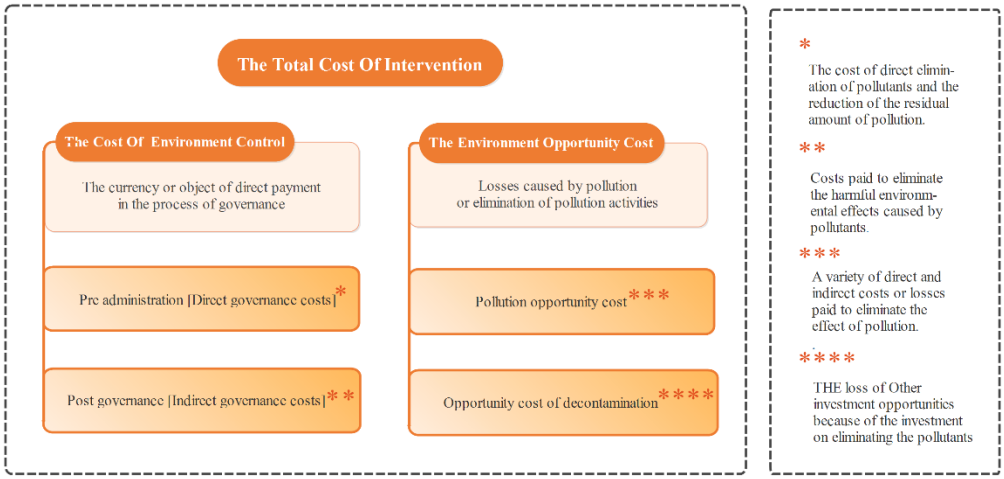

Figure 6 classification of total cost

It is quite easy to calculate the Cost of Environment Control, we could just add the direct and indirect costs of enterprises and governments to pollution control together. However, it is a tough problem to estimate the Environment Opportunity Cost. In order to solve this problem, we will introduce the input-occupancy-output method.

Above all, here is a general introduction of input-occupancy-output form as **Tab.4** and **Tab.5**.

Table 4 Input-occupancy-output form

		1	2	3	Total output
1	Other departments	X_{11}	X_{12}	Y_1	X_1
2	Environmental department	X_{21}	X_{22}	Y_2	X_2
3	Initial input	V_1	V_2	0	
4	Pollution discharge	E_1	E_2	E_3	E_N
5	Decontamination rate	η_1	η_2	η	

Table 5 Interpretation of indicators

The Explanation of the Index	
V_j	Net surplus or net surplus of various departments
Y_i	Department I products used for the amount of capital formation
X_{1j}	General input-output flow
X_{2j}	Section J investment in the direct purpose of environmental protection
V_2	It does not reflect the operating profit of the environmental protection department, and there is a considerable portion of the transfer payment, and the use is the fund for environmental protection.
E_j	Pollution emissions from sector j.
η_j	The elimination rate of pollution in various departments.

The total social environmental cost in the table should belongs to the direct governance cost of eliminating pollutants. The Environment Opportunity Cost is defined that the direct governance opportunity cost of department j is the total value of the product created when the j sector is used to expand reproduction, defined as ΔX_j.

Suppose that the average marginal capital occupancy of department J is, then there is:

$$X_{2j} = (k_j + a_j)\Delta X_j$$

Thus, the direct governance opportunity cost of department j is:

$$\Delta X_j = \frac{X_{2j}}{k_j + a_j}$$

As an explanation: $a_j = \sum_i a_{ij}$, a_{ij} is the direct consumption coefficient in the general input - output table.

According to **Tab.4** and **Tab.5**, the total social opportunity cost can be estimated to be:

$$\Delta X_1 = \frac{X_2}{k_1 + a_{11}}$$

6. Model Optimization

Oceania is the smallest continent in the world. There are 14 independent countries. The level of economic development in different countries is significant, Australia and New Zealand are developing economically, while other island countries are mostly agricultural countries and their economy is relatively backward. Industry is also mainly concentrated in Australia, followed by New Zealand. The total of about 29 million people in Oceania is one of the world's least populated continents except Antarctica. It accounts for about 0.5% of the world's population. 65% of the population of the whole continent is distributed in the Australian continent. There are significant differences in population density in each island country.

We use the data of Oceania to test the model we established above and find that the model is not applicable to it. We speculate that it is the population occupation ratio that affects the applicability of the model. As we all known, Australia is a sparsely populated country. The Australians consume less cars and cattle, thus emission less CO2 and other greenhouse gases. Therefore, we add an indicator to optimize our model as follows(**Tab.6**):

Table 6 Correlation coefficient of variable

Variable	Coefficient	Prob.
Cereal yield	-0.003526	0.0030
Energy use per units of GDP	0.047035	0.0420
CO_2 emissions per capita	-1.848359	0.0000
GHG net emissions	-0.043762	0.0000
Nationally terrestrial protected areas	0.053327	0.0453
Forest area percentage	-3.289322	0.0946
Population growth	1.821734	0.0684
Urban population growth	0.169382	0.0762
Sea level height	65.352643	0.0032
Annual precipitation	-0.437281	0.0000
Population ratio	-2.897462	0.0232

7. Conclusions

This paper has argued that climate change undermines the fragility of states in the present day and will increasingly do so in the future. It does this by reducing people's access to natural resources that are important to sustain their livelihoods. Climate change is also likely to undermine the capacity of states to provide the opportunities and services that help people to sustain their livelihoods, and which help to maintain and build peace. In certain circumstances, these direct and indirect impacts of climate change on human security and the state may in turn increase the risk of violent conflict.

It seems evident that climate change poses risk to human insecurity principally through its potentially negative effects on people's well-being. This is the a priori reason why climate change is of great concern to many people. Therefore, there is need for considerably more research on the ways it may undermine human security, not least because the level of understanding of state fragility is still sufficiently uncertain for the purposes of designing effective adaptation strategies.

In this paper, we develop a model of the Fragile States Index and explore climate change effects accurately. Based on these outcomes, we conceive some state driven interventions to deal with the problem. We concluded that these could be much more effective in the long term assuming that they are properly implemented by governments.

All in all, people are supposed to enhance the understanding of how climate change increases fragility through direct means or indirectly, including explore the state driven interventions which could alleviate the risk of climate change and prevent a country from becoming more fragile.

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