# Aflatoxin contamination of groundnuts

## A vulnerability analysis of household crop production in Nampula Province, Mozambique

## Introduction

Aflatoxin is a toxic secondary metabolite produced by various molds and commonly contaminates food and feed worldwide. Aflatoxin is an important public health issue known to possess acute toxicity, carcinogenic properties and other chronic adverse effects (Gong, et al., 2016). Aflatoxins occur frequently when high moisture is present during harvest and when crop drying and storage are inadequate (Jaffe, et al., 2019). Countries in latitudes between 40° north and 40° south, including Sub-Saharan Africa, are of high potential exposure to aflatoxins. In Mozambique, high levels of aflatoxin have been documented in the food system (Cambaza, et al., 2018). The northern and central regions, including Nampula Province (Fig. 1), are known hotspots for aflatoxin B1 (AFB1) contamination in maize and groundnut value chains. However, the interacting roles of environmental and behavioral risk factors remains poorly understood, particularly within the context of climate change. This vulnerability analysis utilizes spatial techniques to identify areas within 10 districts of Nampula Province, Mozambique that are most susceptible to aflatoxin contamination of groundnut crops, considering factors of rainfall, slope as a proxy for flooding, and post-harvest drying methods for groundnut producing households.

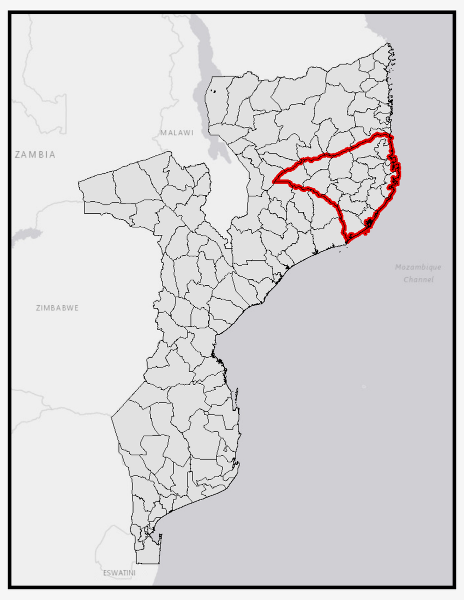

Figure 1. Nampula Province, Mozambique.

## Data

Data collected from the 2018 cross-sectional study, *"Assessing the Relationship of Aflatoxin Exposure and Stunting in Children 6-59 Months of Age in 10 Districts of Nampula Province, Mozambique,"* by the Feed the Future Innovation Lab for Nutrition at Tufts University was used to produce a province-level table of household GPS coordinates; participation in groundnut production; and exclusive use of post-harvest drying practices deemed "risky" for aflatoxin contamination (FAO, n.d.) (Table 1). Average monthly precipitation (mm) was downloaded as a set of 12 raster files from World Clim's Global Climate Dataset of precipitation from 1970-2000. Elevation was downloaded as a raster file from the U.S. Geological Survey's EROS Data Center global digital elevation model (DEM) (30-arc seconds/ approximately 1 km) (1996). A country polygon shapefile, including province and district boundaries, was retrieved from the Global Administrative Boundaries (GADM) data platform.

**Table 1. Classification of crop drying methods**

| | |
|---|---|
| **Risky** | Spreading directly on the dirt; on the floor (cement, brick); or on the roof. |
| **Neutral or protective** | Drying with fans; on platforms; with plastic sheets; hanging in house; hanging in kitchen; other. |

## Methodology

This analysis involved aggregating three indicators to determine the overall risk of aflatoxin contamination of groundnut crops throughout 10 districts of Nampula Province. All analysis activities were conducted in ArcMap 10.7.1. Display XY data was used to join the table of household attributes onto the Mozambique district boundaries layer using latitude and longitude coordinates. Three individual datasets comprising precipitation, elevation, and agricultural attributes were reclassified, categorized by quantile, and ranked on a 1-6 low-high vulnerability scale to form intermediary maps. Prior to reclassification: cell statistics were used to aggregate monthly precipitation values into one yearlong average, and inverse distance weighting was employed to interpolate missing values; slope was calculated using elevation (DEM) values; kernel density of households practicing risky groundnut drying methods was calculated. An unweighted raster calculator was used to sum the three inputs (Fig. 2-4) and produce a final map of overall aflatoxin contamination vulnerability on a 1-18 low-high continuum (Fig. 5). Average risk per district locality was determined using zonal statistics (Fig. 6).

