

# **U.S. Climate Vulnerability Index:** Integrating, visualizing, and prioritizing cumulative impacts of climate change, health, and environment

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**Testimony for Vermont State Senate Committee on Economic  
Development, Housing and General Affairs**

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# Acknowledgments

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\*Special thanks for contributing slide materials

## Community Stakeholders

Achieving Community Tasks Successfully (ACTS)  
Coalition of Community Organizations (COCO)  
Sunnyside Community Redevelopment Organization (SCRO)  
Will County Community Partners  
Lewis University  
South Bronx United  
Michigan United

## Other Partners and Collaborators

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City of Houston  
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Houston Food Bank  
Houston Galveston Area Council GIS data repository  
Rice University Urban Data Platform  
Houston Chronicle

## Funding



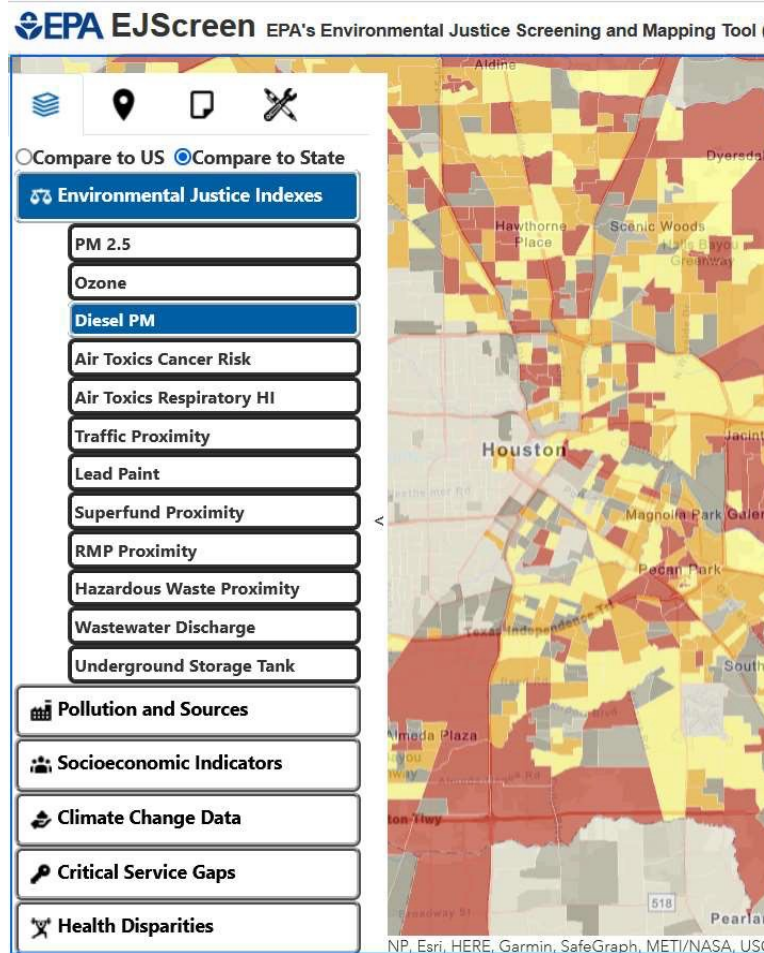
- NIH P42 ES027704 (TAMU Superfund Research Center)
- NIH P30 ES029067 (TAMU Center for Environmental Health Research)
- NIH T32 ES026568 (TAMU Regulatory Sciences in Toxicology and Environmental Health Training Program)
- EPA STAR RD84004601 (Community Resilience to Industrial Pollutants)



# Outline

- **Background and motivation**
- Overview of Climate Vulnerability Index
  - National-level results
  - Tour of CVI for Vermont
- From Data to Action

# Examples of Current Environmental Justice (EJ) Screening Approaches

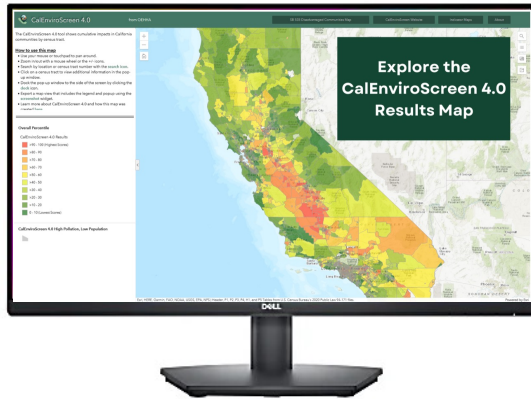


## EPA's EJ Screen

Analogous to a Tapas menu... you can pick and choose what indicators and indices you'd like to look use. By design, lacks cumulative index or score.

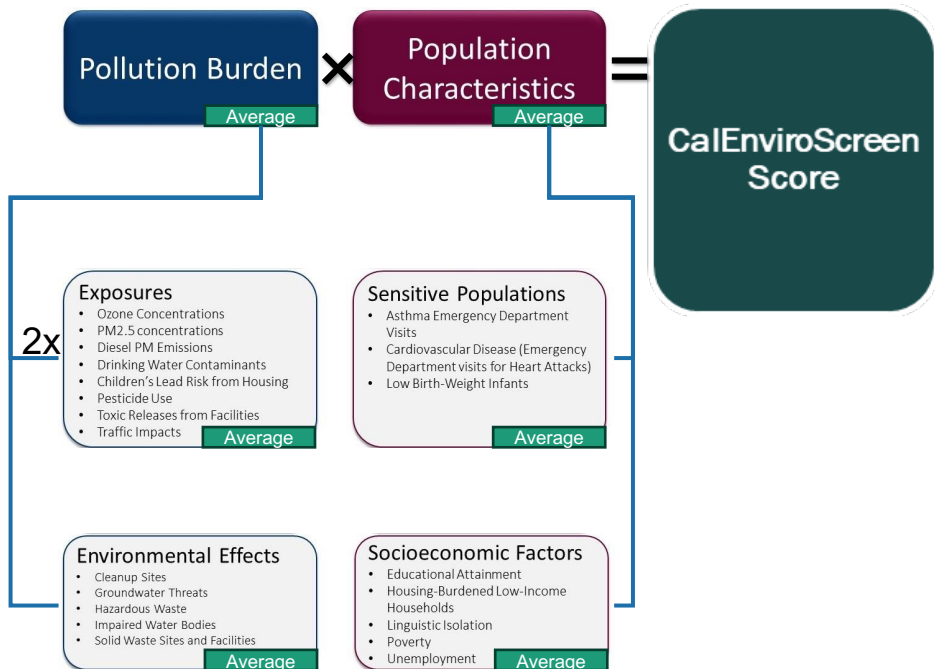


# Examples of Current EJ Screening



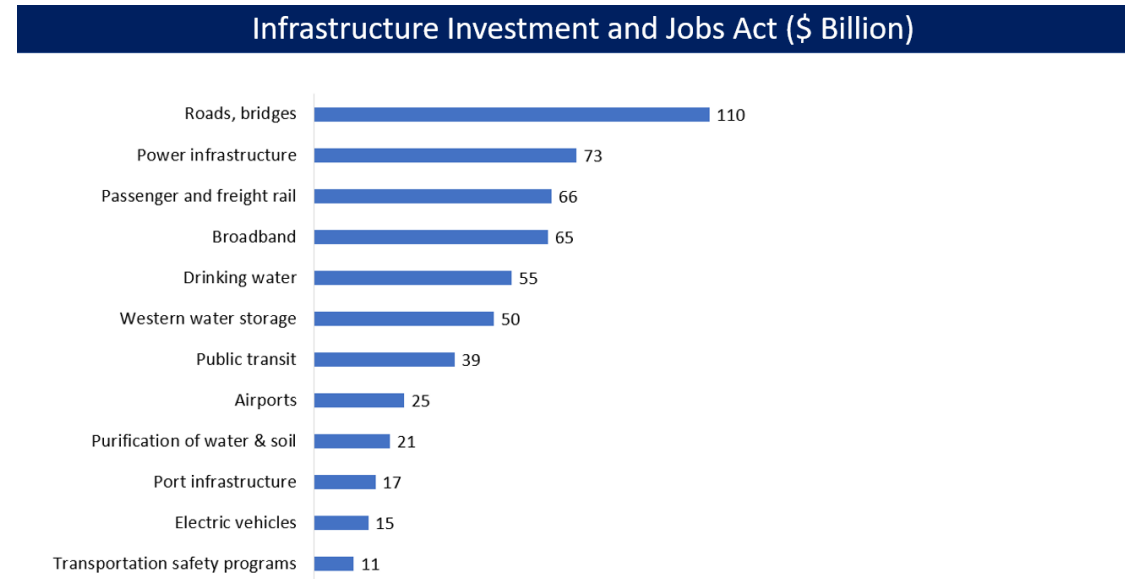
## CalEnviroScreen (now version 4.0)

Analogous to making soup – you know what went into it, but not necessarily what ingredients were most important.



