Student Version 1

Sensing Drought in the Sahel for Household Climate Resilience

Data Science *for the* Public Good

Catherine Back
Data Science

Riley Rudd
Economics & Consumer Studies

Milind Gupta
Computer Engineering

VIRGINIA TECH™

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:

Survey conducted by the World Bank, in 2011, 2014, and 2018. Per Capita Expenditures and Share spent on food, where 50% or above spent on food is classified as food insecure.

2. Food Insecurity:

Representative survey conducted by the government of Niger on vulnerability to household food insecurity for the years 2015 and 2017.

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 seasonal 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.

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

Methodology

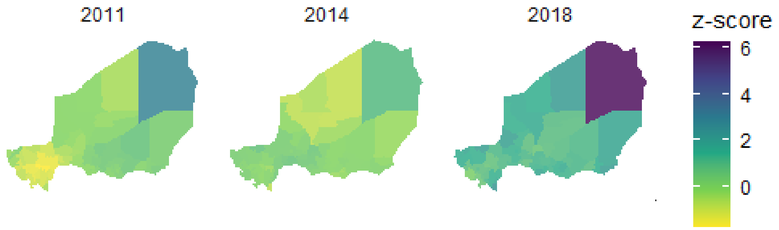
- We use z-score to translate historical weather to “anomalies” from normal (x_I).
- Z-scores allow you to quickly understand how "anomalous" a given value. It in effect asks how different are way to standardize data to make them more comparable to a known distribution of values.

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

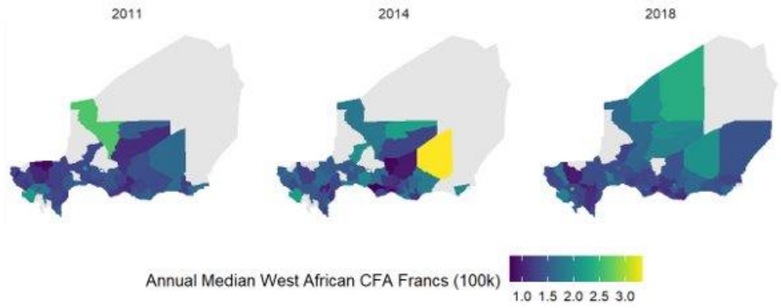
- We examine the correlation between annual weather anomalies and aggregate welfare. The correlation is calculated using Pearson R correlation to measure the strength of the linear association.

Preliminary Results

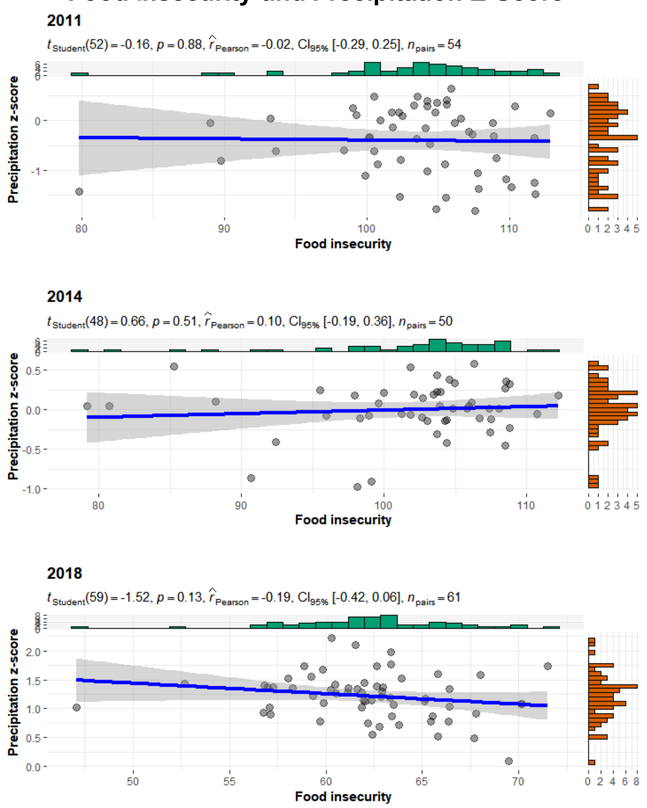
Annual Z-Score Rainfall by Department (Admin 2)



