



INTRODUCTION

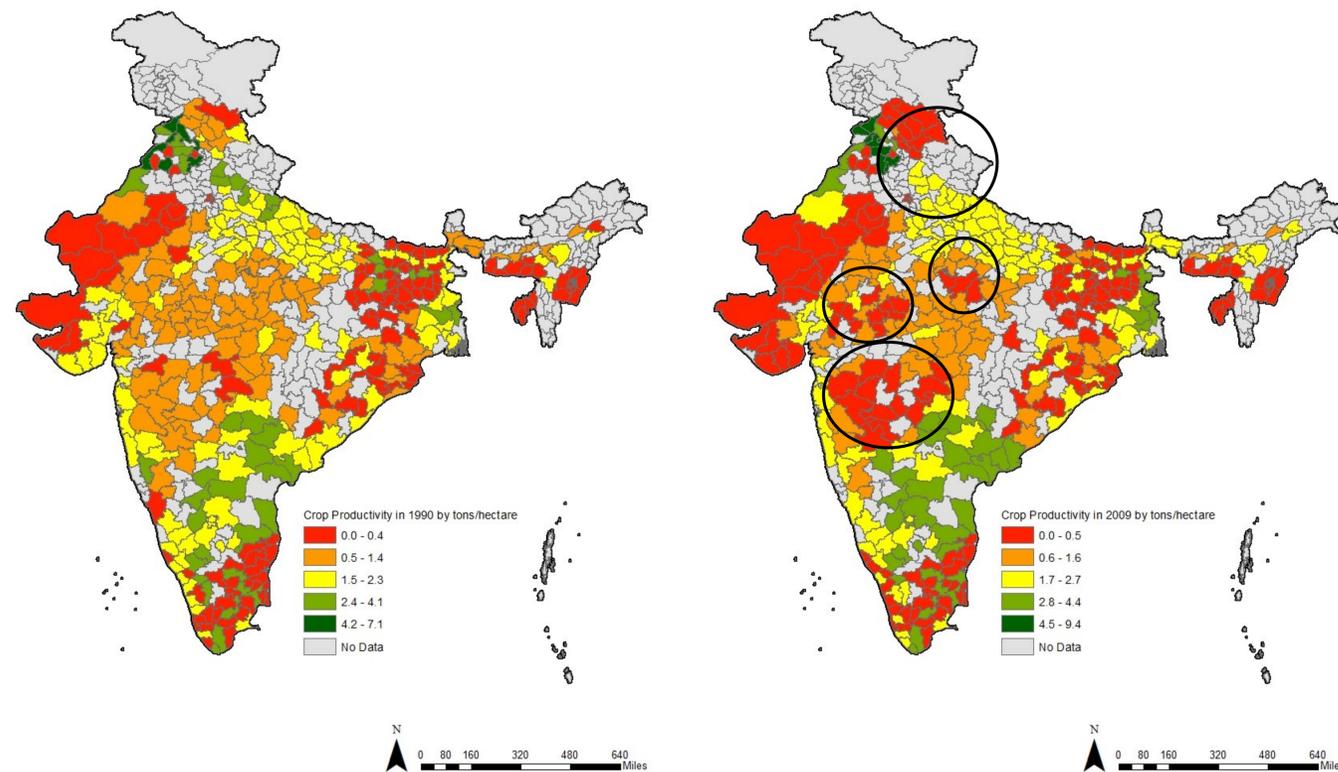
Climate change is becoming a global phenomenon and awareness of how climate change can affect millions is spreading quickly. Climate change has a big impact on crop productivity across the globe (Parry et al, 2004). Erratic rainfall and extreme temperatures are bringing in a lot of uncertainty in crop production. The temperature of Earth has increased by 0.74°C in the last 100 years and by the end of this century it is likely to increase by 1.8° - 4°C due to emission of greenhouse gases. This is turn will result in greater instability of food production (Aggarwal, 2008).

The monsoon rainfall in India has become more intense and less frequent, which poses a threat of drought and flood damage to crops (Auffhammer et al., 2012). In particular the crop production has affected rice yield (which happens to be the most common crop in the Kharif season) in most parts of the country. Around 65% of the total population in India depends on rice and it accounts for 40% of their food production (Bishwajit et al., 2013).

Most farmers grow rice for self-subsistence, but uncertain rainfall patterns or climate change could leave them in vulnerable conditions. Farmers ideally want to optimize their crop production, but over the years weather risks limit their willingness to invest more in measures like the use of fertilizers or better crop variety that might increase their productivity. Weather risks, in particular those arising from fluctuations in rainfall, are pervasive in agriculture (World Bank, 2011). A product like Weather Index Insurance (WII) could be very helpful for farmers. A weather index insurance is an insurance that responds to an objective parameter (e.g. rainfall or temperature) at a defined weather station during an agreed time. A farmer who buys an insurance policy will be assured of monetary compensation in case the defined parameter fails to obtain the required target. For example: If insurance is being purchased for 10 inches of rainfall at a particular weather station for the rainy season, the farmer is assured of at least 10 inches of rainfall or the monetary compensation of his crops if 10 inches of rainfall does not occur. It becomes a win-win situation for farmers, whereby just paying the premium for the insurance assures his livelihood.

