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A Tipping Point and Predict Method to Protect Sustainable Development from Being Fragile

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Abstract: Combining with the actual conditions of Venezuela, we apply fuzzy synthetic evaluation models based on analytic hierarchy process to calculate the tipping point that makes the country fragile. Then, we establish a gray forecasting model and predict that the climate change will push the country to more fragile by indirectly affecting food production, water supply, natural disasters and economy in 3 years. Finally, we have reason to believe that the government can effectively mitigate the impact of climate change on the state fragility through some human intervention.
Keywords: Climate change; fragile states; analytic hierarchy process; fuzzy synthetic evaluation models.

INTRODUCTION

Climate change is one of the principal challenges of our era, its adverse effects on the global environment are unequivocal [1]. Many of these effects will alter the way humans live, and may have the potential to cause the weakening and breakdown of social and governmental structures. Consequently, destabilized governments could result in fragile states [2]. The effects of Climate Change, to include increased droughts, shrinking glaciers, changing animal and plant ranges, and sea level rise, are already being realized and vary from region to region.

Through the analysis by FSI, we find that Venezuela is becoming more and more vulnerable. So we should determine the tipping point about country's fragility and predict when a country may reach it.

METHODS

Fuzzy comprehensive evaluation

Firstly, we use AHP determine the weight for each indicators based on the correlational assumptions.

The result is

Table-1: The weight of each indicator

Indicators x_i	**Weight α_i**
Water supply （x_1）	0.2700
Food production （x_2）	0.2700
Energy （x_3）	0.0799
Rule of law （x_4）	0.0322
Governance （x_5）	0.1473
Corruption and abuse of office （x_6）	0.0695
Economic decline （x_7）	0.0361
External intervention （x_8）	0.0475
Natural disaster （x_9）	0.0475

Then, we establish a fuzzy comprehensive evaluation model to judge the condition of a state. We assume that the fragile states index is$\{x_1, x_2, \cdots x_i\}$. Then the model of national vulnerability assessment is

$$y = \sum_{i=1}^{9} \alpha_i x_{iscore} \qquad (1)$$

Where, y denotes comprehensive evaluation score, α_i demotes the weight of each evaluation indicator, x_{iscore} denotes the score of each evaluation indicator.

We find the score of the weight of each evaluation indicator, and calculate the score of each country to identify when a state is fragile, vulnerable, or stable.

Table-2: The definition of the state's fragility

Condition	**Range of the score**
Fragile	>7.5
Vulnerable	≥5~7.5
Stable	<5

Venezuela's condition

In the Venezuela, the main natural disaster in this country is floods. From the comprehensive score, we know that when a state's overall score is greater than 7.5, the state becomes very fragile. Therefore, we use as a reference value for a stable state. However, there are many other factors that affect the comprehensive score of a country. In order to consider only the impact of climate change, we assume that in the coming years, several factors that are not related to climate change are stable. The evaluation index score sheet of Venezuela in the past five years is shown as the table below.

$$\mathrm{y} = \sum_{i=1}^{9} \alpha_i x_i = 7.5 \ (1)$$

Table-3: The evaluation index score sheet of Venezuela in the past five years

Indicators	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
2017	7.5	7.1	7.2	8.5	7.3	5.7	7.3	5.4	6.4
2016	7.3	6.8	6.9	8.3	6.8	5.8	7.0	5.6	5.9
2015	6.9	6.6	6.6	8.2	6.5	5.7	6.5	4.3	5.7
2014	6.8	6.5	6.4	7.8	6.2	5.8	5.5	4.6	5.4
2013	6.5	6.2	6.2	7.7	6.5	5.6	5.4	4.9	5.2

First, the comprehensive score of the evaluation index that can be calculated from the model 1 is

$$\mathrm{y} = \sum_{i=1}^{9} \alpha_i x_{iscore} = 7.09 \ (2)$$

Because we only consider the impact of climate, y' will not change much in the next few years. So, predicting when a country becomes fragile is to predict when x will grow so large that it adds y to reach the threshold of 7.5. y is also affected by the x evaluation index, so we need to predict the changes of each evaluation index in the future. Therefore, we establish a gray prediction model.