Median Annual Per Capita Food Expenditure by Department
Units in 100,000 West African Francs, with 400-600 Francs to 1 USD

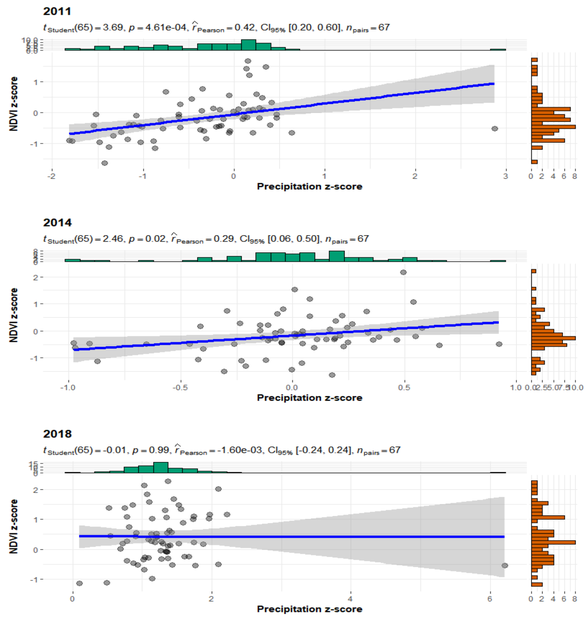


Food Insecurity and Precipitation Z-Score



- 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 2015 (r = -0.04).
- 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).
- NDVI z-score has very little association with food insecurity in 2014 (r=0.17) but in 2011 (r=-0.03) and 2018(r=0.05) which is approximately 0.

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 indicators 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

Brown, J. (n.d.). *NDVI, the foundation for Remote Sensing Phenology active*. NDVI, the Foundation for Remote Sensing Phenology | U.S. Geological Survey. Retrieved July 15, 2022
Central Intelligence Agency. (2022, July 1). *Niger - The World Factbook*. Central Intelligence Agency. Retrieved July 13, 2022
Laya, D. and Fuglestad, . Finn (2021, April 29). *Niger. Encyclopedia Britannica*.
Sahel adaptive Social Protection Program (ASPP). World Bank. (2020, June 1). Retrieved July 13, 2022
Niger - Enquête Harmonisée sur le Conditions de Vie des Ménages 2018–2019. (2022). Worldbank.

Elinor's edits and suggestnos on top of version 1

Friday July 22

Sensing Drought in the Sahel for Household Climate Resilience

Data Science *for the* Public Good

Catherine Back
Data Science

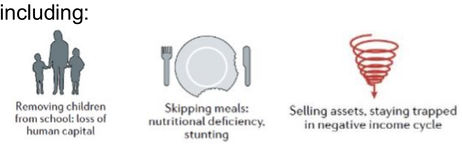
Riley Rudd
Economics & Consumer Studies

Milind Gupta
Computer Engineering

VIRGINIA TECH™

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.

Objectives

1. How do two commonly used drought indicators compare to one another in the same area?
2. How much do these indicators correlate to differences in food security?

Data Sources

Welfare/Food Insecurity

1. Living Standards Measurement Survey :

Survey program conducted by the World Bank, available for years 2011, 2014, and 2018. Per Capita Expenditures and Share spent on food, where 50% or above spent on food is classified as food insecure.

2. Food Insecurity:

Representative survey conducted by the government of Niger on vulnerability to household food insecurity for the years 2015 and 2017.

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 seasonal cumulative amount in mm

2. Peak Annual NDVI:

NDVI extracted from AVHRR (1km spatial resolution, daily values) over 1981-2022.