# Challenges moving from EJ screening to action and mitigation

- Existing focus has been on chemical pollution, but recent initiatives are broader in scope
- Existing approaches have difficulty “zooming in and out” from the individual indicators to cumulative impacts
- Identifying key stressors needed to identify key interventions and ultimately improve people’s lives



# There is a critical need for a tool that

- Equips policymakers with data to effectively prioritize resources and interventions.
- Facilitates a clear roadmap for planners, local governments, federal agencies, research teams, and others to take targeted action.
- Gives community-based organizations access to local data that can help them take advantage of grant opportunities for reducing disparities in their communities.

# Outline

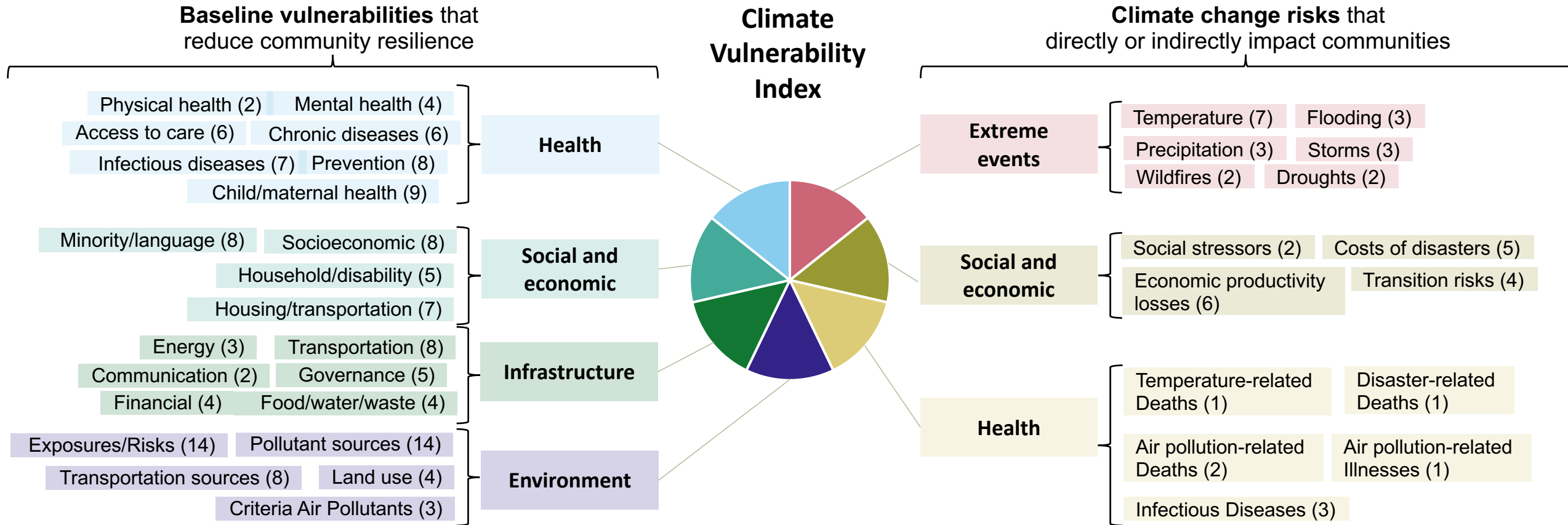
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# Climate Vulnerability Index

- **Overall Goal:** Identify local climate vulnerabilities on a national scale through a data-driven, GIS-based mapping tool integrating cumulative impacts of climate change, health, and environment
- **Anticipated Outcomes:**
  - Improve our understanding of the intersection between baseline vulnerabilities and climate change risks
  - Disentangle factors contributing most to vulnerability and inequity
  - Empower vulnerable communities and policymakers to develop effective action plans for today and tomorrow

# Pulling in 184 sets of data, the CVI creates a comprehensive vulnerability score and ranks more than 70,000 U.S. census tracts.

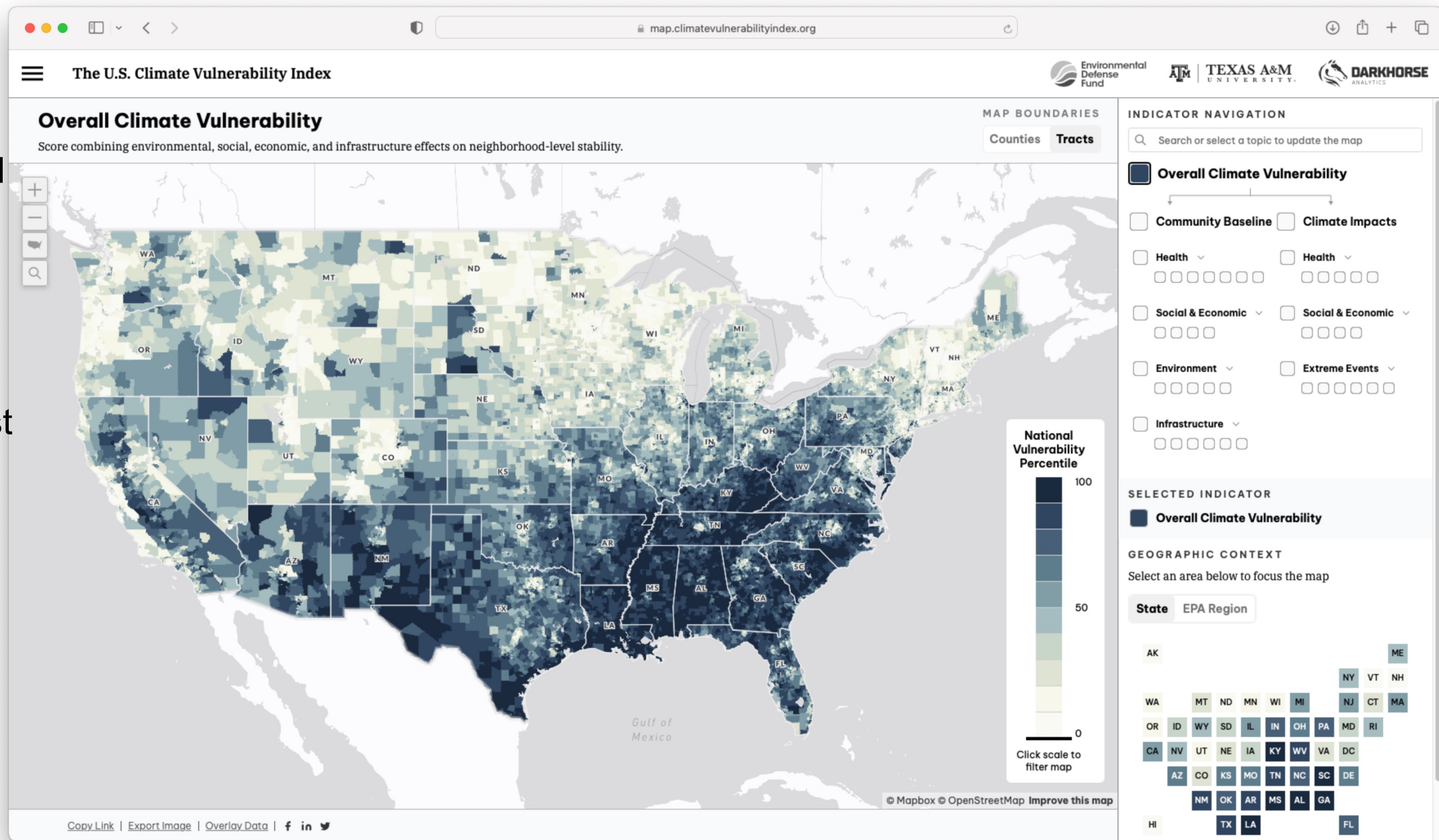


Peer reviewed and published in scientific journal:

Tee Lewis PG, Chiu WA, Nasser E, Proville J, Barone A, Danforth C, Kim B, Prozzi J, Craft E. Characterizing vulnerabilities to climate change across the United States. Environ Int. 2023 Feb;172:107772. doi: <https://doi.org/10.1016/j.envint.2023.107772> PMID: [36731185](https://pubmed.ncbi.nlm.nih.gov/36731185/)

# Overall CVI:

- Highest the Southeast and Southwest
- Lowest in the Northeast, upper Mid-West, and along the West Coast

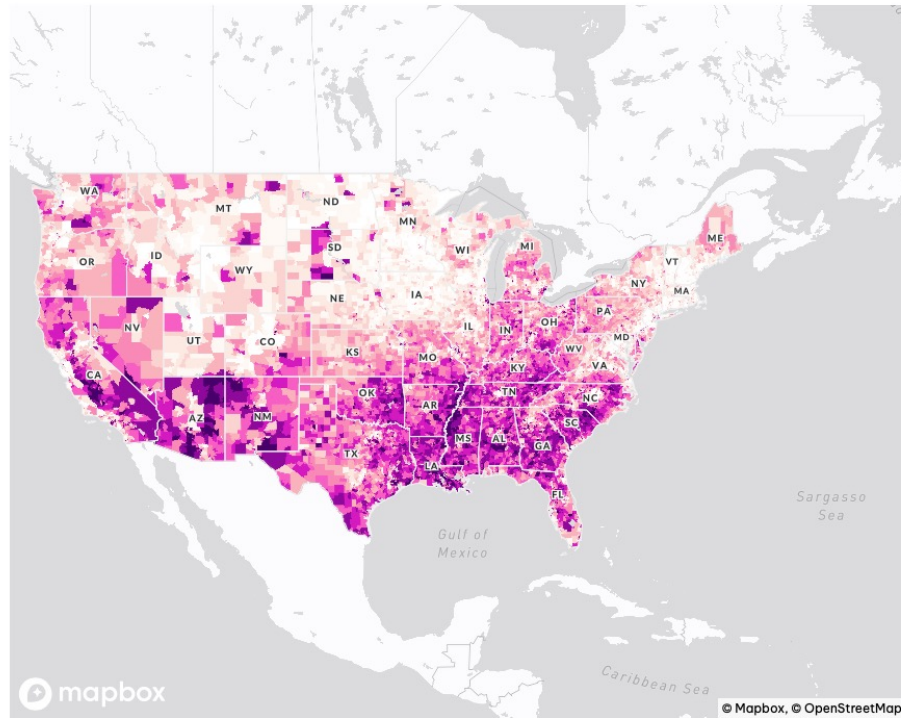


<https://ClimateVulnerabilityIndex.org>

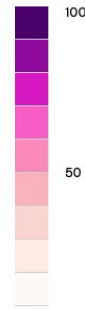
# Baseline Vulnerabilities have more localized patterns than Climate Impacts

## Community Baseline

The long-standing inequities shaping resilience to climate impacts.



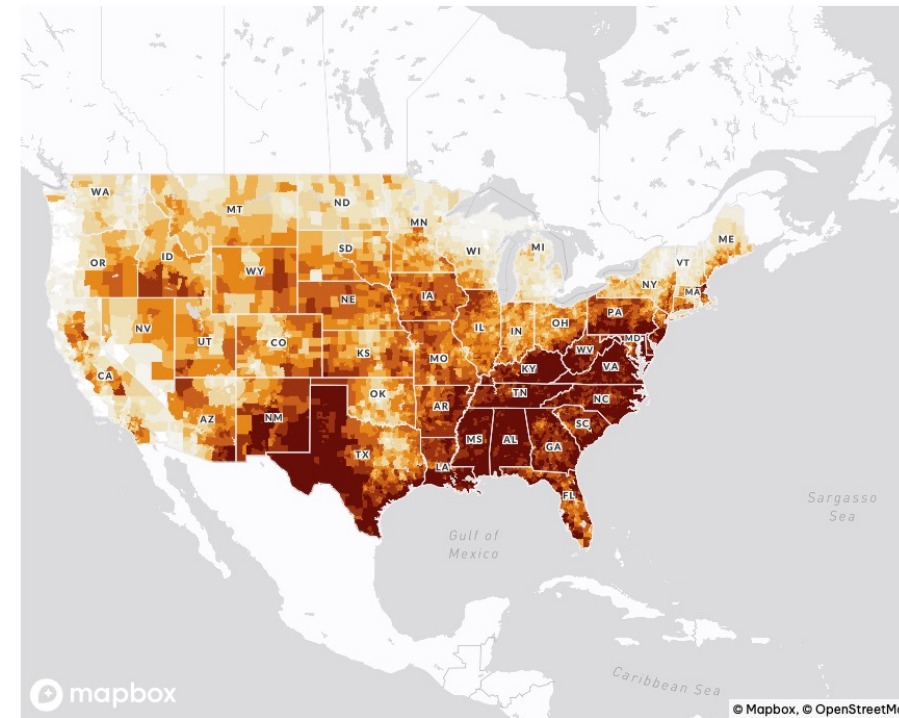
National Vulnerability Percentile



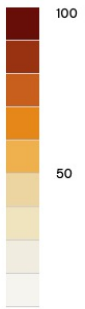
0  
Click scale to filter map

## Climate Impacts

How a community is vulnerable to environmental and economic disruptions.



National Vulnerability Percentile

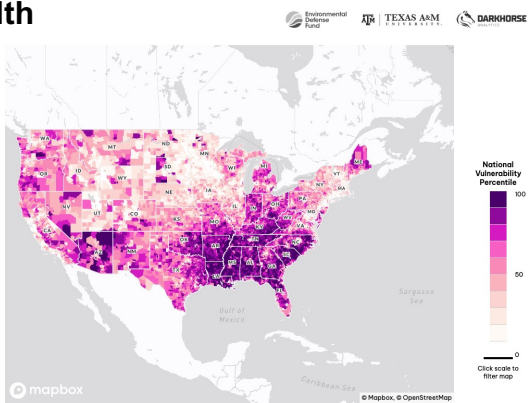


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Click scale to filter map

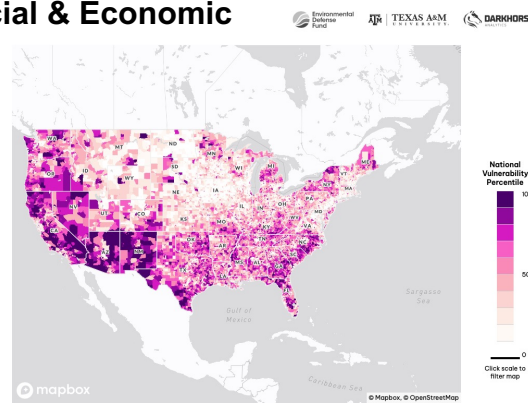
# Each Domain has its own geographic pattern

