# Vulnerability of States Influenced by Climate Change

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## Abstract

**With the Global Climate Change, the effects of Climate Change have been a hot concern. However, the effects of Climate Change are already being realized vary from region to region and many of the effects will increase the vulnerability of a state. In this paper, a series of methods are developed to help to measure the vulnerability of a state and predict the vulnerability. We use AHP to calculate the weights of the four elements summarized (security, economy, politics and society) and determine a new index to measure the vulnerability of a country to simplify the analysis. Meanwhile, we create a scale factor P called corrosion degree to connect the Climate Change and the effects of Climate Change on the four elements. We can see Climate Change affects the four elements through P and then affects the vulnerability. We select Sudan as our research object. By analyzing Sudan's temperature, Sudan's rainfall and the value of vulnerability, we find Sudan's annual temperature changes are highly correlated with the national vulnerability index and show a certain linear relationship. We conclude that the Climate Change in Sudan mainly affects the national vulnerability index through temperature changes and use our Model to test its correctness.**

## Keywords

**Vulnerability, States Influenced, Climate Change.**

## 1. Introduction

At present, because of the Climate Change's severity, complexity and urgency, the Climate Change has become one of the most challenging global issues. [1] With the Climate Change in the world，the living environment in some areas becomes poor and the number of natural disasters increases, which may have a profound impact on human life, social and economic development. Even more seriously, the influence of Climate Change may increase a country's vulnerability.

Common indicators of the vulnerability include a country's central government that is very weak, inability to control most of its territory effectively, failure to provide public services, widespread corruption and crime in the country, refugees and involuntary migrants, a sharp economic downturn. [2]And these indicators are influenced by the Climate Change, such as directly or indirectly.

So to deal with the challenge, there is demand to look for the relationship of Climate Change and the vulnerability of a country. That is to say, we need to find how the instability of an area influenced by the Climate Change. To embrace a more depict description of the vulnerability, pay attention to figure 1.

## 2. Assumptions and Symbol Explanation

To simply the problems, we make the assumptions. The following assumptions are reasonable.

National Vulnerability Standard is influenced by four elements directly. These factors are independent of each other. Because it is attributed to many scholars define. As is shown in Figure2. [1]

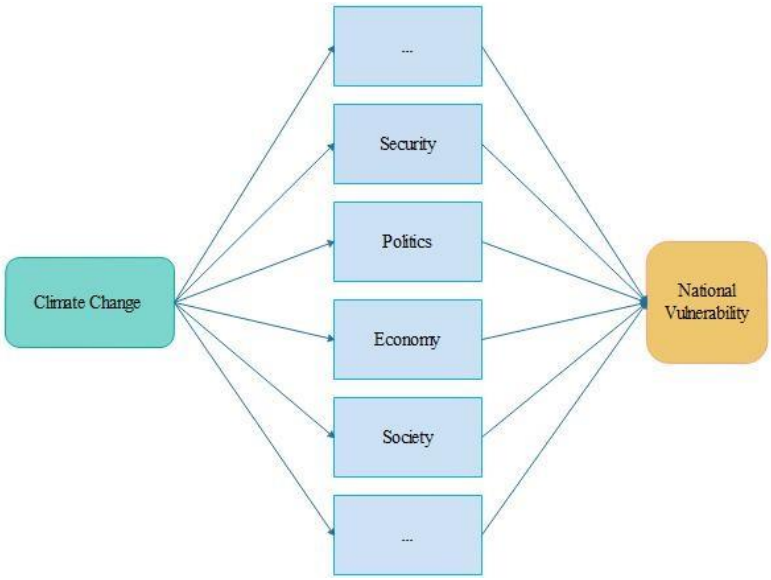


Figure1.The Vulnerability Influenced by the Climate Change

| Index name/Structural dimensions | Security | Politics | Economy | Society | Environment |
|---|---|---|---|---|---|
| CIFP Vulnerability Index of Carleton University | √ | √ | √ | √ | √ |
| Vulnerability Index of System Peace Research Center | √ | √ | √ | √ | |
| Weakness Index of Brookings | √ | √ | √ | √ | |
| Unstable Conflict Books of University of Maryland | √ | √ | √ | √ | |
| Failed national index of the Peace Foundation | √ | √ | √ | √ | |
| National Vulnerability Index of George Mason University | √ | √ | √ | √ | |
| CPIA Index of World Bank | √ | √ | √ | √ | |
| Political instability index of Economist Intelligence Union | | √ | √ | √ | |
| National Weakness Index of Bertelsmann Foundation | √ | √ | | | |

