Sensing Drought in the Sahel for Household Climate Resilience

Data Science *for the* Public Good

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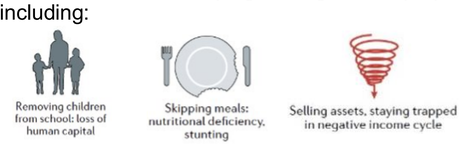
Introduction

- Without effective social protection, extreme weather in sub-Saharan Africa causes people to resort to harmful coping strategies that perpetuate the poverty cycle, including:



- Research shows that the frequency and severity of drought in the Sahel region of Africa is increasing.
- Our research focuses on Niger, as it is a high poverty and food insecure country with poor living standards.
- The World Bank is seeking ways to identify a proactive approach to social protection that builds on understanding the links between environmental and social conditions, so that they can determine when, where, and how to use environmental data to target funds.

Objective

1. To compare two commonly used drought indicators in the same area
2. To estimate the correlation between these indicators and food security

Data

Welfare

1. Living Standards Measurement Survey:

Surveys conducted by the government of Niger with the support of the World Bank in 2011, 2014, and 2018.

Here we use per capita expenditures data and classify people as food insecure when 50% or above of their expenditures go to food.

We then calculate the share of observations facing food insecurity to represent the food insecurity values in each year. We have aggregated the values with median at Department administrative unit.

Drought

1. Precipitation CHIRPS:

Global rainfall dataset ranging from 1981 to present, showing gridded rainfall time series at ~5km spatial resolution. This dataset is often used for trend analysis and seasonal drought monitoring. We take the annual cumulative amount in mm

2. Peak Annual NDVI:

Indicator of vegetative growth extracted from the near infrared (NIR) and red bands of the AVHRR sensor (1km spatial resolution, daily values) over 1981-2022.

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{Red}}{\mathrm{NIR} + \mathrm{Red}}$$

Methodology

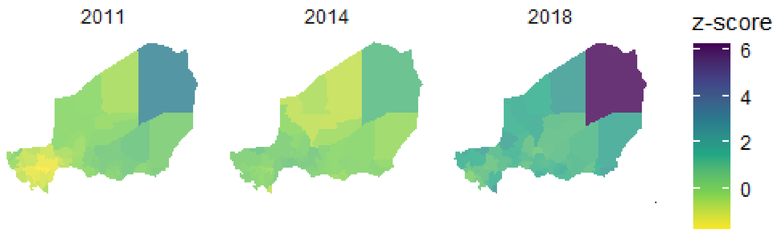
- Use z-scores to translate historical weather to “anomalies” from normal (xI). Z-scores (Zit) quantify how "anomalous" a given annual precipitation amount or NDVI value s by comparing that value (xI) to the mean ($\bar{x}$) of those values in a prior period (here 1981-2010) and dividing by the standard deviation (si) across that same baseline period.

$$Z_{it} = \frac{x_{it} - \bar{x_i}}{s_i}$$

- Examine the relationship between annual weather anomalies and aggregate welfare using the Pearson R correlation coefficient, which measures the strength of the linear association between the variables

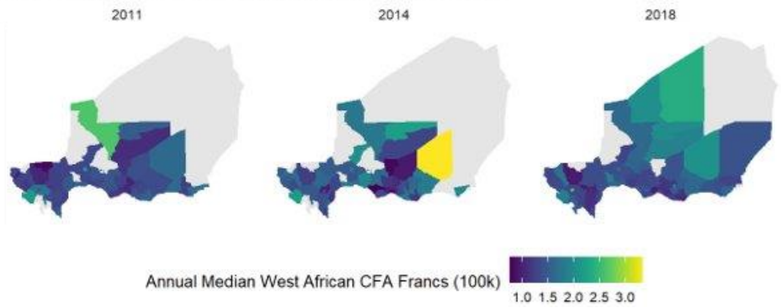
Preliminary Results

Annual Z-Score Rainfall by Department (Admin 2)

