Climate Change - The Effect on Fragile States

Team Control Number - 93358

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1 Introduction

Over time, the affect of one country on another has increased dramatically. As this has happened, ”it has become conventional wisdom that poorly performing states generate multiple cross-border “spillovers,” including terrorism, weapons proliferation, organized crime, regional instability, global pandemics, and energy insecurity (Stewart, 2006).” It has been shown that there may be some credence to this idea as well (DiRienzo, 2017). This has led to concept of fragile states, defined in this paper as states that are ”not able to, or choose not to, provide the basic essentials to its people” (ICM Problem). This can be measured in many ways, but the most common is to have 4 main categories with many subset categories. These categories are the economic status, the political status, social welfare, and security. The purpose of this paper is to determine what effect, if any, climate change has on these categories, and subsequently, the classification of whether a state is fragile or not. For our purposes, this classification comes under 3 classes designations: fragile, vulnerable, and stable.

2 Methodology

2.1 Defining the Problem

In order to determine whether climate change has any affect on a states fragility, we first need to determine what factors make up the fragility of a country. The FSI (Fragile State Index), developed by Fund for Peace, is a current index that runs from 2006 to 2017. When developing our model, it will be compared with this index for accuracy. The 4 main categories are adopted here as well with 13 subcategories. The categories are defined as follows:

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Economic	Political
GDP per Person GNI per Person Inflation GINI Index	Government Debt Governance Corruption Political Stability
Social	**Security**
Life Expectancy Literacy Rate Primary School Enrollment Secondary School Enrollment	Homicides per 1000 People

When calculating the correlation between each of these factors throughout time and one countries FSI scores, it was found that there were 6 factors that correlated heavily, while the others were much less so. These factors are shown here with their corresponding category:

Economic	Political	Social
GDP per Person	Corruption	Life Expectancy
GNI per Person	Government Effectiveness	
	Political Stability	

It is assumed that the other factors are negligible when calculating whether a country is considered fragile, vulnerable, or stable.

When looking at the impact of climate change on the fragility of a country, it is necessary to identify the factors that describe climate change.

The following is a satisfactory graphic to represent some of these factors:

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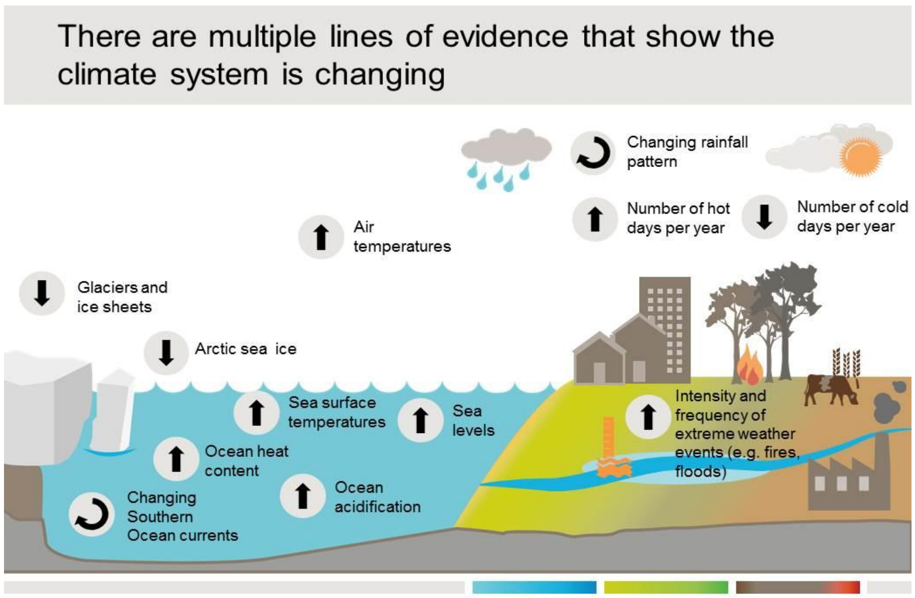

Image can be found at environment.gov.au

Since all countries do not share the same landscape (i.e. mountains, coastline), it is necessary to evaluate characteristics that the countries share. Since this is the case, and the data for climate change is limited, the elements collected were the average annual temperature and rainfall. Rainfall was found not to correlate with the fragility score, so the only data point used to represent climate change is the temperature.