Figure2. Structural Dimensions of the National Vulnerability Index

## 2.1 Symbol and Explanation

| Symbol | Explanation |
|---|---|
| x1:Security | Include:C1 Security Apparatus, C2 Factionalism Elites, C3 Group Grievance |
| x2:Politics | Include:P1 State Legitimacy, P2 Public Services, P3 Human rights |
| x3:Economy | Include:E1 Economy, E2 Economic Inequality, E3 Human Flight and Brain Drain |
| x4:Society | Include:S1 Demographic Pressures, S2 Refugees and IDPs, X1 External Intervention |
| Z | Vulnerability of a country |
| A | The paired comparison judgment matrix of Z-x |
| P0 | The impact of Climate Change on each measure of a country's vulnerability |

## 3. The relationship between Climate Change and Vulnerability

### 3.1 Previous analysis

Based on literature we referred [2] [3], we concluded that the object influenced by Climate Change directly and the four elements influenced by Climate Change indirectly. We use AHP to calculate the weights of the four elements and determine a new index to measure the vulnerability of a country. Besides, the seriousness, complexity and urgency of Climate Change have a great impact on the water resources, food resources and energy resources of a country in particular. No matter what kind of resources affected, it will seriously reduce the utilization of a piece of land. So we create a scale factor P called Corrosion degree to indicate the ratio of the land affected by Climate Change to the total land of the country (Excluding the effects of a particular climate change in a country's original specific environment, such as the effects of a tropical desert climate in the desert). Moreover, we use P to connect the object influenced by Climate Change directly and the effects of climate change on the four elements.

### 3.2 The Ascertain of the Weight of Each Category

Weighting models is essential to evaluate the different contribution of the indicators. Consequently, we set up Model1 to get more scientific results.

As is shown in Table1, the vulnerability of a country is decided by x1, x2, x3 and x4. According to experts' evaluation, there is a judgment matrix of A-Z.

$$A=\begin{pmatrix} 1 & 5 & 1 & 3 \\ \frac{1}{5} & 1 & \frac{1}{5} & \frac{1}{2} \\ 1 & 5 & 1 & 3 \\ \frac{1}{3} & 2 & \frac{1}{3} & 1 \end{pmatrix}$$

The feature vector corresponding to the largest eigenvalue of the matrix is 0.394, 0.075, 0.394 and 0.137. The consistency test is carried out as follow:

Consistency Index (*CI*)

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

The result of calculation is *CI*=0.0014

In the case *N*=4, the average random consistency index *RI*=0.90

Consistency Ratio (*CR*)

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

The result of calculation is *CI*≈0.0015556.

The consistency of the judgment matrix is acceptable, for *CR*<0.1.

The expression for the vulnerability of a country is

$$A=0.394x1+0.075x2+0.394x3+0.137x4.$$

Based the formulas above and the data, we divide three indicators. It is shown in Table2.

Table2. Three Indicators

| State | Standard |
|---|---|
| Fragile | A≥25.1 |
| Vulnerable | 20.2≤A＜25.1 |
| Stable | 0≤A＜20.2 |

Through the Ascertain of the weight of each category, we create a new indicator of national vulnerability called P, which is a scale factor, to simulate the impact of Climate Change on national vulnerability approximately. We regard the impact of Climate Change on a country's vulnerability as the same. And we assume that P has a certain range.

$$0 \leq P \leq 0.5.$$

Pay attention to Figure3.

