

CAFÉ PAVES THE WAY: Addressing food insecurity in Puerto Rico through diversified coffee farming

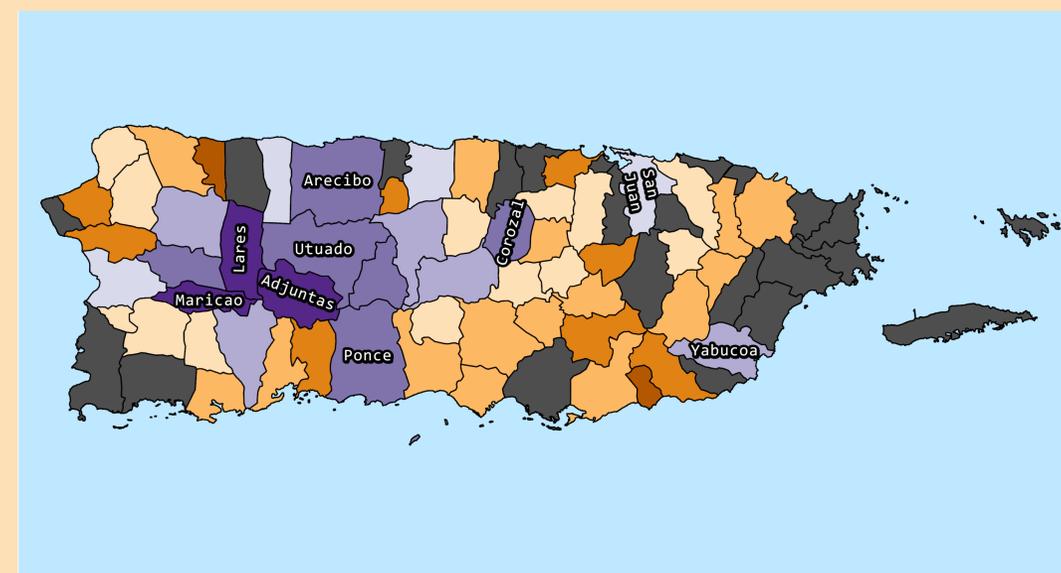
Background

- Hurricane Maria devastated the island of Puerto Rico in 2017 drawing worldwide attention to a major humanitarian crisis for food security. What many may not realize, however, is that the situation on the island was desperate even before the disaster struck.
 - In 2016, Puerto Rico **imported 85% of the food** for consumption and over a **third of the population** relied on federal food assistance (food stamps/SNAP equivalent) despite the island's tropical climate ideal for year-round crop production.
- Ground roots organizations are promoting **diversified agriculture** on the island as a path to greater food security and climate resilience. **Coffee** (*Coffea arabica*) is a globally important tropical crop that is well-suited to growth under a diverse shade canopy but it is often grown in full-sun monocultures in an effort to maximize production.
- Data on coffee production and federal food assistance from pre-Maria (2016) Puerto Rico were synthesized to identify regions that had a high need for **enhanced food security** and a high potential for **agricultural diversification** to fill that need.

Methods

- Data on coffee farm abundance and farm management type (shaded/diversified versus full-sun/monoculture) were obtained at the *municipio* level from the USDA agricultural census 2012.
- Federal food assistance data, also at the municipality level, were retrieved from the American Community Survey of 2016 (5-year estimates from 2012-2016). Households receiving food stamps/SNAP equivalent were used here as a proxy for food insecurity.
- In ArcGIS Pro, the food insecurity and coffee production data were spatially joined to a *municipio* shapefile downloaded from the GADM database. The "polygon to raster" tool was used to create the raster layers pictured below. The data in each were split into 5 classes by natural breaks using the "splice" tool. Finally, raster calculator was used to add all layers together and create a heat map ranking the municipalities by their "Coffee Farm Diversification for Food Security Index" (3 as low potential; 15 as high potential).
- Statistical analysis was performed in RStudio software (Version 1.1.453). A generalized linear model was built with both the total number of coffee farms and the percent of sun-grown farms as predictor variables and the number of households receiving federal food assistance as the dependent variable. The model included an offset for total households and specified a Poisson distribution.