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

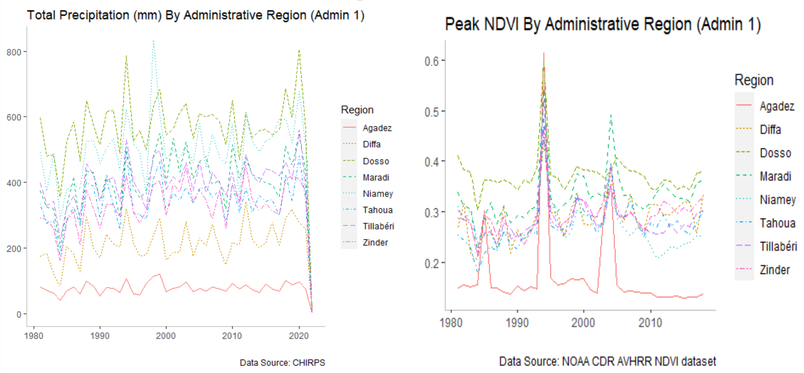
DSPG is creating a replicable data analysis pipeline between drought and welfare in Niger. We use z-score to translate historical weather to "anomalies" from normal (x_I), then examining the linkage between anomalies in a year vs aggregate welfare. Can you also add how you calculate the correlation/what indicator of correlati

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

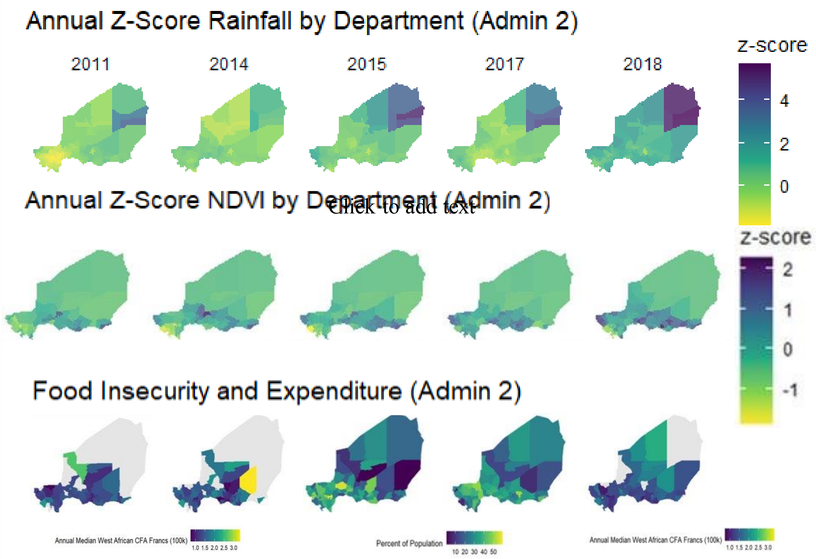
Methods

Z-scores allow you to quickly understand how "anomalous" a given value. It in effect asks how different are way to standardize data to make them more comparable to a known distribution of values.

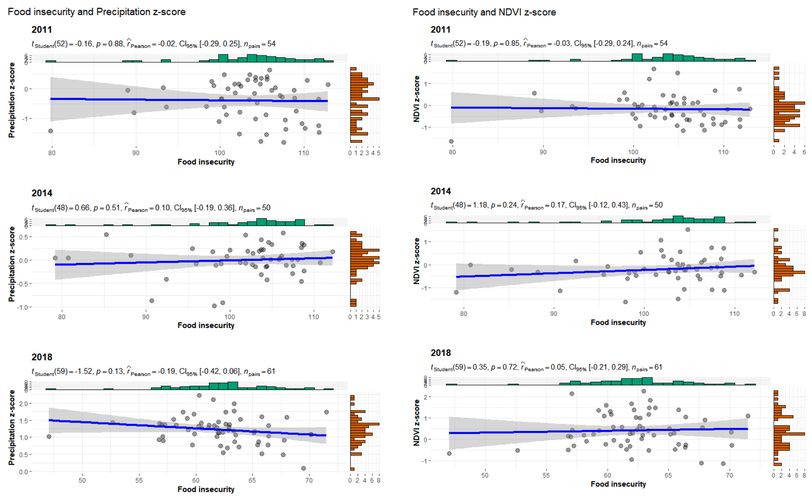
Input Data



In both precipitation and NDVI data we see regions get more precipitation and or vegetation growth and high peaks.