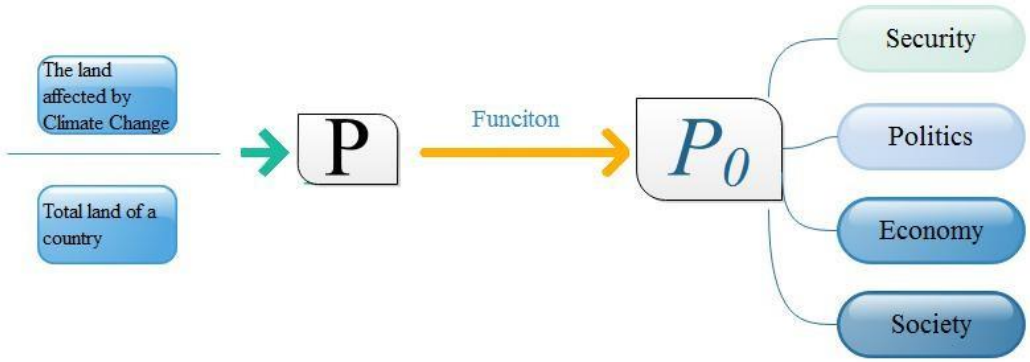


Figure3. Our Analysis about P

Obviously, the impact of Climate Change on each element isn't related linearly. It is exponential approximately, that is to say, the proportion of land influenced by Climate Change gets greater and the impact of Climate Change on each element is greater. P is the connection of the impact of Climate Change on the four elements and it is related to the proportion of land influenced by Climate Change linearly. Based on above analysis, we try to look for a function of ***P*** and ***P0*** :

$$P_0 = e^{ap} - 1$$

The range of P can be easily obtained:

$$0 \leq P0 \leq 30.1.$$

Through the calculation and analysis of the state of fragility index in the past ten years, we can gain the average highest value of P0 is 25.9 and the variance of P0 is close to 0. We take P0=25.9 into consideration to get the value of a .And the value is 6.51. So the function about P0 is:

$$P_0 = e^{6.51p} - 1$$

Then we take P0 into the elements, we can get the numerical vulnerability of national vulnerability:

$$Z = (x1 + P_0) \times 0.394 + (x2 + P_0) \times 0.075 + (x3 + P_0) \times 0.394 + (x4 + P_0) \times 0.137$$

## 4. Solution of Problem

Many parts of Africa are frequent droughts and they have long been plagued by cyclical droughts [4]. We select Sudan as our analysis object. Because Sudan is located in northeastern Africa and the west coast of the Red Sea, the Nile Valley runs through the middle of it. Due to its special geographical location, Sudan's national climate varies greatly, namely, its climate translate from tropical desert climate to tropical rain forest climate from north to south. Besides, its highest temperature can reach 50 Celsius and the national average temperature is 26 Celsius. In addition, Sudan is all year round, the average annual rainfall is less than 100 mm [5]. So we can see Sudan is located in the ecological transition zone. Therefore, it can easily suffer from drought, flood and desertification. We collect and organize Sudan's data of temperature and rainfall from the year of 2006 to 2015. Based on that the climate change is mainly affected by temperature and rainfall, we use both temperature and rainfall to discuss the relationship of them and the vulnerability.

We can see that the annual average temperature in Sudan and the Sudan's annual national vulnerability index have basically the same trend of change. And if the annual average temperatures are sorted by size, it can be concluded that the annual average temperature in Sudan is close to the national vulnerability index in a linear relationship.

However, it is difficult to obtain the relationship of the annual average rainfall in Sudan and the annual national vulnerability index in Sudan.

Based on the climate type and geographical location of Sudan, we conclude that Sudan is located in an ecological transition zone and is highly vulnerable to drought, floods and desertification. The national average annual rainfall is less than 100 millimeters and the annual rainfall increases from 20 millimeters to 1,000 millimeters from north to south. Due to regional difference, the impact of rainfall on the north and south of Sudan is different, making it difficult to measure the impact of rainfall on the national vulnerability index.

## 5. Conclusion

Consequently, based on the analysis above, we can see the annual average temperature change in Sudan is more relevant to the national vulnerability index and shows a linear relationship almost.We conclude that climate change in the Sudan affects the changes in the national vulnerability index primarily by affecting changes in temperature. As climate change increases the temperature, the National Vulnerability Index also shows an upward trend and national vulnerability rises.

## References

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