Assessing parts of India for a WII would be an important input for insurance companies or the government. Certain regions that experience weather fluctuations could experiment with WII and implement depending on their success.

CHANGE IN CROP PRODUCTIVITY OVER TIME



METHODS

The input layers for all the maps were rainfall data, crop data, India census district level data and the international boundary layer. The unit of rainfall is measured in millimetres and crop productivity by total output in tons by area under irrigation in hectares. The rainfall data was cleaned in STATA and then dummy variables were created for the year 1990 and 2009. If the rainfall had changed (increased or decreased) by more than 30% from the base year (in this case 1990) as compared to 2009 then it was coded 1 or else 0. A Spatial Join with rainfall, crop productivity and census district table was done.

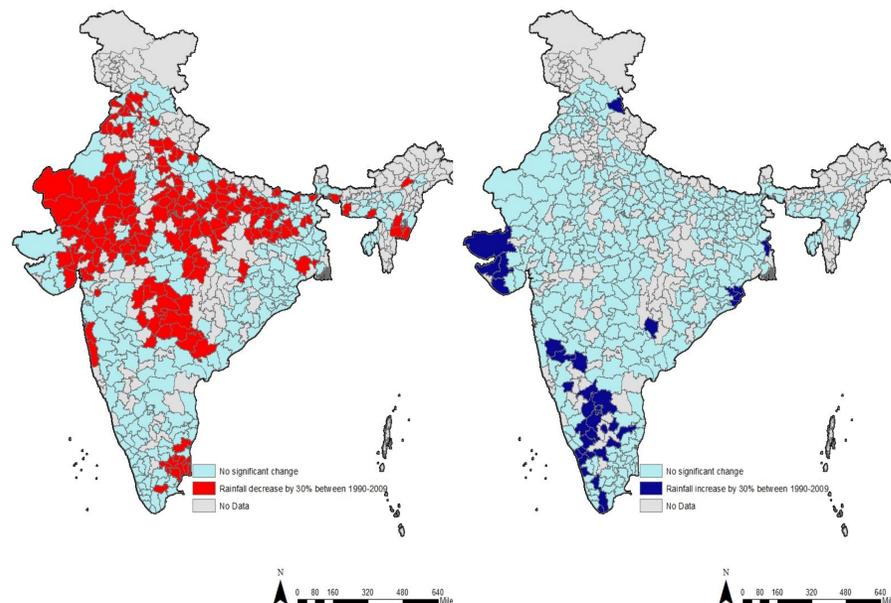
Space-time Analysis for Rainfall and Crop Productivity

India is a vast country and rainfall varies a lot over different states. I decided to select only top 9 states in India which contribute (in terms of agriculture contribution to GDP) to select these states. This data set was used for rainfall and crop productivity. I defined the XY coordinate in the attribute table and then exported the data to a shape file. I created a space time cube using Space time pattern mining tool. The rainfall data is the average of the average monsoon season (June-September) for all the years. First the average for each month was noted. Then average over four months was noted. Then emerging hot spot analysis was done. This gave the hot spot analysis of rainfall (over 40 years) and crop productivity (over 45 years) in India.