## Baseline Vulnerabilities

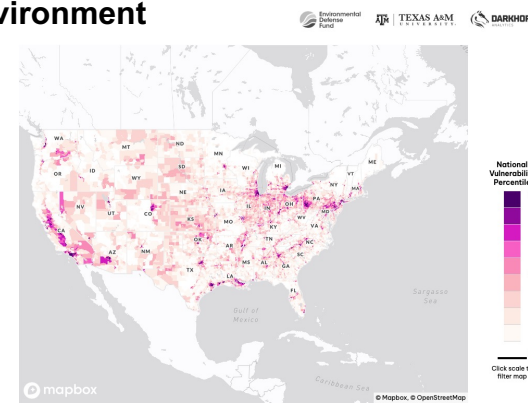
Health



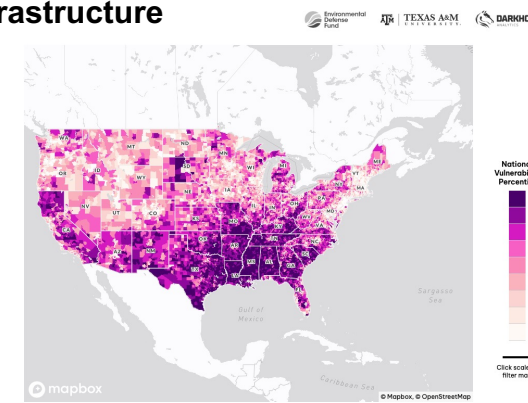
Social & Economic



Environment

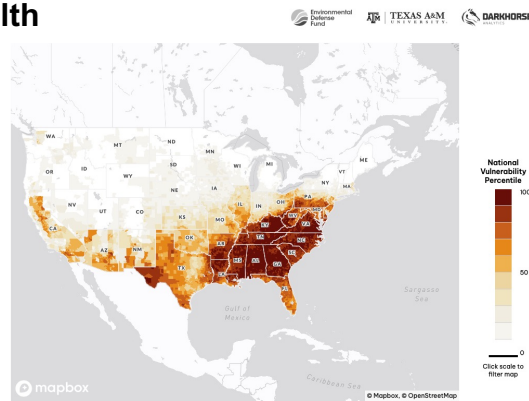


Infrastructure

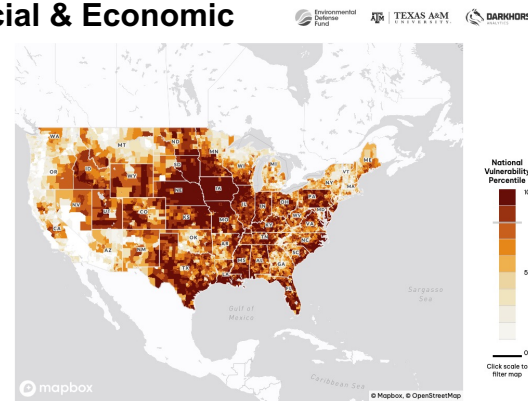


## Climate Impacts

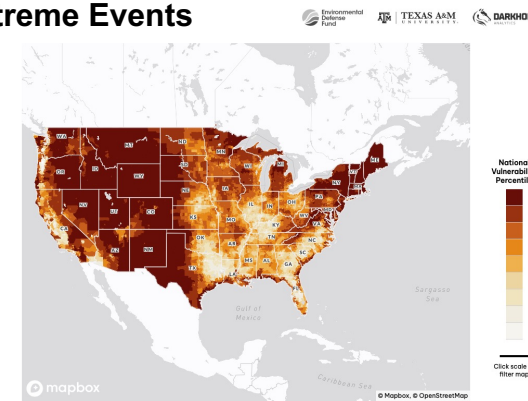
Health



Social & Economic



Extreme Events

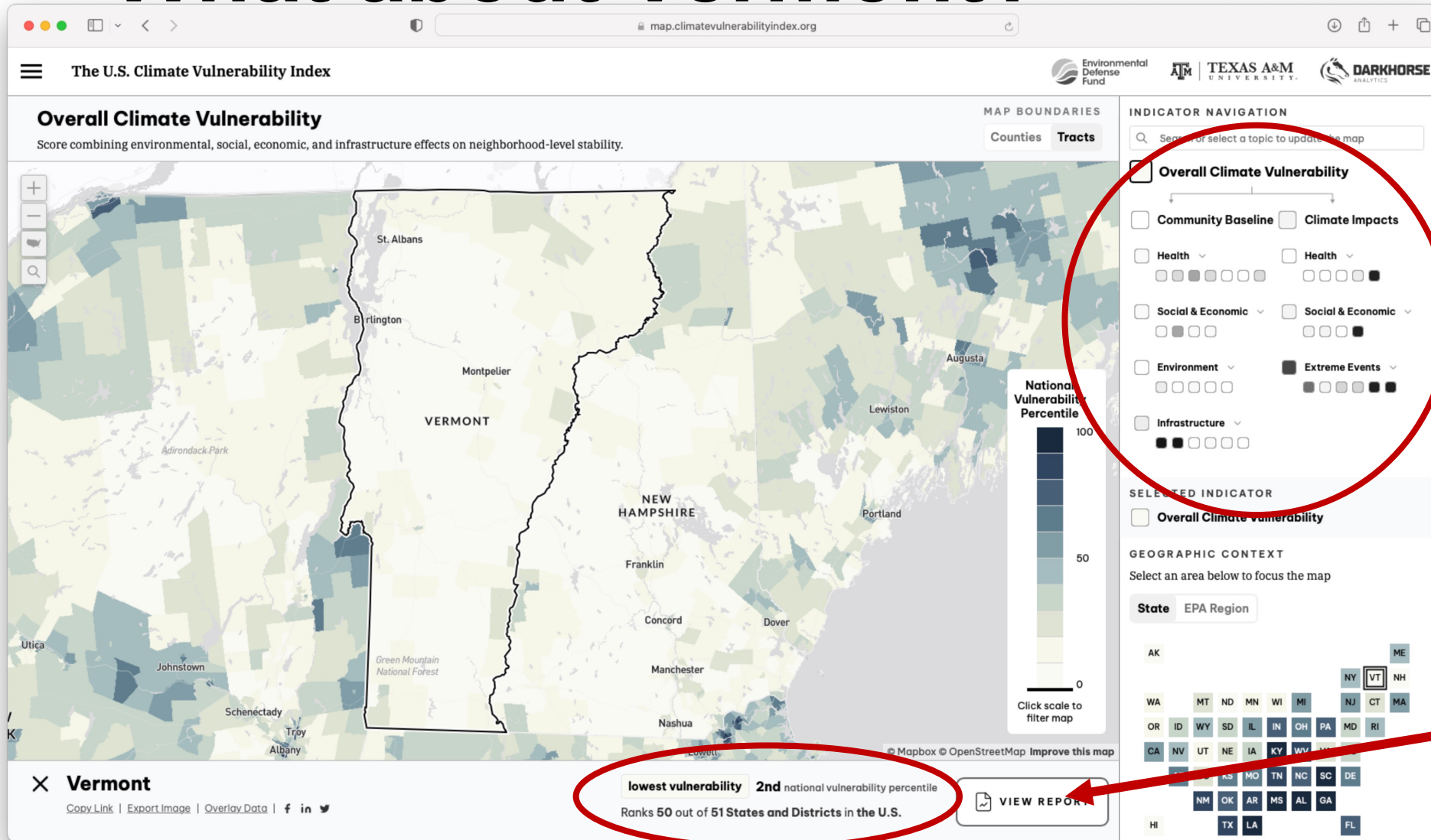


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- Background and motivation
- **Overview of Climate Vulnerability Index**
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# What about Vermont?