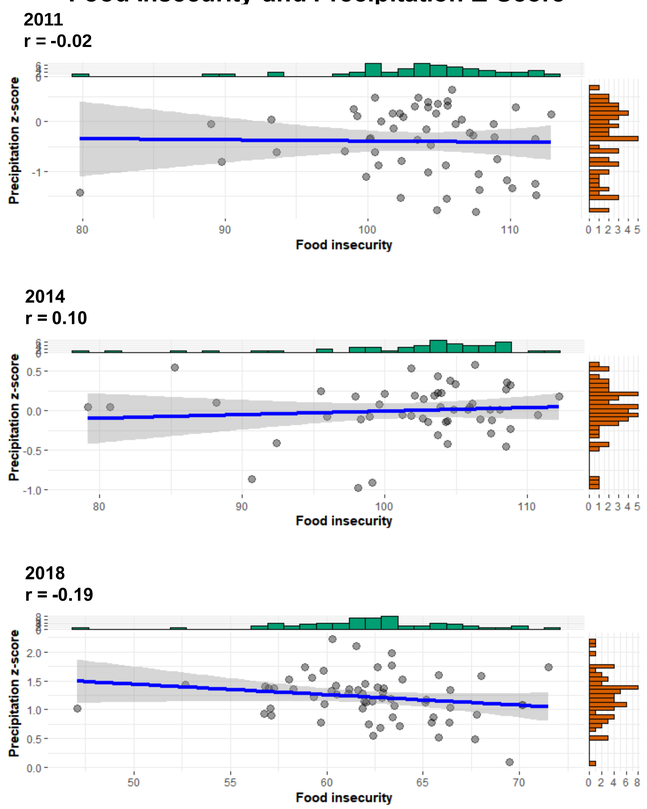


Median Annual Per Capita Food Expenditure by Department

Units in 100,000 West African Francs, with 400-600 Francs to 1 USD

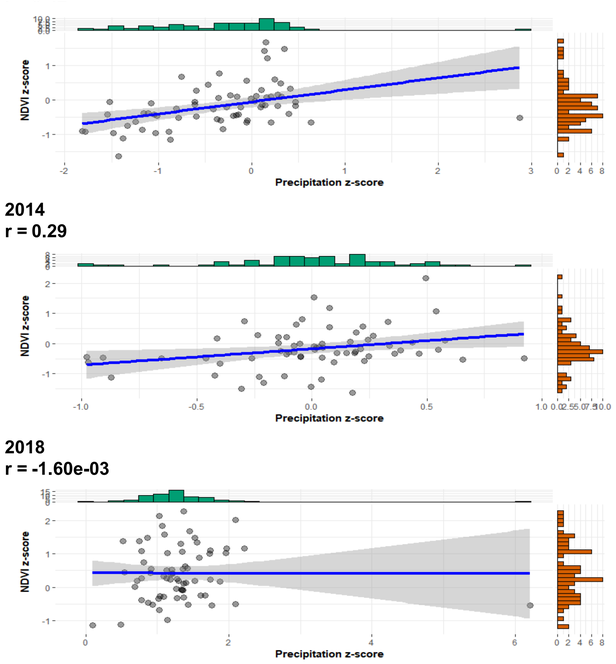


Food Insecurity and Precipitation Z-Score



- There is little to no correlation between Food insecurity and Precipitation.
- Similar results (not presented here were found for NDVI)

Relationship Between Precipitation and NDVI



Conclusion & Next Steps

- Precipitation and NDVI correlate the most in 2011 (r = 0.42) and the least in 2018 (r = -1.60e-03).
- Precipitation is negative associated with food insecurity in 2018 (r = -0.19) and 2011 (r = -0.02) but is positively associated with food insecurity in 2014 (r = 0.10).

Takeaways

- Although NDVI and Precipitation appear to positively correlate with one another -- especially in 2011 and 2014 when droughts were reported -- we observe little correlation between precipitation (NDVI) and food insecurity.
- This limited relationship may be a result from the high degree of aggregation across spatial units that causes us to loses some of the variation in underlying conditions.

Next steps:

- Including alternative indicators for drought e.g., water resource stress index and soil moisture may also exhibit greater correspondence with agricultural drought conditions.
- Disaggregating the food insecurity data to focus on smaller administrative units would illustrate greater variation over space.
- Evaluate alternative approaches to measure correspondence that may account for nonlinear relationships

References

Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., ... & Michaelsen, J. (2015). The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. *Scientific data*, *2*(1), 1-21.

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