

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

- To compare two commonly used drought indicators in the same area
- 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.

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

Methodology

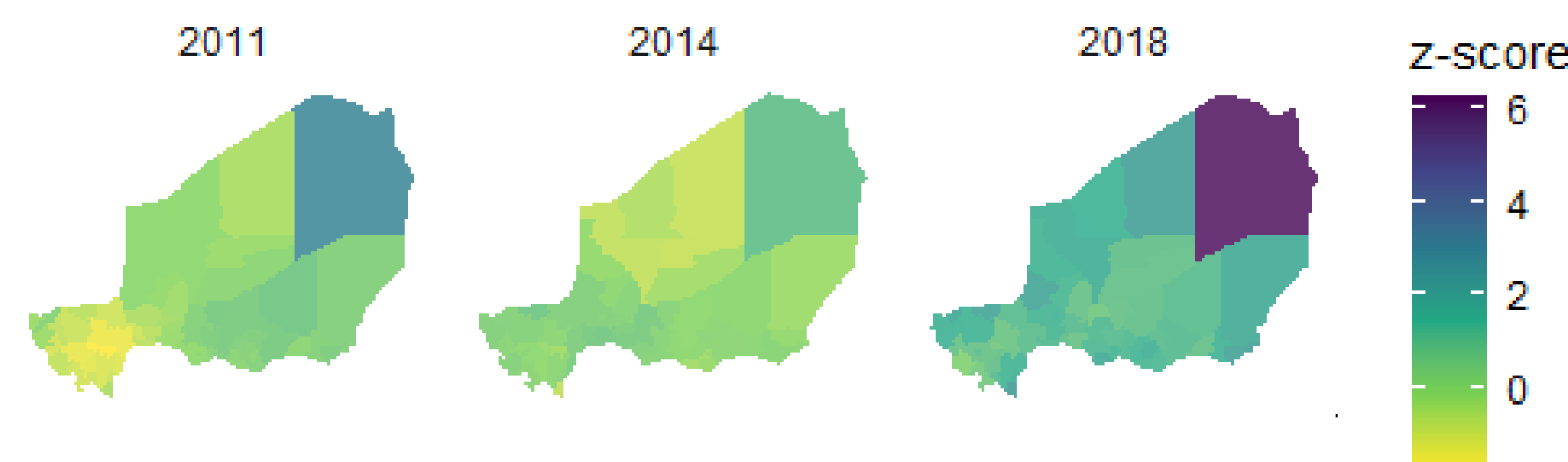
- We use z-score to translate historical weather to “anomalies” from normal (x_i).
- Z-scores allow you to quickly understand how “anomalous” a given value. It in effect asks how different are way to standardize data to make them more comparable to a known distribution of values.

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

- 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.