Build Grey Model

Step-1: Data inspection and processing

To ensure the feasibility of the GM modeling method, we need to test the known data. Let the original data be listed as $x^{(0)} = \left(x^0(1), x^0(2) \ldots\ldots\ x^0(i)\right)$, then calculate the rank of the series.

$$\lambda(k) = \frac{x^0(k-1)}{x^0(k)} \quad , k = 2, 3, \ldots, i \qquad (3)$$

If all levels fall within the allowable coverage area $x = \left(e^{\frac{-2}{i+1}}, e^{\frac{2}{i+1}} \right)$, then the sequence x^0 can establish a GM model and can be gray-predicted. Otherwise, the data need to be properly transformed, such as translation transformation.

$$y^{(0)}(k) = x^{(0)}(k) + c \quad , k = 1, 2, \ldots, i \qquad (4)$$

The value of c needs to make the rank of data columns fall within the allowable coverage.

Step-2: Establish Grey Model

Let x satisfy the above requirement and use it to establish a Grey Model for the data column.

$$x^{(0)}(k) + az^{(1)}(k) = b \qquad (5)$$

Using regression analysis to obtain the estimated values of a and b, then we get the corresponding albino model.

$$\frac{dx^{(1)}(t)}{dt} + ax^{(1)}(t) = b \qquad (6)$$

$$x^{(1)}(t) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-a(t-1)} + \frac{b}{a} \qquad (7)$$

Then we get the predicted value.

$$\hat{x}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-ak} + \frac{b}{a} \quad , k = 1, 2, \ldots, i-1 \qquad (8)$$

Thus, the predicted value is obtained accordingly.

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k) \quad , k = 1, 2, \ldots, i-1 \qquad (9)$$

Step-3: Test the predicted value

Calculate the relative residual.

$$\varepsilon(k) = \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)}, k = 1,2, \ldots, i \quad (10)$$

If all results satisfy$|\varepsilon(k)| < 0.1$, the higher requirements are considered; If all results satisfy$|\varepsilon(k)| < 0.2$, the general requirements are considered.

Test the level deviation.

$$p(k) = 1 - \frac{1-0.5a}{1+0.5a}\lambda(k) \quad (11)$$

If all results satisfy$|p(k)| < 0.1$, the higher requirements are considered; If all results satisfy$|p(k)| < 0.2$, the general requirements are considered.

Draw the conclusions

After MATBLA programming calculations, we predict the changes of various evaluation indicators as follows:

Table-4: Changes in Venezuela's evaluation indicators

Indicators	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
2018	7.6	7.2	7.3	8.7	7.3	5.7	7.5	5.2	6.6
2019	7.8	7.4	7.5	8.8	7.5	5.6	7.8	5.4	6.9
2020	8.1	7.6	7.6	8.7	7.4	5.8	8.0	5.3	7.3
2021	8.2	7.7	7.8	8.9	7.6	5.7	8.1	5.6	7.5
2022	8.4	7.9	7.9	9.1	7.8	5.9	8.3	5.4	7.6

Based on the predicted values, we can find that in the next few years, the indicators of great change include: water supply, food production, energy, economic decline, natural disasters and so on. By calculating the Venezuelan comprehensive evaluation score, we found that in 2020.

$$y = \sum_{i=1}^{9} \alpha_i x_{iscore} = 7.51 > 7.5 \quad (12)$$

Therefore, we believe that in two years, Venezuela will make the country very vulnerable by affecting factors such as water supply, food production, energy, economic decline and natural disasters.

Improve

Through our model, we can see that climate change push Venezuela to be more fragile by means of floods. If no measures are taken to intervene, the state is very likely to enter the fragile state by 2020.

Measures and budget

Floods and debris flows can occur episodically the northern coast of Venezuela they are mainly induced by intense and prolonged rainfall. Due to the abundant precipitation, a dam of comparable size to the Guri dam was constructed on the northern coast of Venezuela, supplying Venezuela with electricity and increasing food imports.