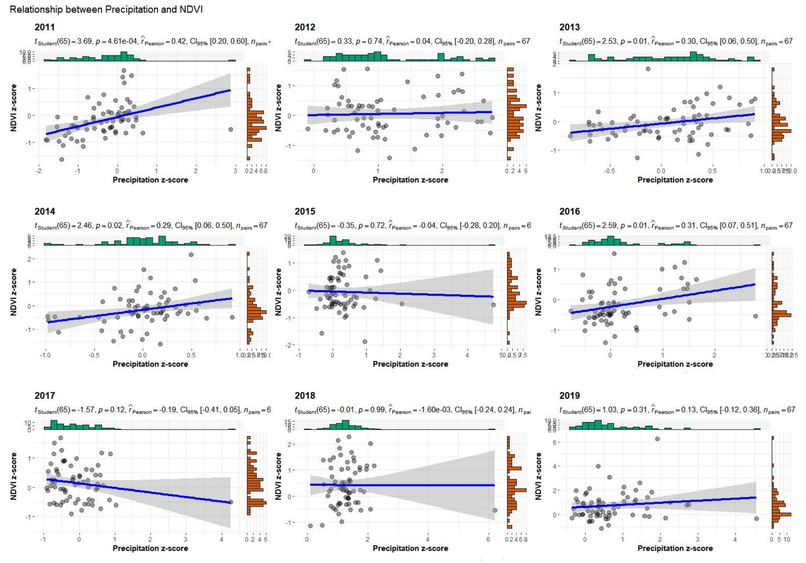


Comparisons of Precipitation, NDVI using z-score along with Food Expenditure and Food Insecurity Maps



These show that there is little to no correlation with Food insecurity, Precipitation, and NDVI.

Preliminary Results & Conclusions



Looking at the relationship between Precipitation and NDVI for years 2011 to 2019, we see that some years have higher correlation than others. [could probably delete – doesn't add much – what you write in the conclusion section was much stronger]

The key takeaways from our research are: [probably don't need, especially if these results

- The correspondence between the precipitation z-score and NDVI-z-score is strongest in 2011 (R^2 =0.42) and weakest in 2015 (r=-0.04).
- Precipitation z-score has a negative association with food insecurity in 2018(r=-0.19) and 2011(r=-0.02) ,but in 2014(r=0.10)
- NDVI z-score has very little association with food insecurity in 2014 (r=0.17) but in 2011 (r=-0.03) and 2018(r=0.05) which is approximately 0.

This implies that there is little correlation between the NDVI and Food Expenditure as well as Precipitation and Food Expenditure while NDVI and Precipitation somewhat follow each other. [Would delete this sentence as it's very general -- could speak to this, but would encourage you to use this space to draw out results more[

Consider:
1) Rationale for why you may be seeing the results you do (too coarse resolution, for example, or degree of aggregation that loses some of the variation in underlying conditions)
2) In next steps, mention alternative indices that could be used e.g. water resource stress index)
3) Techniques that use out-of-sample prediction to evaluate performance

[Doesn't add much, would delete this next stenence:] The next steps involve conducting a vulnerability analysis and comparing the variables to better understand the relationship between the drought index and welfare index which would in turn help to identify the most vulnerable areas and scale the protection programs.

References

Brown, J. (n.d.). *NDVI, the foundation for Remote Sensing Phenology active*. NDVI, the Foundation for Remote Sensing Phenology | U.S. Geological Survey. Retrieved July 15, 2022

Central Intelligence Agency. (2022, July 1). *Niger - The World Factbook*. Central Intelligence Agency. Retrieved July 13, 2022

Laya, D. and Fuglestad, . Finn (2021, April 29). *Niger*. *Encyclopedia Britannica*.

Sahel adaptive Social Protection Program (ASPP). World Bank. (2020, June 1). Retrieved July 13, 2022

Refs to your data sources! (LSMS)

Susan's edits + Elinor's

Sunday July 24

Sensing Drought in the Sahel for Household Climate Resilience

Data Science *for the* Public Good

Catherine Back
Data Science

Riley Rudd
Economics & Consumer Studies

Milind Gupta
Computer Engineering

VIRGINIA TECH™

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.

