Spatial Analysis of Health Risk of Droughts in US Counties for 2010-2014 and 2015-2019

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Abstract

Drought is probably the most complex among natural hazards to assess its effects. While most drought indicators and risk assessments are developed around agricultural or water shortages effects of drought, its effect on human health is highly understudied because of its unclear and complicated path towards physical and mental health effects.

This study assesses the health risk of latest decadal drought over the US counties by spatially superimposing several proxy variables of counties' health vulnerabilities over their drought levels. We have used different variations of Local Moran's I statistics to assess spatial distribution of drought-vulnerability in two five-year study periods (2010-2014 and 2015-2019) and their differences. Our results show large clusters of significant risk increase in the west due to increases in both vulnerability and hazard indicators in the second study period.

Since the used vulnerability variables include indicators of agriculture, drinking water, and sociodemographic prosperities, results of this study can help researchers and policymakers in these areas to distinguish areas in need of higher attention for interdisciplinary study and planning in national or regional scales.

Introduction

Droughts are extended periods of low precipitation that lead to shortages in water supply [1]. Research has shown that drought can lead to several physical and mental health outcomes [2]. With the increase in frequency and severity of droughts, it is important to analyze the spatial distribution of drought and vulnerabilities to identify at-risk communities [3].

This work can help facilitate interventions to reduce potential adverse health effects of drought, through spatial analysis of highly vulnerable communities under high hazards of drought.

Data and Methods

Data

Vulnerability Indicators

Socioeconomic. Source: ACS[1] 5-year estimates (2010-2014 & 2015-2019) [4,5]

% Age Over 65
% Age Under 5
% Below Poverty level

Environmental:

% Cropland. and *% Open Water*
Source: NLCD[2] 2019 and 2013 [6]
% Small Community Water dependence. Source: EPA[3] SDWIS[4] [7]

Hazard Indicators from USDM[5]

Intensity: Considered categories D3 or D4.
Duration: Consecutive Weeks in Intensity during study period.
Frequency: Total weeks in Intensity over study period.

Methods

Local Moran's I analyses [8] :
Figure 1: Differential Univariate Local Moran's I
Figure 3: Bivariate Local Moran's I: Vulnerability with hazard as spatial lag
Figure 4: Bivariate Local Moran's I: Total Vulnerability and Total Hazard as spatial lag.

Results

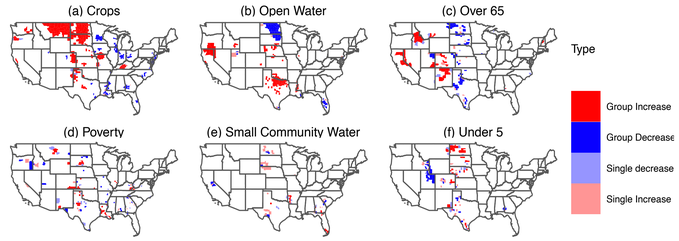

Figure 1. Result of Local Moran's I analysis for changes in vulnerability ratios over the periods.

- 1(a): Large clusters of significant increase in crop land ratios are recognizable in North Central sections
- 1(b): ND experienced most area of group decrease (Low-Low) of Open Water. Northern CA and Northern TX large increases in open water
- 1(c) Considerable increased clusters of elderlies in Northern CA, ID, and NM.

- In each county value of second study period subtracted by the first study period (in weeks)
- From 32 counties in the high 99 percentiles of increase in Duration Indicator (a), 27 located in CA and five in NV.
- For Frequency Indicator (b), 19 counties from California and eight in Arizona are two states with highest number of counties involved in top increases

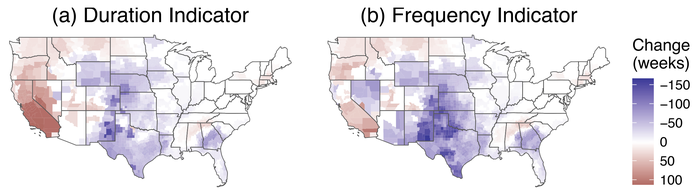

Figure 2. Changes in Hazard Indicators

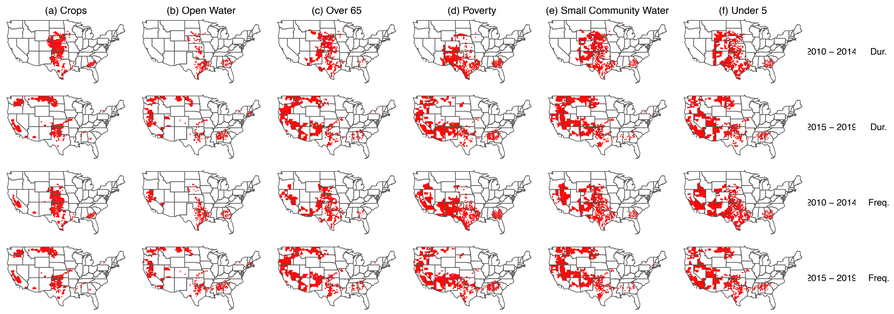

Figure 3. Counties in High vulnerability - High Hazard Conditions.

- Clear spatial shift of hotspots in Duration Indicators (Top two rows) from Midwest in the first to West and Southwest in the second study period, for all cases.
- Risks from Frequency Indicator expands into Northern part in the second period (Bottom two rows).

- Change of high-risk areas from South-Midwest in the first period to Southwest in the second.
- Low hazard of Northwest in the first period changes into high hazard in the second study period.
- Large areas in east, especially in the first study period contain clusters of low vulnerable counties, while in the second study period many counties in this area do not show significance.

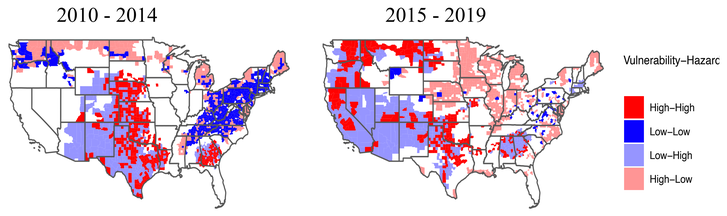

Figure 4. Risk levels in each Study Period

Conclusion

- Applying bivariate LISA analysis distinguishes areas of high risk through their significance level, while separating the vulnerability from the hazard levels through the distinction of central and spatial lagged variables.
- Considerable shifts of high hazard areas from the Midwest to the West, mostly resulted from the hazard shift and shows the importance of capturing climatic effects and their trends in estimating future risks.
- The results of this study can inform decision makers and scientists by providing maps of health risks of recent droughts with distinction of its components. This can show the spatial variability and change of different vulnerabilities and the hazards.

Abbreviations

1. ACS: American Community Survey
2. NLCD: National Land Cover Database
3. EPA: Environmental Protection Agency
4. SDWIS: Safe Drinking Water Information System
5. USDM: U.S. Drought Monitor

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