- Low vulnerability overall
- High vulnerability for some types of indicators



# Top Drivers of Overall Climate Vulnerability

## Climate Impacts

National vulnerability percentile



## Community Baseline

National vulnerability percentile



Vulnerability Rank in VT, out of 51 states and districts

Vulnerability Rank in VT, out of 51 states and districts



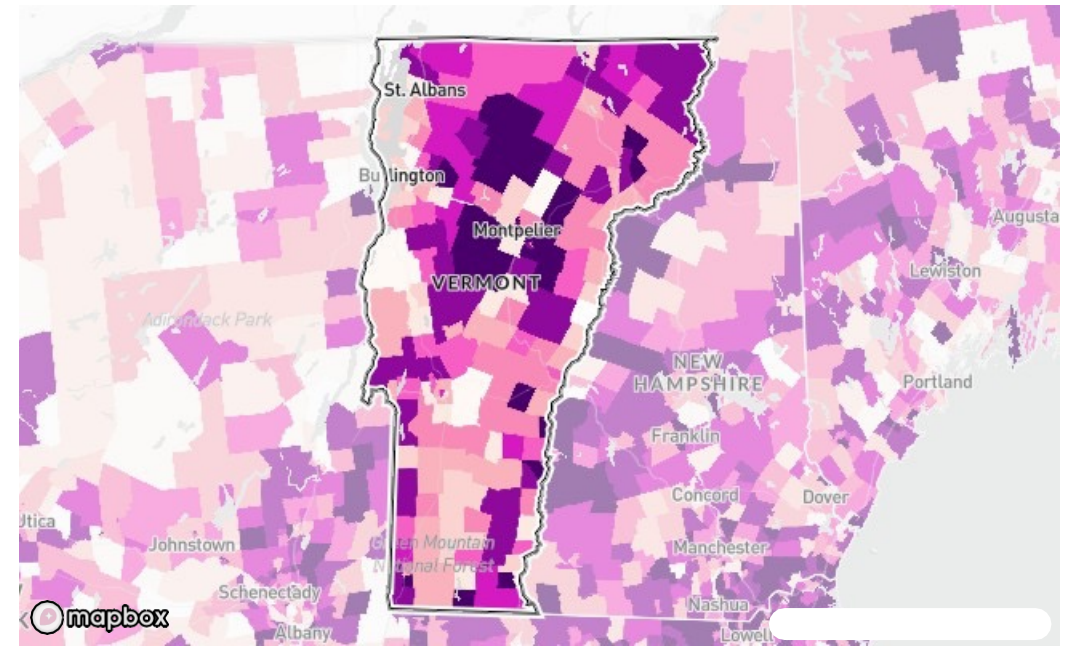
# Vermont

Overall Climate Vulnerability    Community Baseline    Infrastructure

## Transportation

The quality and accessibility of transportation options.

Ranks 5 out of 51 States and Districts in the U.S.



## Composition of Infrastructure: Transportation

### Lane miles

Total miles of road lanes per person; lower lane miles indicates higher vulnerability.

This state ranks **1** out of **51 States and Districts** in the U.S.

**highest vulnerability** 100th national vulnerability percentile

### Bridge Quality and Maintenance

Percentage of bridges of poor quality; lower bridge quality indicates higher vulnerability.

This state ranks **2** out of **51 States and Districts** in the U.S.

**highest vulnerability** 98th national vulnerability percentile

### Bikeability

Bikeability score described as how easy it is to bike to local destinations; lower bikeability score indicates higher vulnerability.

This state ranks **2** out of **51 States and Districts** in the U.S.

**highest vulnerability** 98th national vulnerability percentile

### Flooding risk to roads

Average flooding risk to roads in a census tract.

This state ranks **5** out of **51 States and Districts** in the U.S.

**highest vulnerability** 92nd national vulnerability percentile

### Walkability

Walkability score based on how pedestrian friendly an area is and its closeness to local services; lower walkability score indicates higher vulnerability.

This state ranks **5** out of **51 States and Districts** in the U.S.

**highest vulnerability** 92nd national vulnerability percentile

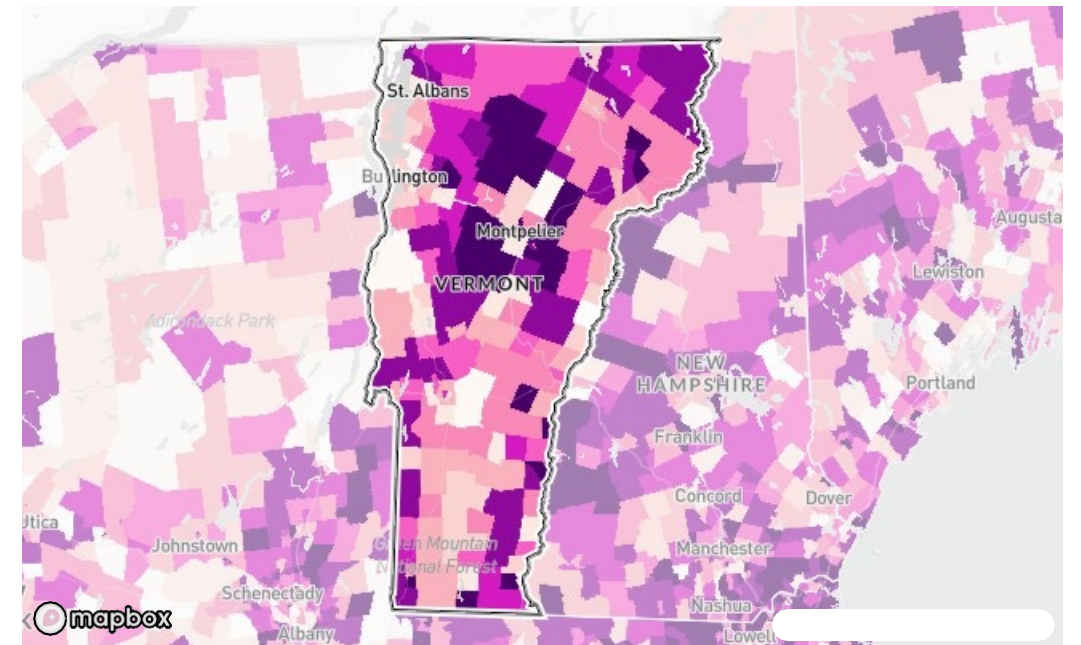
## Vermont

Overall Climate Vulnerability Community Baseline Infrastructure

## Transportation

The quality and accessibility of transportation options.

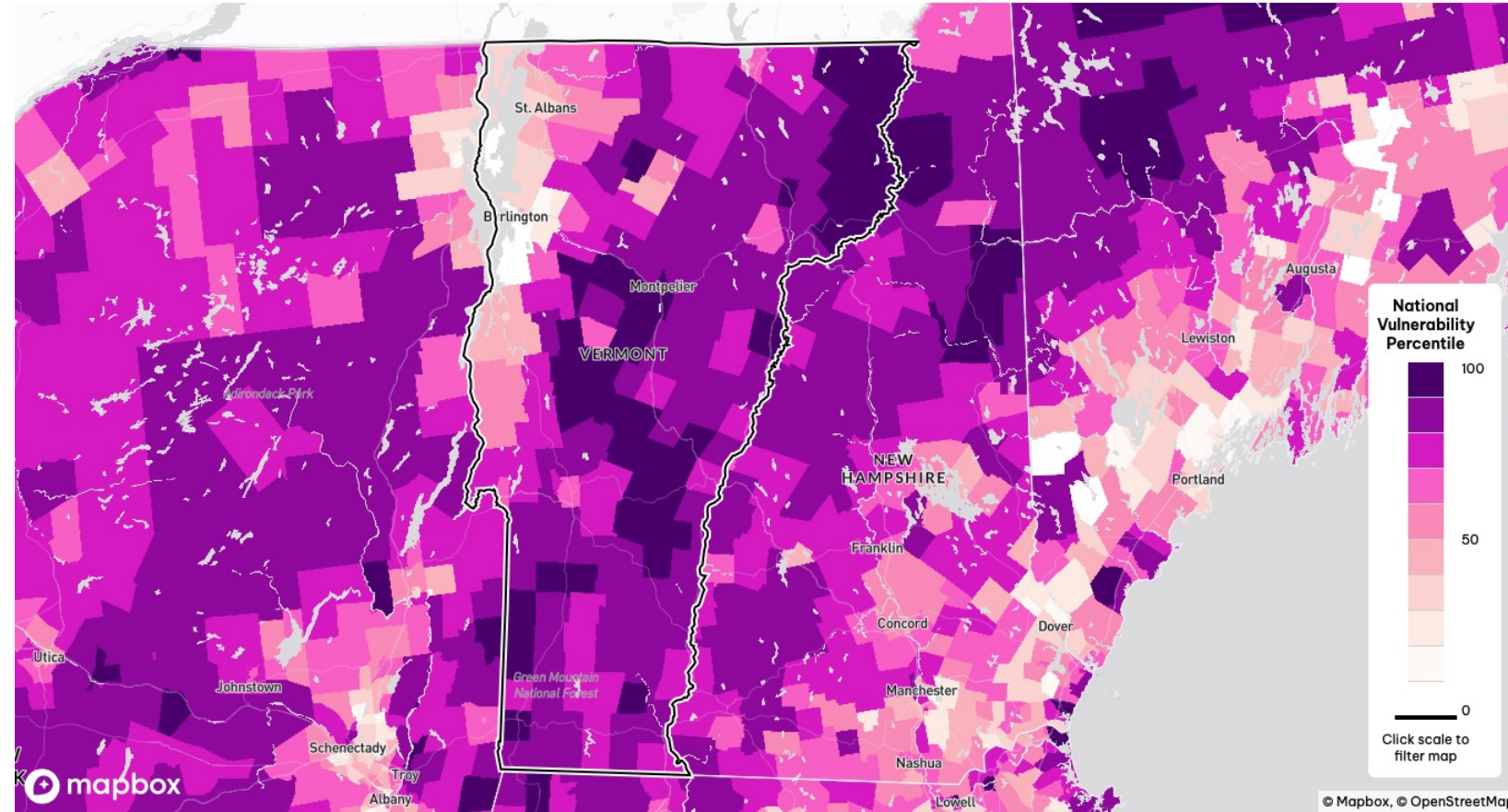
Ranks **5** out of **51 States and Districts** in the U.S.