## Results

The analysis of precipitation, slope, and risky drying practices show different geospatial distributions across the 10 districts. The highest precipitation levels occur in the central-western region close to the Zambezia border (Fig. 2). While slope is relatively continuous across the districts, the northwestern and central-western regions show similarly high (steep) values compared to the southern and eastern parts of the province (Fig. 3). Density of households practicing risky post-harvest drying methods is more intense in the southeastern districts, with some pockets of density occurring in the central districts (Fig. 4). We found that areas most vulnerable to aflatoxin contamination include sections of Murrupula, Rapale, Mogovolas, Moma, and Angoche (Fig. 5,6).

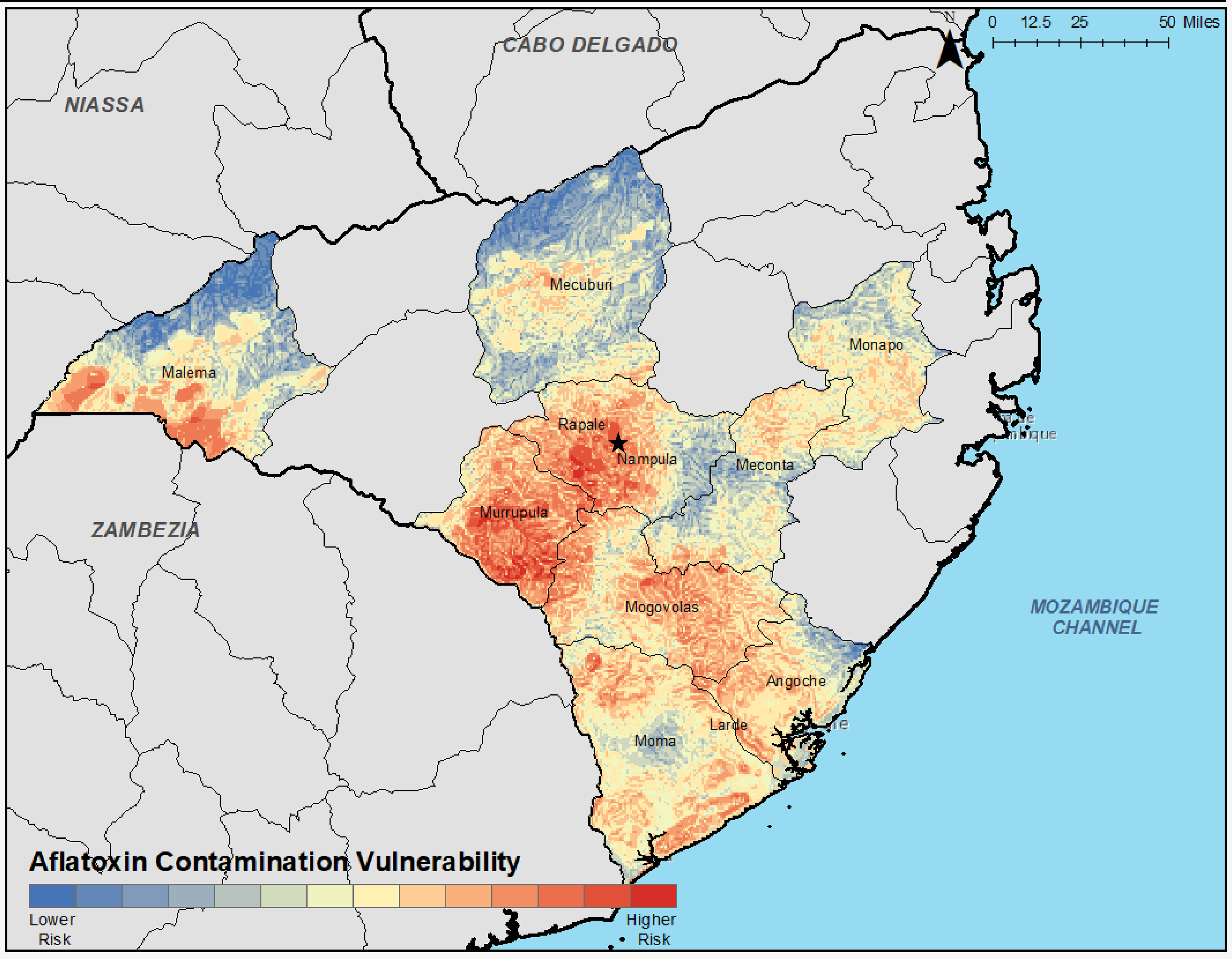


Figure 5. Vulnerability Assessment.

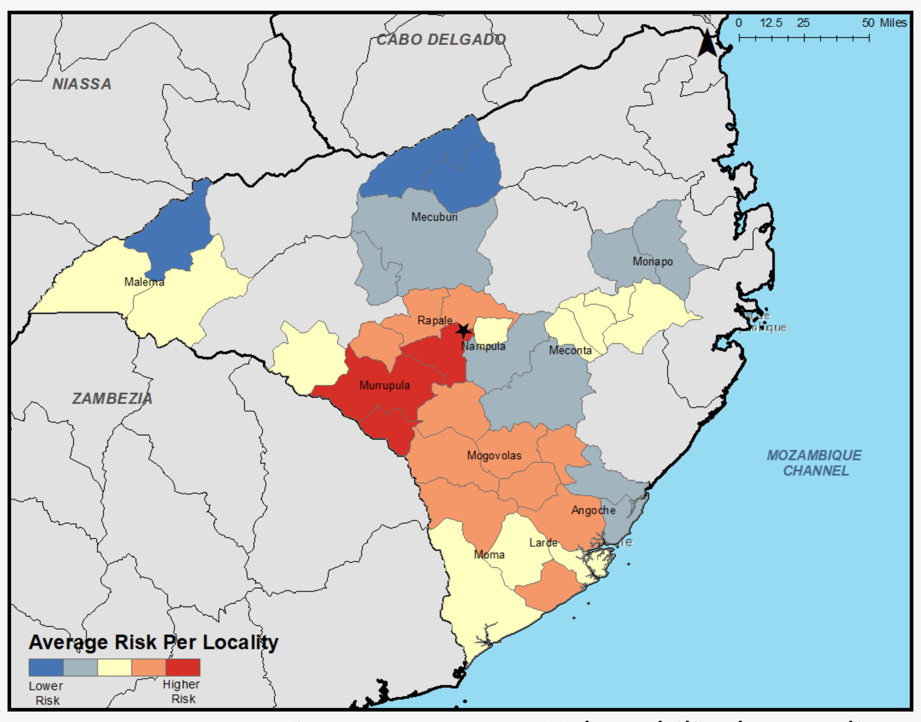


Figure 6. Average Vulnerability by Locality.

## Discussion

The densest areas of households practicing risky drying methods are largely in contrast to the areas of higher average precipitation and slope. It is possible that groundnut producing households dry their crop on the dirt, floor, or roof more commonly in areas with historically less rainfall and extreme weather events like flooding. Rainfall patterns will likely shift with climate change, however, potentially putting these areas at greater risk for aflatoxin contamination without post-harvest behavior change. This analysis links district-level risk factors for aflatoxin contamination to the broader research on aflatoxin incidence in Nampula Province and surrounding regions. Vulnerability information is critical to inform decision-makers, including public health officials, government organizations, researchers and NGOs, on where resources for aflatoxin intervention and prevention should be allocated.


Cartographer: Amy Byrne

Tufts University, NUTR231: Fundamentals of GIS


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Projection: World Mercator

Data Sources: Tufts University, World Clim, USGS

References:


Gong, Y. Y., Watson, S., & Routledge, M. N. (2016). Aflatoxin Exposure and Associated Human Health Effects, a Review of Epidemiological Studies. Food Safety, 4(1), 14–27; Jaffe, S., Henson, S., Unnevehr, L., Grace, D., & Cassou, E. (2019). The Safe Food Imperative: Accelerating Progress in Low- and Middle-Income Countries. International Bank for Reconstruction and Development/The World Bank; Cambaza, E., Koseki, S., & Kawamura, S. (2018). Aflatoxins in Mozambique: Impact and Potential for Intervention; FAO. (n.d.). Rural structures in the tropics: design and development: grain crop drying, handling and storage. Chapter 16, pp 363-386.