2.2 Mathematical Model

For calculating the fragility score of each country, the KNN regression model (K Nearest Neighbor) was used on the 2015 data for all countries included in the FSI database for that year. This is the model used to calculate all scores in the future. When tested against the FSI scores from 2006 to 2017 in Afghanistan, the model was shown to have an SSE (Sum of Squares Error) of 838, which is an average of ± 6 fragility points for the years tested. It is assumed that the countries all follow the same classification status, thus, the model is also assumed to be accurate for all countries and for all years that the data is available. From here, a polynomial interpolation of the data points calculated from the KNN regression models the general trend of the FSI scores calculated, hereon called the Fragility Interpolation. The Fragility Interpolation was calculated for Afghanistan in this case.

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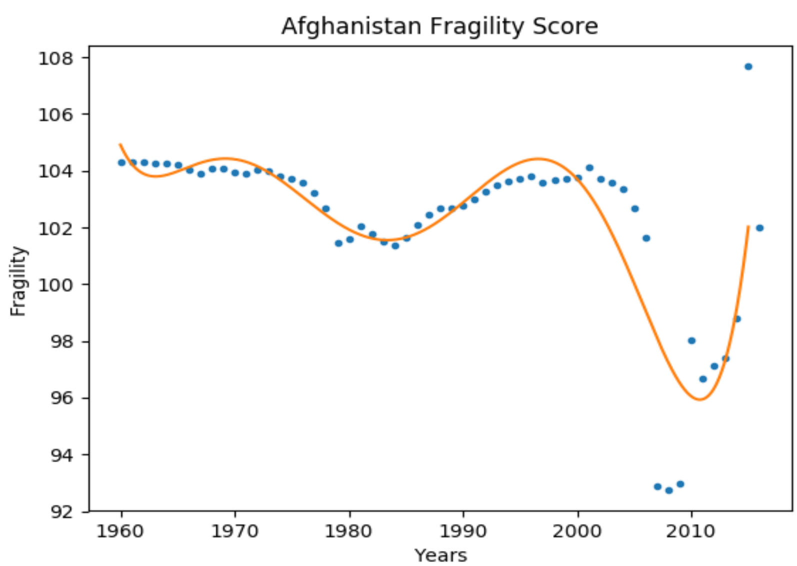
Now that the model can approximate the FSI score, the climate change is modeled. Once more using polynomial interpolation, but on temperature, the Fragility Interpolation is compared to the Temperature Interpolation. This was again done for Afghanistan. In order to assess whether there was any correlation between the two functions, the second derivative of each was taken and the inflection points were found by calculating where the derivatives were equal to zero. From here, the inflection points were considered if they were less than or equal to 2 years apart. Of the 5 inflection points Temperature Interpolation, 3 were significant, which corresponded to 3 of the 4 inflection points for the Fragility Interpolation. This led to a closer look at the plots to find that there seemed to be a relationship between the 2 interpolations in general. Overlaying the graphs and multiplying the Temperature Interpolation by a factor of 8 allowed closer analysis of the data. Here we found that there was an inverse relationship between temperature and the fragility score.

We model a linear regression that starts two years before the inflection point. The slope of that model is calculated by averaging the slope of the previous five years after that point. This model predicts what would have been the fragility of Afghanistan if the temperature is not taken into account. For 1965 the actual fragility score was 103 and the predicted fragility was 99. This means that the climate change increased the fragility in four. We are able to predict this to all other inflection points as well.