Results and Discussion

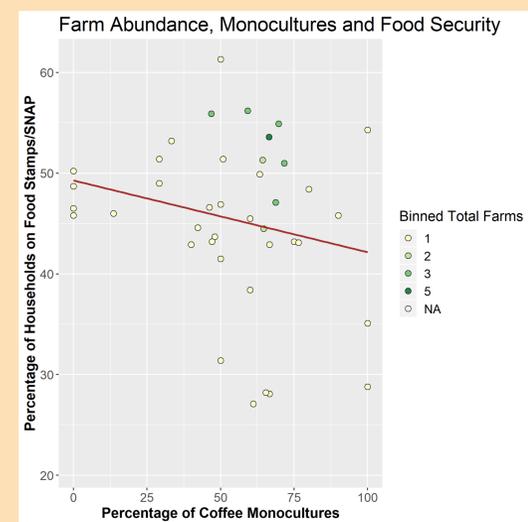


Coffee Farm Diversification for Food Security Index



Spatial Analysis

- The individual raster maps illustrated interesting trends in the spatial distribution of population, federal food assistance, and coffee production. In general, both coffee production and higher rates of food insecurity reached their peak in rural areas along the island's interior, but they did not entirely overlap. *Municipios* with a larger number of farms tended to have an intermediate distribution of sun monocultures versus shade-grown farms, whereas areas with a small number of farms had more extreme values (80% diversified shade-grown or 80% sun-grown monoculture).
- Adjuntas, Lares, and Maricao were the three *municipios* that received the highest value of the "Coffee Diversification for Food Security Index." These areas therefore had a high potential for coffee farm diversification to address local food insecurity. Interestingly, besides being among several *municipios* in the lowest class of total households, the three differed in all other composite maps suggesting that no single variable dominated the calculated index.



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 Data sources:
 • United States Department of Agriculture National Agricultural Statistics Service. 2012 Census of Agriculture - Municipio Data. Table 44: Coffee Harvested for Sale: 2012 and 2007.
 • United States Census Bureau. 2012-2016 American Community Survey 5-Year Estimates. FOOD STAMPS/ Supplemental Nutrition Assistance Program (SNAP).
 • GADM Version 3.6. 2018. Puerto Rico- Administrative Areas.
 • Flag: Wikimedia commons
 Acknowledgements: I'd like to thank my instructor, Kyle Monahan, for his guidance throughout this project.



Statistical Analysis

The statistical analysis revealed a significant positive effect of the total number of coffee farms on rates of food insecurity ($F=2613$, $df=1$, $p<0.0001$). There was also a slight, but significant, negative relationship between the percentage of monoculture farms and rates of food insecurity ($F=2348$, $df=1$, $p<0.0001$). This trend was likely driven by a couple *municipios* with relatively low rates of food aid and exclusively sun-grown monocultures. The plotted results supported a greater effect of the total number of coffee farms, rather than farm management type, since the darker circles are clustered in the upper half of the graph. Although the data here show no evidence of coffee farm diversification enhancing food security, they highlight target areas where coffee farms could be diversified to incorporate additional nutritional resources and alternative farmer income.

Limitations and Future Directions

- The present analysis was limited in a couple important ways. First, the approach focused on a handful of variables and assumed census data on federal food aid was an appropriate proxy for food insecurity. Second, the agricultural census does not differentiate farms with a single species of shade tree from those with a more biodiverse canopy, nor does it indicate whether farmers use the shade trees to supplement their income and/or nutrition. Field data collection with a higher spatial resolution and a more comprehensive ecological assessment would add rigor to the analysis.
- Hurricane Maria presented an opportunity to rebuild local agriculture on the island through sustainable and diversified food systems. The analysis will be expanded as agricultural and community census data on post-Maria Puerto Rico become available.