**CVI → Baseline Vulnerabilities → Infrastructure → Transportation → Flooding risk to roads: High Vulnerability (confirmed in July 2023)!**

**Flooding risk to roads**

Average flooding risk to roads in a census tract.

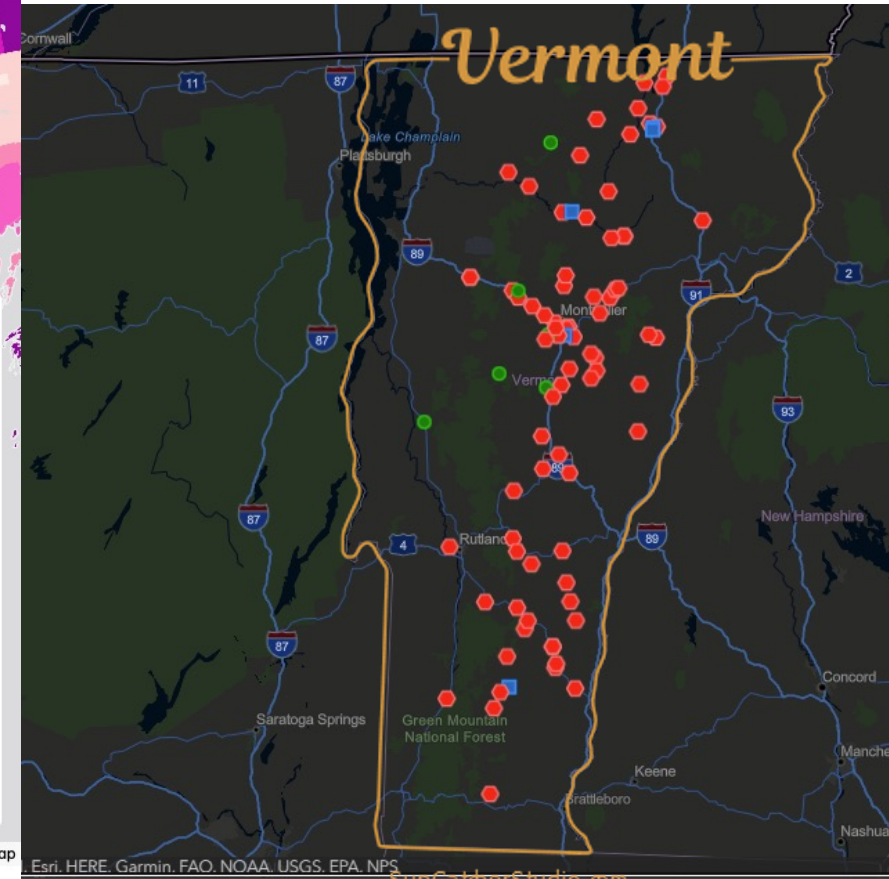


**Vermont**

map.climatevulnerabilityindex.org

**highest vulnerability** 92nd national vulnerability percentile  
Ranks 5 out of 51 States and Districts in the U.S.

Figure from weather.gov: Status of state and U.S. highway total road closures (both lanes, red dots) at 230am EDT on Tuesday, July 11th.



<https://www.weather.gov/btv/The-Great-Vermont-Flood-of-10-11-July-2023-Preliminary-Meteorological-Summary#:~:text=Flooding%20reports%20were%20widespread%20across,cities%20of%20Barre%20and%20Montpelier.>

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# Connecting to Policy and Action

- IRA, IJA, and CHIPS allocates hundreds of billions of dollars to address both baseline vulnerabilities and climate change risks
- CVI facilitates matching community needs to funding opportunities

Vulnerability or Risk Category Improved	Climate vulnerability and risk-related funding in major recent legislative efforts						
	Inflation Reduction Act, 2022		Infrastructure Investment and Jobs Act, 2021		CHIPS Act, 2022		Combined
	billion \$	% of bill total	billion \$	% of bill total	billion \$	% of bill total	billion \$
<b>Total Baseline</b>	188.9	43%	418.9	48%	33.0	13%	640.8
- Health	0.9	0%	21.6	3%		0%	22.6
- Social & economic	43.9	10%	20.4	2%	16.1	6%	80.4
- Infrastructure	105.3	24%	344.4	40%	16.7	7%	466.4
- Environment	38.7	9%	32.5	4%	0.2	0%	71.4
<b>Total Climate Change (may overlap with Baseline)</b>	369.0	84%	152.5	18%	13.7	6%	535.2
<b>Total (Entire Bill)</b>	437.0		863.9		248.1		1,549.0

# Matching Vulnerabilities and Impacts to Resources

- EDF and Columbia Law School developed a comprehensive [list of current and forthcoming IRA related resources](#)
- We matched these resources along with those in the IIJA, and Justice 40 to the indicators and domains in the CVI in order to help communities plan, prepare, and adapt to climate change.

## Matching Vulnerabilities and Impacts to Resources

The passage of the [Inflation Reduction Act \(IRA\)](#) in 2022 and the [Infrastructure Investment and Jobs Act \(IIJA\)](#) in 2021 marks a historic level of federal investment in measures to help the United States meet its goal of reducing U.S. greenhouse gas emissions by 50% or more by 2030 (compared to 2005) levels and improve the infrastructure, health, equity, and resilience of American communities. In addition, the [Justice 40 Initiative](#) is a whole-of-government initiative to ensure that 40% of the overall benefits of certain federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution.

Below you will find a comprehensive list of current and forthcoming IRA, IIJA, and Justice 40-related resources that can help communities plan, prepare, and adapt to climate change.

## Contents

### Baseline Vulnerability – Health

1. [Brownfield Grant Funding](#)
2. [Brownfield Job Training Grants](#)
3. [Clean Ports Program](#)
4. [Clean School Bus Program](#)
5. [Clean Water State Revolving Fund](#)
6. [Diesel Emissions Reduction Act Program](#)
7. [Distance Learning and Telemedicine Grants](#)
8. [Drinking Water State Revolving Fund](#)
9. [Environmental and Climate Justice Grants](#)
  - a. [Environmental and Climate Justice \(ECJ\) Grant Program](#)
  - b. [Environmental Justice Thriving Communities Grantmaking \(EJ TCGM\) Program](#)
  - c. [Environmental Justice Collaborative Problem-Solving \(EJCPS\) Cooperative Agreement Program](#)
  - d. [Environmental Justice Government-to-Government \(EJG2G\) Program](#)
10. [Home Energy Rebate Programs](#)
11. [Orphan Well Site Plugging, Remediation, and Restoration Programs](#)
  - a. [Orphaned Well Site Plugging, Remediation, And Restoration Program](#)
  - b. [Federal Orphaned Well Program](#)
  - c. [Orphaned Wells on Tribal Lands](#)
12. [Reduction of Truck Emissions at Port Facilities Program](#)
13. [Renew America's Schools](#)
14. [Renew America's Nonprofits Program](#)
15. [Sanitation Facilities Construction Program](#)
16. [Superfund Hazardous Substance Research and Training Program](#)
17. [Underground Injection Control Grants](#)