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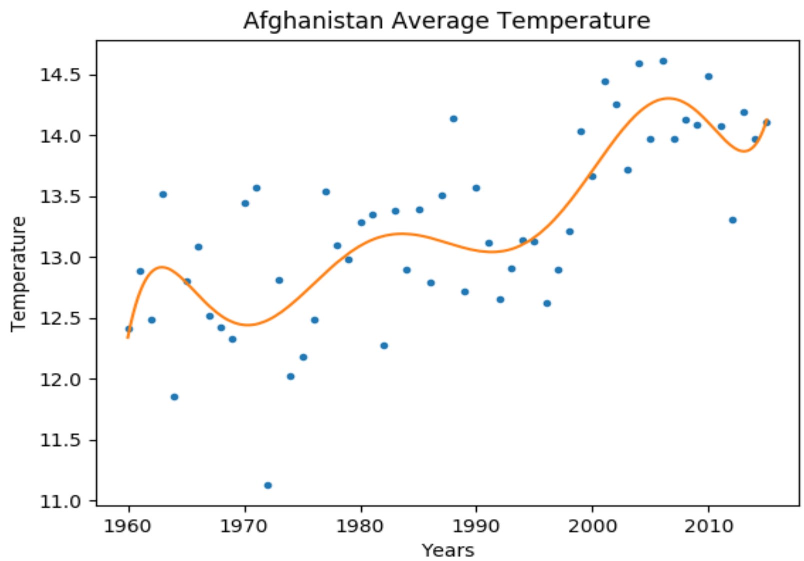

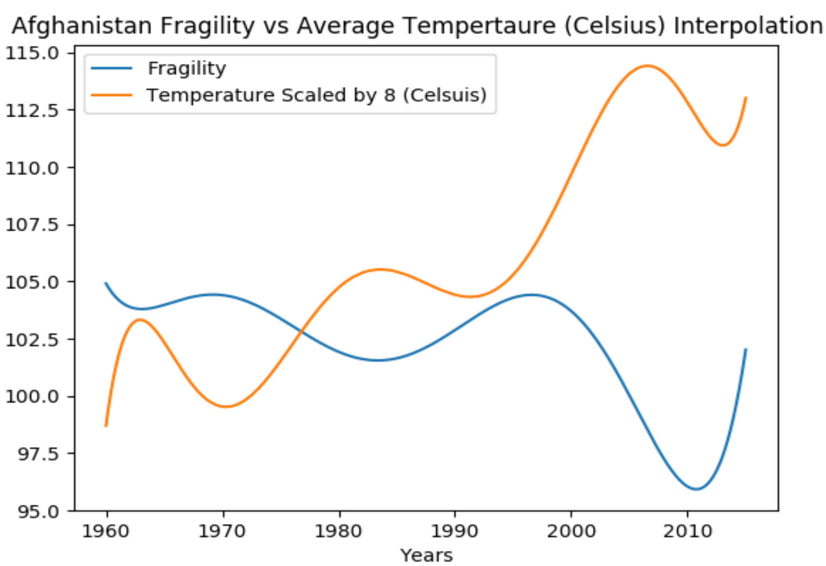

This shows, surprisingly, that a decrease in temperature, rather than an increase, is likely to increase the fragility of that country.

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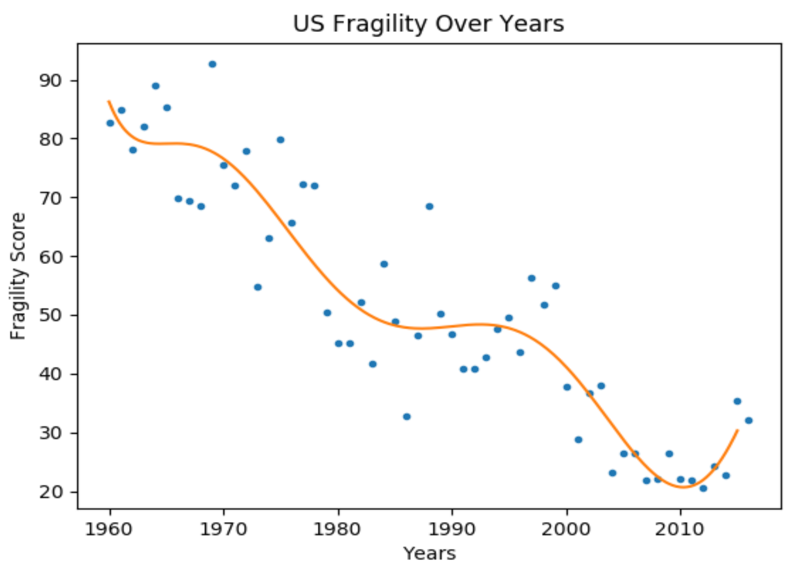
Moving away from Afghanistan, the next consideration is a country outside of the top 10 most fragile countries. The country under consideration is the United States. Again, the Fragility Interpolation is calculated using KNN regression on the 2006 to 2017 data of our 6 variables and finding a polynomial interpolation. The Fragility Interpolation was again compared to the Temperature Interpolation of the U.S. temperature data. Using the second derivative test once again, the number of inflection points that correlates was 3 out of 4 points. A closer look at the graphs again show the same type of correlation. This supports our previous analysis of Afghanistan and gives credence to our model.