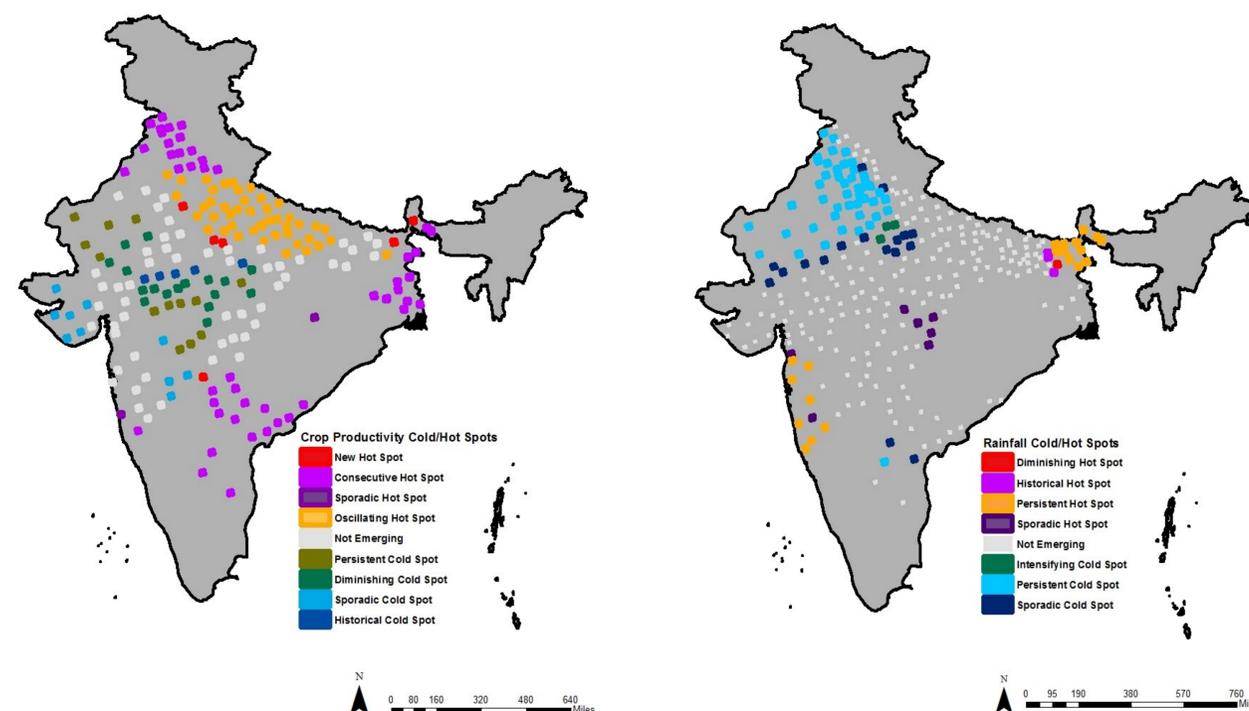
ANALYSES

Weather Index Insurance would be a suitable product for companies where rainfall has sporadic cold/hot spots, persistent hot/cold spots. They could be also suitable in places where crop productivity has oscillating hot spots, consecutive hot spots (if rainfall is also showing persistent cold spots), sporadic cold/hot spots or diminishing cold spots. Though factors leading to change in crop productivity may be affected by many other external factors like temperature, natural disasters or pesticides attacks but rainfall could be one of them. By introducing WII in these places the farmers would be able to mitigate their risks by paying a small amount as premium. The compensated amount is calculated on the amount of land owned by each individual farmer. The western and south eastern parts of India see a lot of fluctuations.

CHANGE IN RAINFALL OVER TIME



SPACE-TIME ANALYSES FOR RAINFALL & CROP PRODUCTIVITY



RESOURCES

Cartographer: Nandish Kenia
UEP - 0102, Advanced GIS
9th May 2017

Project Coordinate System: WGS_1984_UTM_Zone_47N
Transverse Mercator

Data Sources:

- Indian Meteorological Department, Ministry of Earth Sciences in New Delhi—India
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- India Census 2011

Aggarwal. (2008). Global climate change and Indian agriculture: impacts, adaptation and mitigation.

Auffhammer, M., Ramanathan, V., & Vincent, J. R. (2012). Climate change, the monsoon, and rice yield in India. *Climatic Change*, 111(2), 411-424.

Bishwajit, G., Sarker, S., Kpoghomou, M.-A., Gao, H., Jun, L., Yin, D., & Ghosh, S. (2013). Self-sufficiency in rice and food security: a South Asian perspective. *Agriculture & Food Security*, 2(1), 10.

Parry, M., Rosenzweig, C., Iglesias, A., Livermore, M., & Fischer, G. (2004). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change*, 14(1), 53-67.

World Bank. (2011). *Weather index insurance for agriculture*. <https://www.agriskmanagementforum.org/sites/agriskmanagementforum.org/>

In the crop productivity map, we can see many consecutive hot spots in the north west region and in the southern parts of India. This suggests stable crop production in these regions. In the western parts there are persistent and diminishing cold spots which suggests crop productivity is decreasing. We can also see many sporadic cold spots in the central north region.

In the rainfall map, we can see persistent cold spots in the north western part of India. This suggests rainfall is decreasing over a period of time. In the western and north eastern parts we can also see a persistent hot spots which suggests good rainfall in those regions. By looking at these cold/hot spots in India, insurance companies can look to introduce WII in these regions.

DISCUSSION & LIMITATIONS

There could be many other factors such as temperature, fertilizers or quality of seeds which would be affecting crop productivity. Due to various factors, one cannot establish a causal relationship between rainfall and crop productivity. In places like Andhra Pradesh and Punjab where rainfall has reduced, crop productivity remains constant. This suggests that farmers do irrigate their fields even though rainfall has reduced. The alternate source of irrigation would be ground water. It would be interesting to see the ground water levels in these regions. The further discussion could be what impacts will depletion of ground water have? Is this sustainable in the long run?

The limitation to this study is the lack of data collected for other independent variables. It would have been interesting to see the regression results if temperature, type of seeds data would be available. The other limitation could be there accuracy of data. Sometimes the data could be missing or values were negative for crop productivity. India being a vast country, rainfall and crop productivity may not show a causal relationship over time.