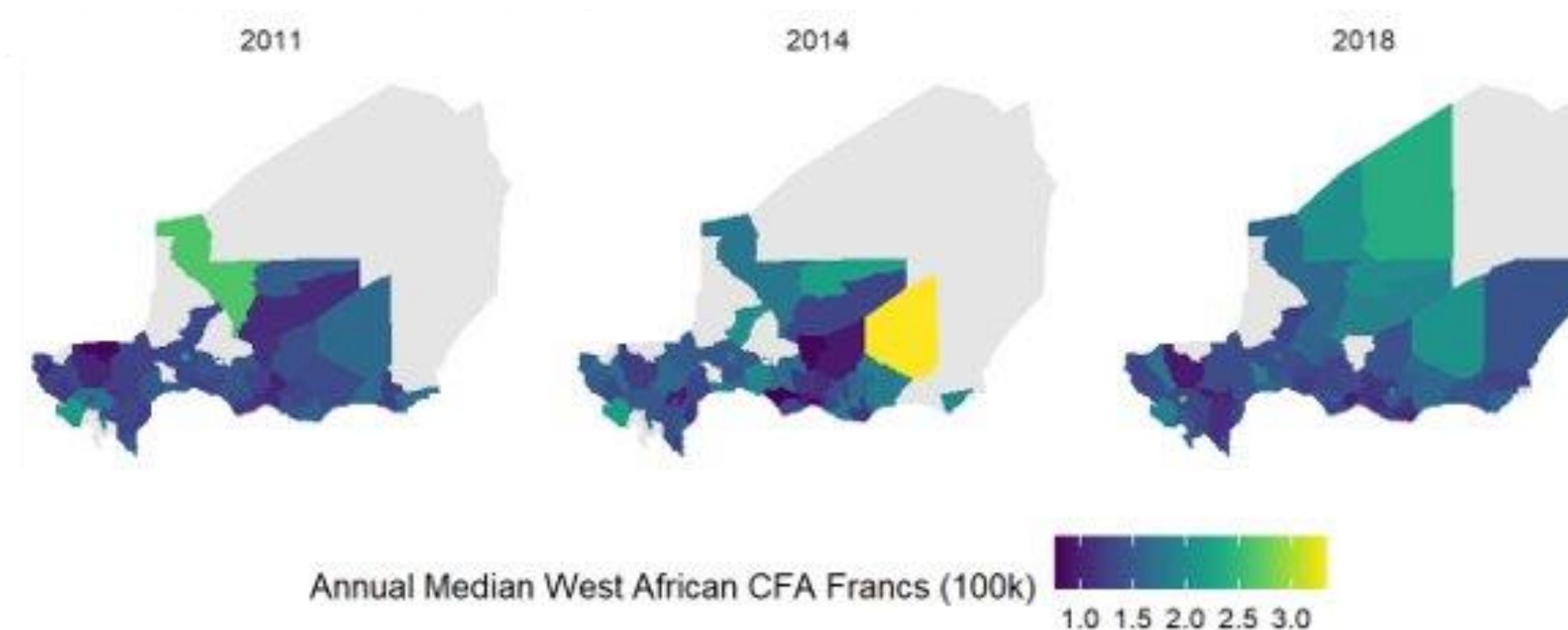
Preliminary Results

Annual Z-Score Rainfall by Department (Admin 2)