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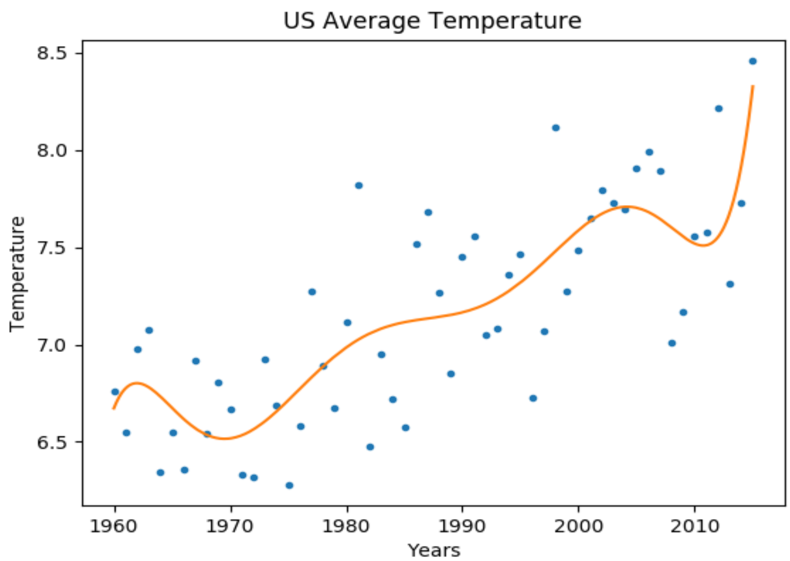

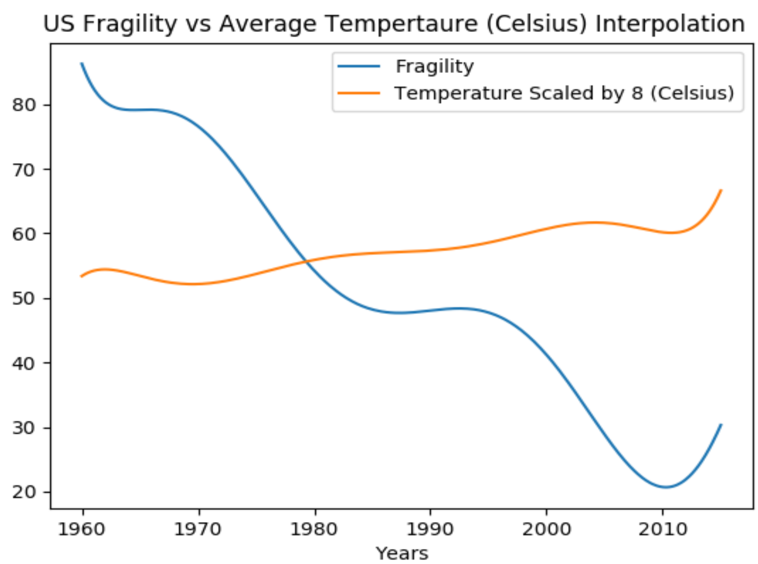

Again, the temperature seems to be an excellent indicator of fragility, specifically a decrease in temperature causing an increase in fragility.

3 Conclusion

There exists a possible correlation between cooling global temperatures and increasing fragility. This is shown in the graphs above, where temperature seems to have an inverse affect with fragility score.

As temperature decreases, fragility increases. Other climate change factors could have been included in the analysis, but there was insufficient data, and the apparent correlation temperature has with fragility provides stimulating insight.