### Baseline Vulnerability – Social & Economic

1. [Affordable Connectivity Program](#)
2. [Building Codes Implementation for Efficiency and Resilience Program](#)
3. [Building Resilient Infrastructure and Communities](#)
4. [Building, Training, and Assessment Centers](#)
5. [Career Skills Training](#)

6. [Clean Energy Production Tax Credit and Clean Electricity Investment Credit](#)
7. [Clean Vehicle Credit](#)
8. [Competitive Grants for Non-Federal Forest Landowners](#)
9. [Discrimination Financial Assistance Program for Farmers, Ranchers, and Forest Landowners](#)
10. [Energy Efficiency and Conservation Block Grant Program](#)
11. [Energy Infrastructure Reinvestment Program](#)
12. [Emergency Food and Shelter Program](#)
13. [Empowering Rural America New ERA Program](#)
14. [Federal Income Tax Credits and Incentives for Energy Efficiency](#)
15. [Federal Emergency Management Agency Public Assistance Program](#)
16. [Flood Mitigation Assistance Grant Program](#)
17. [Green and Resilient Retrofit Program](#)
18. [Hazard Mitigation Assistance Grants](#)
19. [Home Efficiency Rebates](#)
20. [Home Electrification and Appliance Rebates](#)
21. [Home Energy Rebate Programs](#)
22. [Low Income Home Energy Assistance](#)
23. [National Flood Insurance Program](#)
24. [Orphan Well Site Plugging, Remediation, and Restoration Programs](#)
  - a. [Orphaned Well Site Plugging, Remediation, And Restoration Program](#)
  - b. [Federal Orphaned Well Program](#)
  - c. [Orphaned Wells on Tribal Lands](#)
25. [Reconnecting Communities and Neighborhoods Program](#)
  - a. [Neighborhood Access and Equity Grant Program](#)
  - b. [Reconnecting Communities Pilot Program](#)
26. [Residential Clean Energy Credit](#)
27. [Safeguarding Tomorrow Revolving Loan Fund Program](#)
28. [USDA Funds for Financially Distressed Borrowers](#)
29. [Weatherization Assistance Program](#)

### Baseline Vulnerability – Infrastructure

1. [Active Transportation Infrastructure Investment Program](#)
2. [Advanced Battery R&D Consortium](#)
3. [Advanced Energy Manufacturing and Recycling Grant Program](#)
4. [Affordable Connectivity Program](#)
5. [Airport Terminal Program](#)
6. [All Stations Accessibility Program](#)
7. [Battery Manufacturing and Recycling Grants](#)
8. [Battery Material Processing Grants](#)
9. [Bioproduct Pilot Program](#)
10. [Bridge Investment Program](#)
11. [Broadband Equity, Access, and Deployment Program](#)
12. [Building Codes Implementation for Efficiency and Resilience Program](#)
13. [Building, Training, and Assessment Centers](#)
14. [Capital Investment Grants Program](#)
15. [Carbon Capture Demonstration Program](#)
16. [Carbon Dioxide Transportation Infrastructure Finance and Innovation Program](#)
17. [Carbon Reduction Program](#)
18. [Carbon Storage Validation and Testing Program](#)

<https://climatevulnerabilityindex.org/wp-content/uploads/2023/09/CVI-Microsite-Content-Resources.pdf>

# Overall, CVI helps communities and policymakers identify

- **Where** mitigation and intervention are most needed
- **What** are most critical factors underlying cumulative vulnerability
- **How** to match vulnerabilities and resources and develop targeted strategies that improve resilience to climate change

# Questions?



# Appendix I: Individual Indicators



# Baseline Health

**Rationale:** Poorer health and lower access to healthcare leads to individuals and communities being less resilient and more susceptible to climate change-related risks.



## Physical Health

- Life Expectancy
- Self-Reported Physical Health



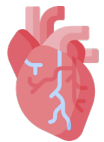
## Access to Care

- Hospital Beds per 100K
- COVID Vaccinations
- Lack of Health Insurance
- Access to Hospitals
- Access to Nursing Homes
- Medically Underserved Areas



## Mental Health

- Self-Reported Mental Health
- Fatal Drug Overdose
- Alcohol Abuse
- Suicide



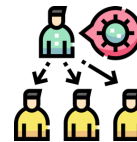
## Chronic Diseases

- Asthma
- Stroke
- Chronic Obstructive Pulmonary Disease (COPD)
- Heart Disease
- Cancer
- Diabetes



## Chronic Disease Prevention

- High Blood Pressure
- High Cholesterol
- Routine Doctor Visit
- Colonoscopy
- Mammogram
- Older Men Preventative Screening
- Older Women Preventative Screening
- Dental Exams



## Infectious Diseases

- COVID deaths
- Hepatitis A & B
- HIV
- Chlamydia
- Gonorrhea
- Syphilis



## Maternal & Child Health

- Infant Mortality
- Low Birth Weight
- Pre-term Births
- Childhood Asthma
- Teen Births
- ADHD prevalence and Treatment
- Child mortality
- Free or reduced price school lunch



# Baseline Social and Economic

**Rationale:** Many social and economic conditions hamper the ability of individuals and communities to prepare for and recover from climate change-related hazards.



## Minority Status/ Language

- Minority
- Speaks English Less than Well
- Undocumented Population
- Hate Crimes
- Prison Population
- Redlining
- Homeless Population
- Veterans Population



## Socio-economic Stressors

- Below Poverty
- Unemployed
- Low Income
- No High School Diploma
- Homicide Rate
- Gun Violence
- Religious Organizations
- Civic and Social Organizations



## Household Composition/ Disability

- Aged 65 or Older
- Aged 17 or Younger
- Civilian with a Disability
- Single-Parent Households
- Foster Children



## Housing Type & Transportation

- Multi-Unit Structures
- Mobile Homes
- Crowding
- No Vehicle
- Group Quarters
- Housing Foreclosure Risk
- Percent of Housing Units Built Between 1940-1969 as of 2015-2019



# Baseline Infrastructure

**Rationale:** Inadequate infrastructure (physical, digital, financial, etc.) exacerbates severity of and impedes recovery from climate change-related hazards.



## Transportation

- Delay (congestion)
- Flooding risk to roads
- Lane miles
- Road Quality and Maintenance
- Public Transit Performance
- Bridge Quality and Maintenance
- Walkability
- Bikeability



## Communication

- No home internet access
- Smartphone but no other device



## Energy

- Residential Energy Cost Burden
- Share of energy from fossil fuels
- EV Charging Stations



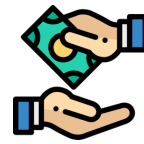
## Governance

- Tax Base: Median Real Estate Taxes Paid
- Voter Turnout 2020
- Public Library Locations
- HUD Public Housing
- Aggregate funding amount for HUD grants



## Food, Water, & Waste Management

- Modified Retail Food Environment Index
- Food Insecurity
- Access to Healthy Foods
- Indoor Plumbing



## Financial Services

- Percent of Unbanked Households
- Payday lending rank
- Housing Affordability (renters)
- Housing Affordability (owners)



# Baseline Environment

**Rationale:** Hazards due to existing environmental stressors and pollutant releases can be intensified by climate change.



## Transportation Sources

- Total vehicle miles traveled
- Passenger vehicle miles traveled
- Truck vehicle miles traveled
- Heavy Duty Vehicle miles traveled
- Proximity to Ports
- Rail Crossings
- Traffic Proximity and Volume
- National Transportation Noise Map



## Exposures & Risks

- Risk-Screening Environmental Indicators (RSEI)
- Air Tox Respiratory
- Air Tox Neurological
- Air Tox Liver
- Air Tox Developmental
- Air Tox Reproductive
- Air Tox Kidney
- Air Tox Immunological
- Air Tox Thyroid
- Air Tox Total Cancer Risk
- Black Carbon
- Agricultural pesticides
- Lead Paint: % housing units built before 1960
- Lead in drinking water violations



## Pollution Sources

- Superfund Sites
- Brownfields
- Stream Toxicity RSEI
- Proximity to facilities participating in air markets
- NPL sites
- Hazardous Waste Management Facilities (TSDFs)
- Hazardous Waste Generator/Incinerators
- Facilities with Enforcement or Violation
- Landfills
- TSCA Facilities
- Risk Management Plan Facilities
- Chemical Manufacturers
- Metal Recyclers
- Active Oil and Gas Wells



## Criteria Air Pollutants

- PM2.5 concentrations
- NO2 concentration
- Ozone concentration



## Land Use

- Parks and Greenspace
- Impermeable Surfaces
- Forest Land Cover
- Native American Lands



# Climate Change: Extreme Events

**Rationale:** Changing climate will increase the frequency and intensity of many extreme events, which will result in further adverse health and economic impacts.