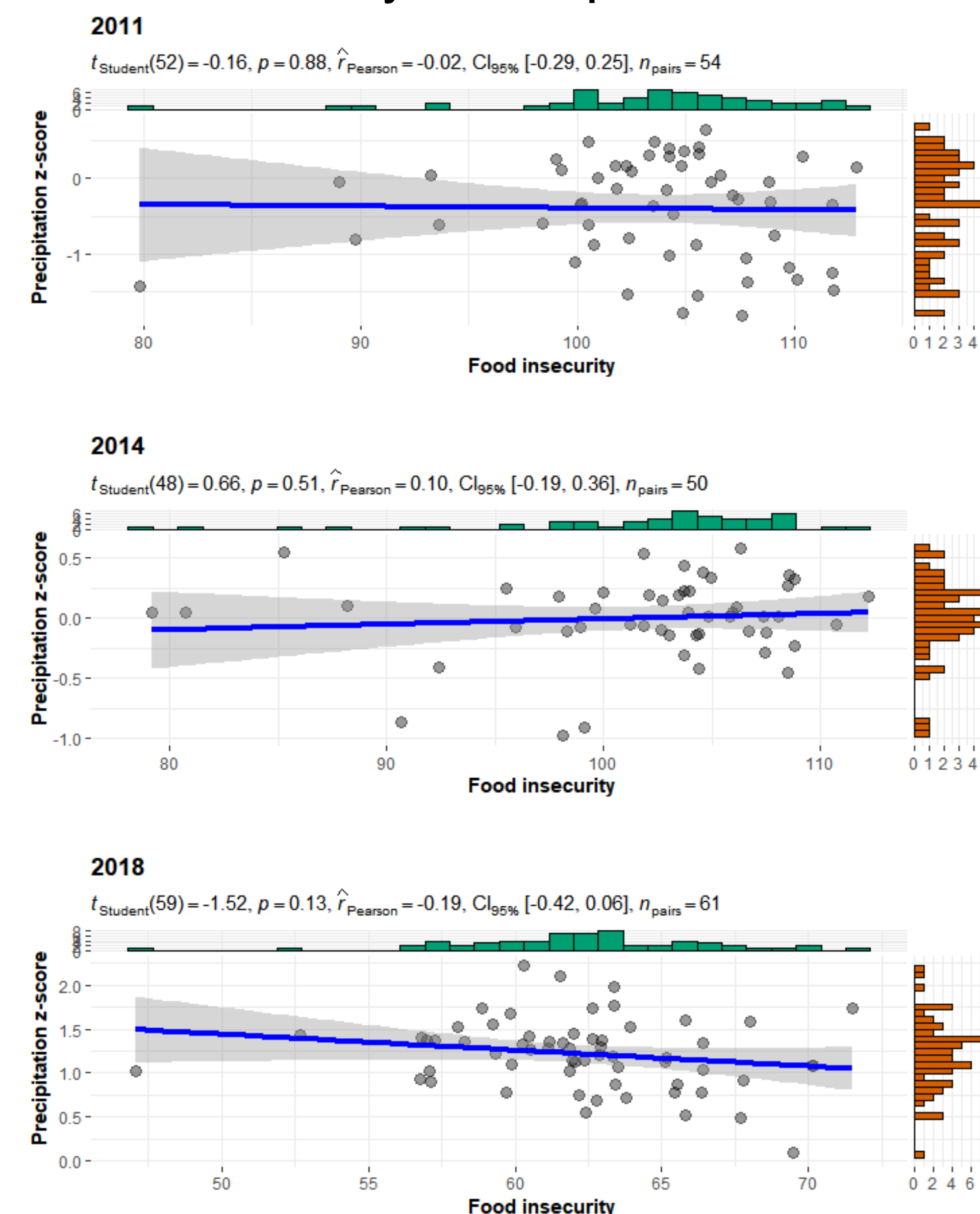


Median Annual Per Capita Food Expenditure by Department

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

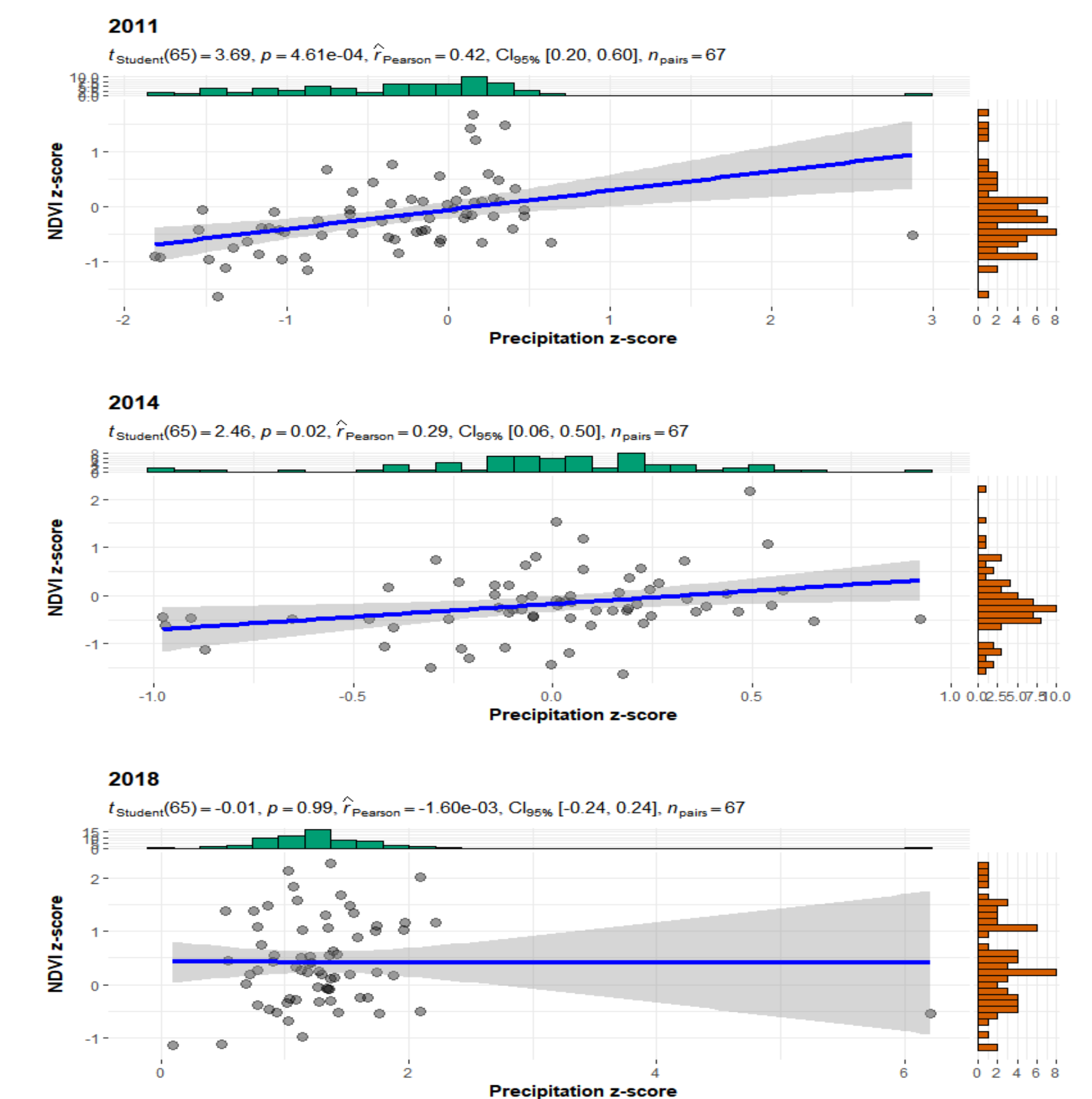


Food Insecurity and Precipitation Z-Score



- 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 lose 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

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