According to an article written about the United States security, it was concluded that, "there is a possibility that this gradual global warming could lead to a relatively abrupt slowing of the ocean's thermohaline conveyor, which could lead to harsher winter weather conditions, sharply reduced soil moisture, and more intense winds in certain regions that currently provide a significant fraction of the world's food production. With inadequate preparation, the result could be a significant drop in the human carrying capacity of the Earth's environment" (Schwartz Randall, 2003).

The thermohaline conveyor refers to the ocean current that brings warm water from the gulf upwards towards Europe, which adds some warmth into the atmosphere, and helps the climate stay temperate.

This will be slowed as global warming melts icebergs in the northern hemisphere, exuding higher quantities of cold water in the currents, disrupting the current balance. This will affect Northern Hemisphere winters in the way described above.

Concerning its affect upon smaller and larger states, such as cities and continents, there are general applications as well as situational differences.

The model suggests that temperature will affect fragility inversely, and as cited this may be because lower temperature implies shorter growing seasons and lower soil moisture content, affecting one of the three most affecting areas by climate change: water, agriculture, and energy (Schwartz Randall, 2003).

All continents and cities will be affected by change in agricultural production, and to some point fresh water availability and the ability to access minerals for energy will also be altered.

However some cities will have the advantage of being in a climate where the affects of the thermohaline conveyor will not be felt directly, as well as being in an area where other resources aren't affected. This could be areas around the equator, and in South America, where the temperature will most likely rise (Schwartz Randall, 2003). Local advantages will be beneficial to some cities, and can not be included in the model.

Continents are difficult to measure by the model because they most likely have many climates, and land area at different distances from areas whose climates change due to the ocean current collapse. However, there may be some validity to inputting a continent's average temperatures and fragility score into the model, due to the fact that the data United States and Afghanistan, whose climates differ greatly (and the U.S has a land mass with many climates), both supported conclusions of the temperature and fragility inverse relationship.

In order the improve the model to better include smaller and larger states, it would be beneficial to recognize their nature: states as having local variability, as well as continents as having various climates and political structures.

Some suggestions for improving the analysis accuracy of states would include its dependency on agriculture, as well as its local energy and economical resources. For example, the economy in West Pennsylvania, although possible affected by shorter growing seasons, could sustain itself economically through thriving coal production, which would be used in national trade.

When analyzing modifications to the model for continents, international relations must be considered, as well as if it's positively or negatively affected by temperature change. Both countries used in the model are in the Northern Hemisphere, and are negatively affected by a thermohaline conveyor collapse, and would continue to be affected, which is not so much with Southern Hemisphere countries, whose temperature is predicted to increase in an event of the collapse.

Since stronger states usually persist climate alterations the best, it would prudent to suggest that continents with stronger unity would also thrive better in comparison with those that wouldn't.

While this analysis does indicate that there is a strong correlation between the temperature and the fragility of the state, there are assumptions that have been made. From the start, it was assumed that the FSI was accurate as it was our basis for the model. The definition used by Fund for Peace may have been slightly different than the one used in this paper. It is possible that the model may have been more accurate using data that was more specific to the definition set forth at the beginning of the paper, such as the amount of food available to the people, the amount of clean water, and how many people are malnourished in the country. Another possible point for error is the interpolation. There is possible error in the formulation of these functions. As well as these errors, there is error in the data collection. Much of the data was missing and data wrangling was necessary to be able to model the situation effectively. This was mitigated by cutting down the subcategories of the fragility calculations. Overall, the model seems accurate enough for the purposes of this paper.

4 Citations

DiRienzo, C Dasm J. (2017). The Spillover Effects of Country Fragility in Africa [Abstract]. Developing Country Studies.

Schwartz, P. and Randall, D. “An Abrupt Climate Change Scenario and Its Implications for United States National Security”, October 2003.

Stewart, P. (2006). Weak States and Global Threats: Assessing Evidence of “Spillovers” [Abstract]. Center for Global Development.

[Graphics showing how natural forces interact to create climate change]. (n.d.). Retrieved February 12, 2018, from http://www.environment.gov.au/climate-change/climate e-science-data/climate-science/understanding-climate-change/indicators

All Data From worldbank.org