## Province estimates of historical average precipitation

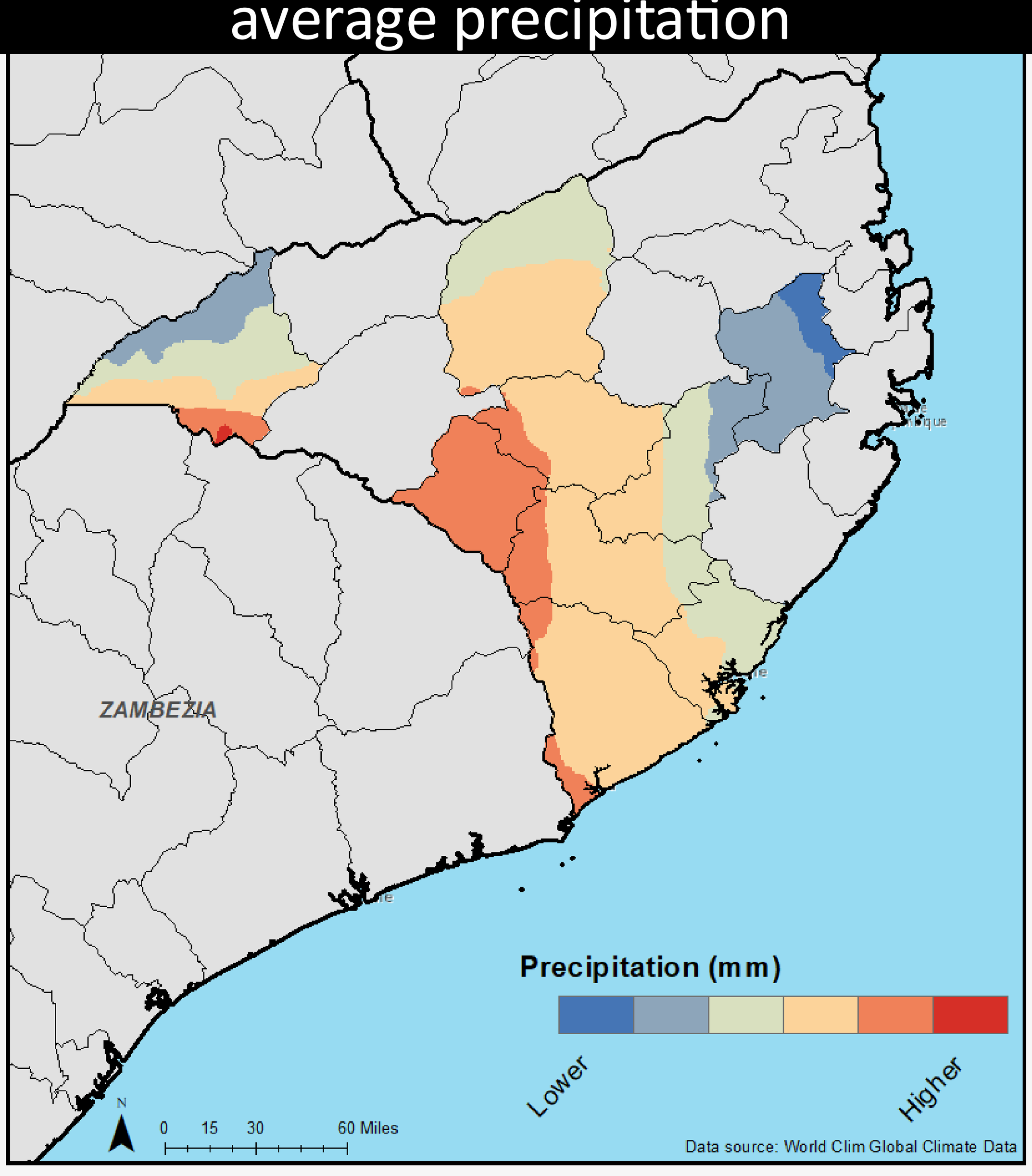


Figure 2. Precipitation Estimates.