Objectives

1. Compare two commonly used drought indicators in the same area.
2. Estimate the correlation between these two indicators & 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.

2. Food Insecurity:
Surveys conducted by the government of Niger on household food insecurity risk in 2015 and 2017.

Drought

1. Precipitation (CHIRPS):
Gridded rainfall time series from 1981-2022 at ~5km spatial resolution. This dataset is often used for trend analysis and seasonal drought monitoring.
We take the seasonal 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.

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

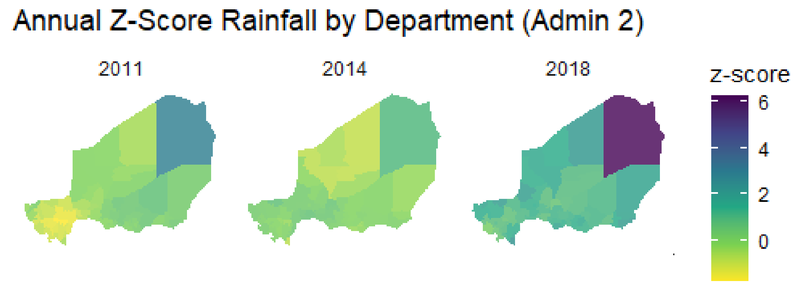
Methods

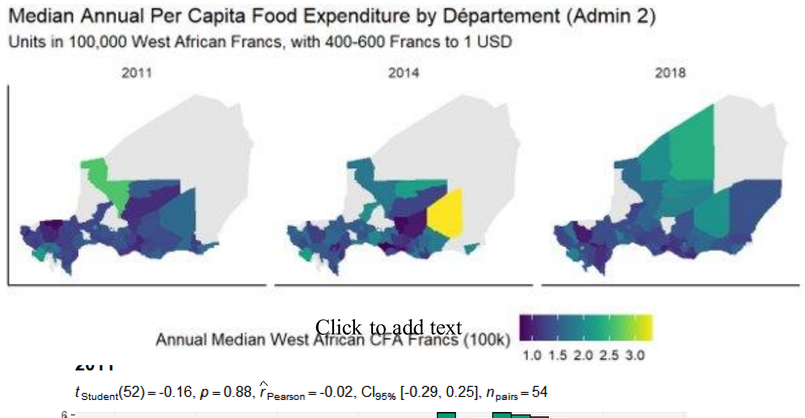
- Use z-scores to translate historical weather to "anomalies" from normal (x_i). Z-scores (Z_{it}) quantify how "anomalous" a given annual precipitation amount or NDVI value s by comparing that value (x_i) to the mean ($\bar{x}$) of those values in a prior period (here 1981-2010) and dividing by the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

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

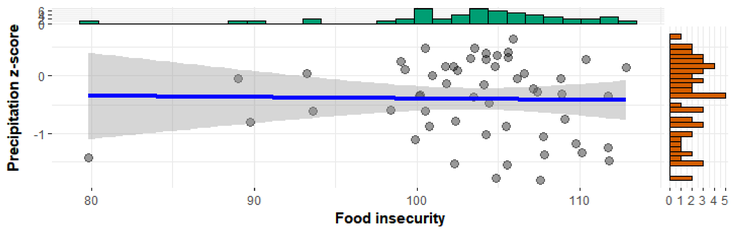
- Examine the relationship between annual weather anomalies and aggregate welfare using the Pearson R correlation coefficient, which measures the strength of the linear association between the variables