To prevent Venezuela becoming fragile, the following measures are proposed based on the impact indicators.

a) Construction of dams to reduce flood hazards while increasing resources such as electricity;
b) afforestation, water and soil conservation;
c) increase food imports and alleviate the food crisis
d) Economic policies to stimulate economic growth
   - Make living affordable
   - Stabilize the currency
   - Eliminate dysfunctional price controls
   - Adjust to lower international oil prices

To promote these disaster prevention measures, it is necessary to have funds. To estimate the total cost of these measures, we provide the following table for the implementation of various measures:

Table-5: Total cost

Methods	**A**	**B**	**C**	**D**
Cost（100 million dollars）	8	0.1	0.6	2

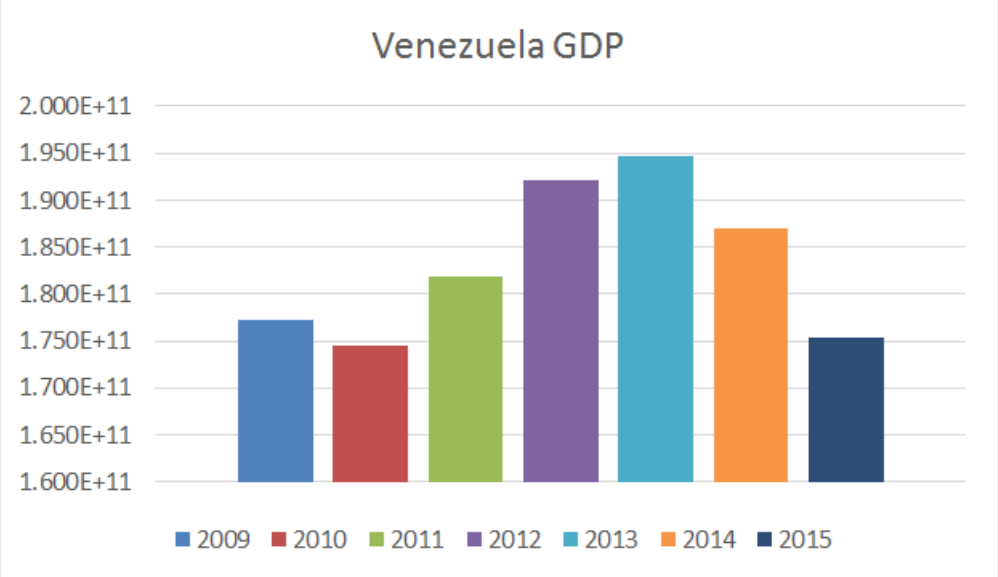

Fig-5: Venezuela GDP

However, considering Venezuela's gross domestic product ($ 17 billion), it found it unable to separate out so much of its GNP in managing the environment. Therefore, according to international experience, the environmental deterioration can be controlled when the investment in environmental pollution control accounts for 1% -1.5% of the GDP. When it reaches 2% -3%, the environmental quality can be improved. Therefore, 3 per cent of Venezuela's gross national product can be spent on implementing measures to improve the environment. Therefore, it is estimated that the country will need to take a total amount of 500 million U.S. dollars annually to implement these disaster prevention measures.

Analyze the effects

Climate change is closely linked with the evaluation indicators such as food, freshwater resources and natural disasters.

From the theoretical analysis, if the risk of climate change can be mitigated by man-made measures, the evaluation index will be lowered, and then the comprehensive evaluation of national vulnerability will be reduced, thus avoiding the country becoming a "fragile country."

From the actual situation analysis, a country can take appropriate measures to reduce the damage caused by disasters to the country, avoid casualties and economic losses, and reduce the disasters that weaken the government's credit. Therefore, man-made interventions are necessary and effective.

CONCLUSIONS

Through our research, we establish fuzzy synthetic evaluation models based on analytic hierarchy process to determine a country’s fragility and simultaneously measures the impact of climate change. Then, combining with the actual conditions of Venezuela, we apply fuzzy synthetic evaluation models to calculate the tipping point that makes the country fragile. Finally, we establish a gray forecasting model and predict that the climate change will push the country to more fragile by indirectly affecting food production, water supply, natural disasters and economy in 3 year And we have reason to believe that the government can effectively mitigate the impact of climate change on the state fragility through imports of food, massive afforestation and Irritating economic policy.

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