## Province estimates of slope

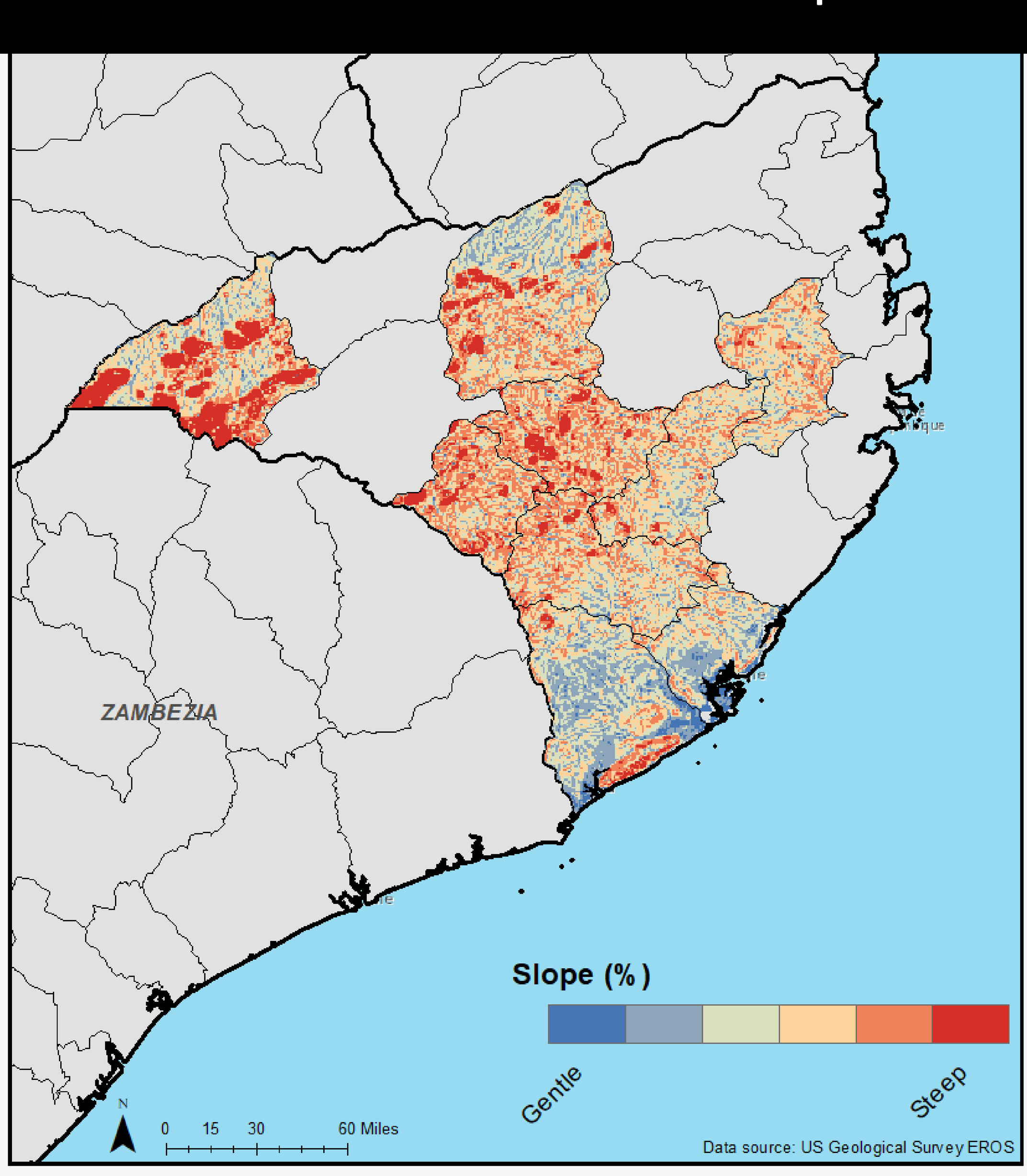


Figure 3. Slope Estimates.