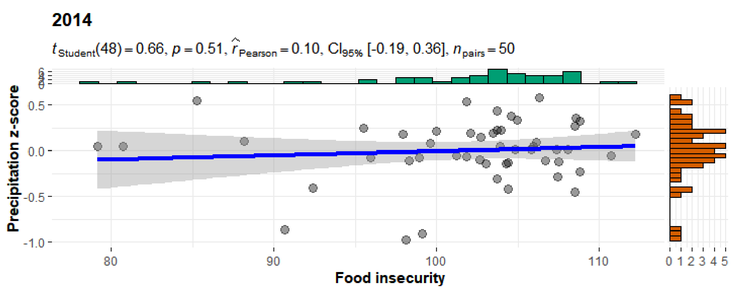
Preliminary Results

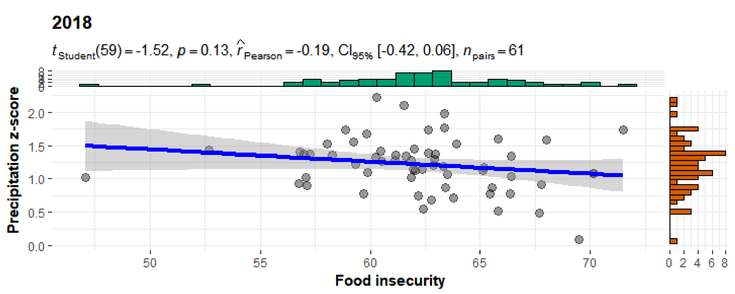




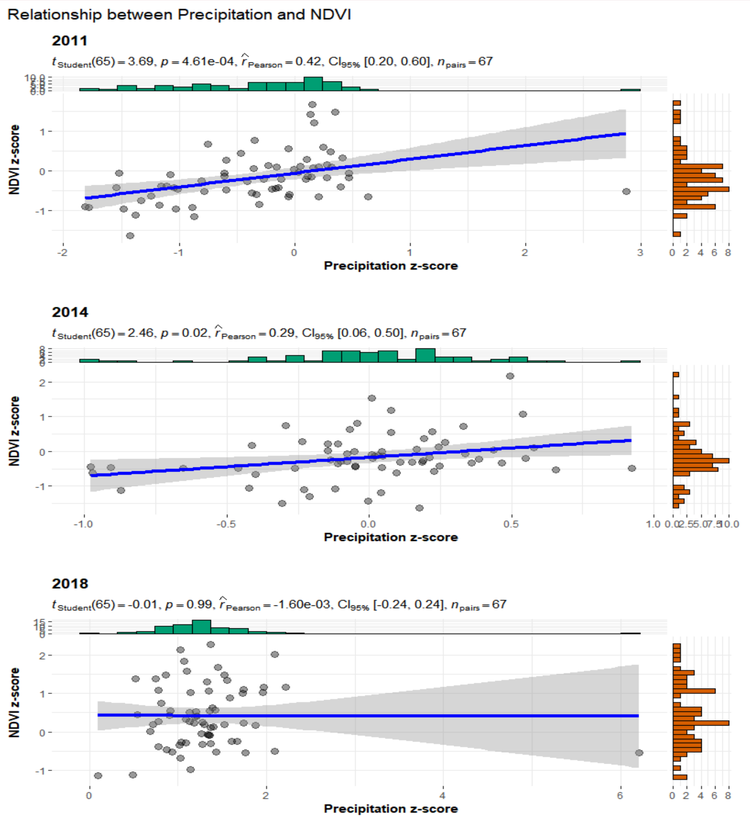
Click to add text







- We observe little correspondence between food insecurity and precipitation.
- Analysis with NDVI presents similar results (not presented here).



Conclusions & Next Steps

- Precipitation and NDVI correlate the most in 2011 (r = 0.42) and the least in 2015 (r = -0.04).
- 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).
- NDVI z-score has very little association with food insecurity in 2014 (r=0.17) but in 2011 (r=-0.03) and 2018(r=0.05) which is approximately 0.

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 indicators 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

- Brown, J. (n.d.). NDVI, the Foundation for Remote Sensing Phenology | U.S. Geological Survey. Retrieved July 15, 2022
- CIA. (2022, July 1). *Niger - The World Factbook*. Central Intelligence Agency. Retrieved July 13, 2022
- Laya, D. and Fuglestad, . Finn (2021, April 29). *Niger. Encyclopedia Britannica*.
- *Sahel Adaptive Social Protection Program (ASPP)*. World Bank. (2020, June 1). Retrieved July 13, 2022
- Lsms ref