FOOD SECURITY ANALYSIS USING REMOTE SENSING FOR INDIA

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Abstract

The World Food Summit defined food security as the following: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"[3]. As it currently stands, 795 million people worldwide do not have access to sufficient, safe, and nutritious food. The objective for this project is to find the relationship between global carbon dioxide emission, technology, precipitation, & temperature to predict the outcome of crop yields in three major countries in the world.

For this project, four coefficients were found as predictors of crop yields in the future. Remote sensing data were used to find the correlation between normalized difference vegetation index (NDVI) and droughts using Palmer Drought Severity Index (PDSI) from 2006-2010. Drought is a period of dry weather that results from a lack of precipitation. PDSI is a indicator that estimates relative dryness with index ranging from -4 to 4, with -4 being dry and 4 being wet.

Introduction

The world population is expected to climb to 9 billion by 2050, which means that the world food population would need to increase by 70%. This figure (70%) may be impossible to achieve given an increase in global population, volatility of agricultural production, temperature, and Carbon dioxide emission.

This project focuses on the current state of food security on India. India was chosen for the sole reason it is one of the fastest growing economy, and it will harbor the largest world population by 2030. It is of prime importance to achieve food security in India as one third of its inhabitants suffers from extreme poverty[8]. India has the second highest undernourished people in the world (FAO). This situation is worsened by the 16 million people being added annually to an already large population. The problem of food insecurity in India rises from low demand of agricultural production. This is exacerbated by rising land degradation, loss of soil fertility, and water logging. Furthermore, low agricultural production is also affected by a lack of awareness with Indian farmers concerning existing technologies.

Food insecurity in India can only be solved by increasing the overall agricultural production. Increased agricultural food production will not only ensure food security but it may also enhance India's economy and rise millions out of poverty.

Methodology

The methodology for the relationship is as follows. Global CO2 emission, average annual temperature in India and Average precipitation in India were downloaded. A technology vector was also made with years ranging from 1961-2012. This is given the fact that technology improves with subsequent years. The purpose of downloading these data was to use MATLAB to find the coefficient of the following equations to predict the outcome of crop yield from these four factors in a given year.

Log(yield)=a+b1*precipitation+b2*temperature+b3*CO2+b4*technology

Remote sensing data of NDVI and monthly precipitation from 2006-2010 were used to find the correlation. For this part, NDVI monthly images are downloaded the from NASA with a resolution 3600x1800. ArcMap was used to find the mean and then PDSI and NDVI averages were graphed to find the correlation. NDVI or Normalized difference vegetation index is used to analyze remote sensing measurements to assess vegetation in certain areas. NDVI values range from -1 to 1, with -1 being the least healthy to 1 being the most healthy. The equation for NDVI is as follows:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

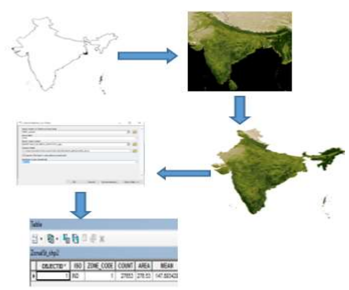

Figure 1. Process for NDVI averages

extreme drought	severe drought	moderate drought	mild drought	incipient dry spell	near normal	incipient wet spell	slightly wet	moderately wet	very wet	extremely wet
-4.0 or less	-3.0 to -3.99	-2.0 to -2.99	-1.0 to -1.99	-0.5 to -0.99	0.49 to -0.49	0.5 to 0.99	1.0 to 1.99	2.0 to 2.99	3.0 to 3.99	4.0 or more

Figure 2. PDSI index

Data

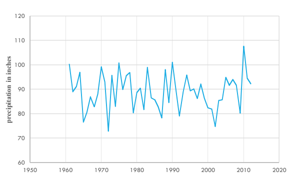

Figure 3. Average Precipitation in India (1961-2012)

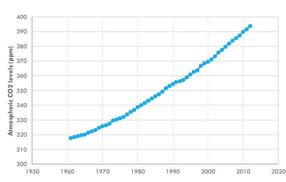

Figure 4. Global Carbon Dioxide Emission (1961-2012)

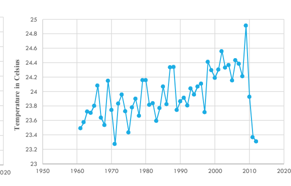

Figure 5. Average Temperature in India (1961-2012)

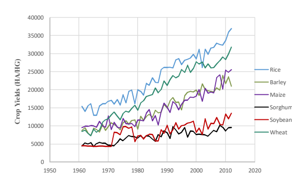

Figure 6. Crop Yield of Six Major Crops in India (1961-2012)

Precipitation Data was obtained from World Bank[4], global Carbon Dioxide emission data was collected from NOAA[7], average temperature was collected from World Bank[5], crop yields for the six major crops was collected from FAO[2], and Average NDVI data was collected from NASA[6]. The average temperature and precipitation fluctuated within the 51 year period. The Global CO2 emission increased each year and the crop yields also increased with some periodic fluctuations.

Results

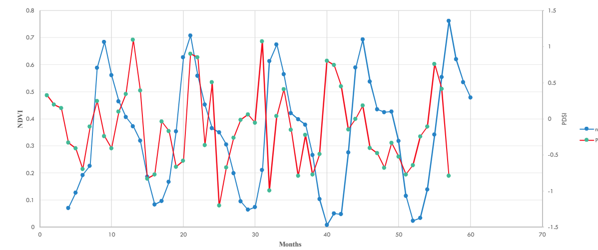

Figure 7. Correlation Between NDVI and PDSI (3 months Lag)

Figure 7. graphs NDVI and PDSI for three months lag. The correlation coefficient was 0.68. A month is lag is used to see whether there is an immediate effect of drought on NDVI or not. The Coefficients for the equation previously mentioned is as follows: b1= 2.364585641627246E-4, b2= -0.017470868488298034, b3= 0.004999030024183589, b4= 0.0014040131901416003

Conclusion

MATLAB was used to come up with coefficients that are helpful in predicting the impact of each factors, namely precipitation, temperature, technology, and CO2 emission, in crop yields. The graphs for NDVI and PDSI with different month lags were used to determine the effects of droughts on vegetation. In India, there was a relatively high correlation between NDVI and PDSI on the three months lag. This meant that the effect of drought on vegetation was not immediately seen on vegetation; it rather took some time to see the effects.

It's important to note that an increase in temperature is beneficial for colder region; However, it has an overall negative impact on the world. Furthermore, an increase in carbon dioxide emission leads to crop enrichment, but this is ultimately negative for the pure fact that we are producing carbon dioxide in excess amount.

Achieving food security in developing nations is important in ensuring economic growth and ending world hunger and poverty. Securing food security can only be achieved by limited the magnitude of climate change.

Acknowledgement

I would like to express my deep gratitude to Professor Tarendra Lakhankar, especially to ou advisor Ehsan Najafi (P.h.D candidate) . I would also like to thank Dr. Shakila Merchant, Professor Reza Khanbilvardi, and everyone part of NOAA CREST for providing this opportunity.

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"NOAA CREST program is funded by NOAA/EPP Grant # NA11SEC4810004" and "NOAA CREST HIRES program is a part of the Science Research Mentoring Program and funded by Pinkerton Foundation".