## Density of households practicing risky post-harvest drying methods

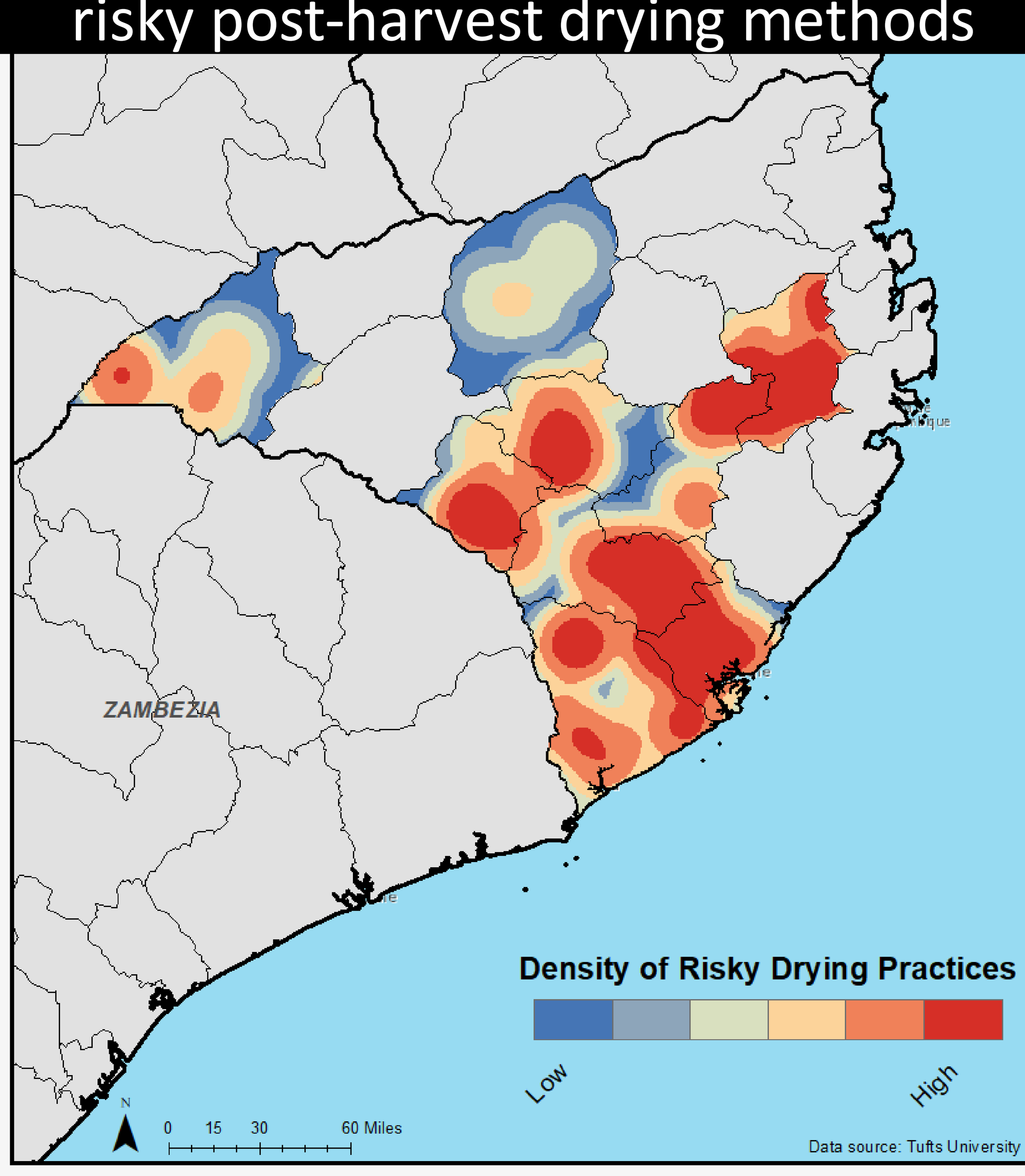


Figure 4. Density of Risky Drying Methods.