## Temperature

**Historical:**

- Cold Wave
- Urban Heat Island

**Projected:**

- Days with above 35C
- Days with above 40C
- Frost Days
- Maximum of maximum temperatures
- Mean temperature



## Droughts

**Historical:**

- Drought

**Projected:**

- Consecutive Dry Days



## Wildfires

**Historical:**

- Wildfire

**Projected:**

- Surface PM2.5



## Precipitation

**Projected:**

- Snowfall
- Total Precipitation
- Standardized Precipitation Index



## Flooding

**Historical:**

- Coastal Flooding
- Riverine Flooding

**Projected:**

- Sea Level Rise



## Storms

**Historical:**

- Hurricanes
- Tornadoes
- Winter Weather



# Climate Change: Social and Economic

**Rationale:** Changing climate will lead to social and economic dislocation and mitigation costs in a variety of sectors.



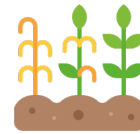
## Costs of Climate Disasters

### Historical:

- FEMA Hazard Mitigation Grants
- Cost of climate disasters

### Projected:

- Flooding risk to properties
- Wildfire risk to properties
- Property taxes expected to be lost by 2045 due to chronic inundation



## Economic and Productivity Losses

### Projected:

- High-Risk Jobs Productivity (% Change)
- Yields (% change)
- Outdoor workers - work days at risk
- Expected Annual Loss - Agriculture Value
- Expected Annual Loss - Building Value
- Expected Annual Loss - Population Equivalence



## Transition Risks

### Historical:

- Residential Energy Expenditures (% change)
- Share of Jobs in Agriculture
- State energy-related CO2 emissions by year
- Methane Emissions



## Social Stressors

### Projected:

- Property Crimes (% change)
- Violent Crimes (% change)



# Climate Change: Health

**Rationale:** Changing climate will have direct adverse effects on individual and community health and well-being.



## Temperature-related deaths

**Projected:**

- Temperature-related mortality



## Air pollution-related illnesses

**Projected:**

- Increase in childhood asthma incidence



## Disaster-related deaths

**Historical:**

- Deaths from climate disasters



## Infectious Diseases

**Projected:**

- Aedes albopictus dengue transmission increase
- Aedes aegypti dengue transmission increase
- Aedes aegypti zika transmission increase



## Air pollution-related deaths

**Projected:**

- Increased PM2.5 mortality - CVD (ages 65+)
- Increased Ozone mortality (all ages)



# Appendix II: Clustering Analysis

# Clustering Analysis

- Same score  $\neq$  same vulnerabilities and risks
- Can we identify clusters of “similar” vulnerabilities and risks?
- What is the geographic distribution of these clusters?

# Clustering Analysis

**A:** areas with both high non-environmental baseline vulnerabilities and heightened health and social/economic climate risks

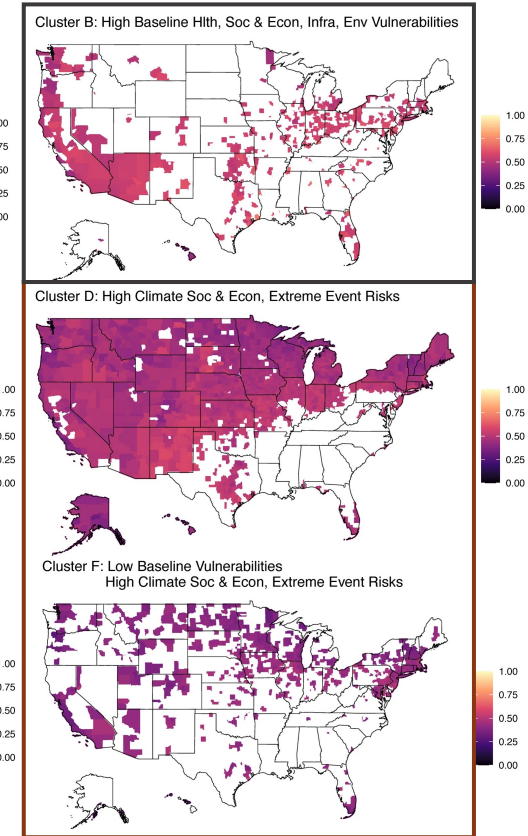
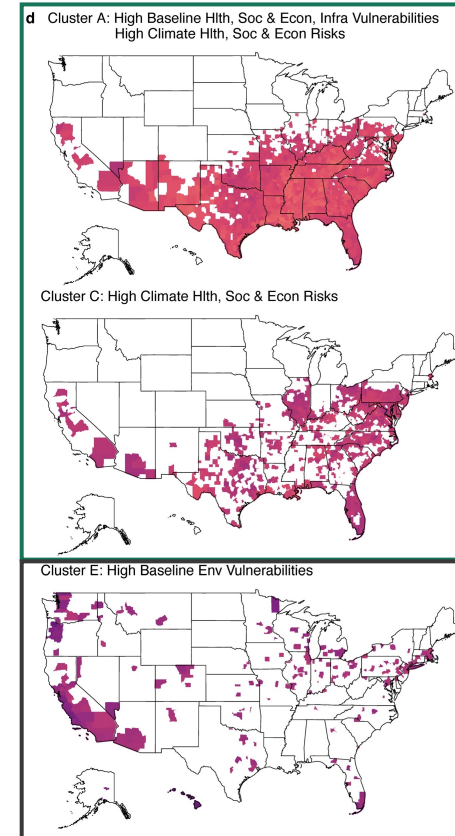
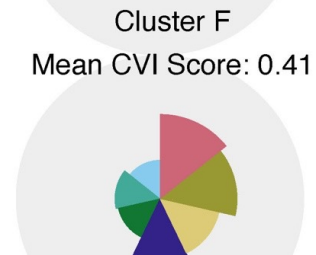
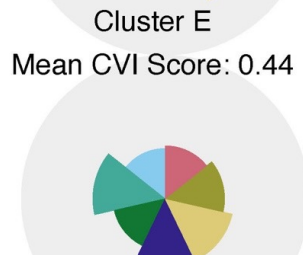
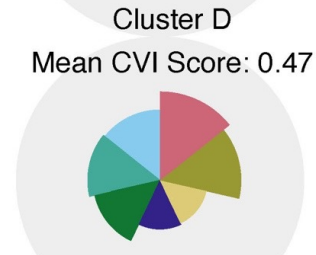
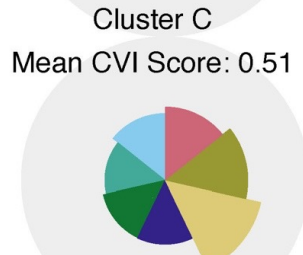
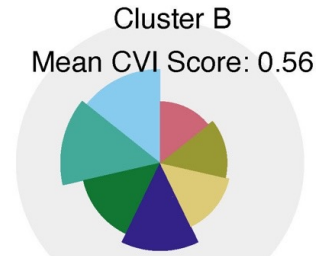
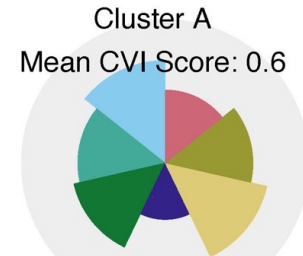
**B:** traditional urban/polluted environmental justice areas without heightened climate risks

**C:** areas of average baseline vulnerability with heightened health and social/economic climate risks

**D:** areas of average baseline vulnerability with heightened social/economic and extreme event climate risks

**E:** more affluent urban/polluted areas without heightened climate risks

**F:** areas with below average baseline vulnerability but heightened social/economic and extreme event climate risks

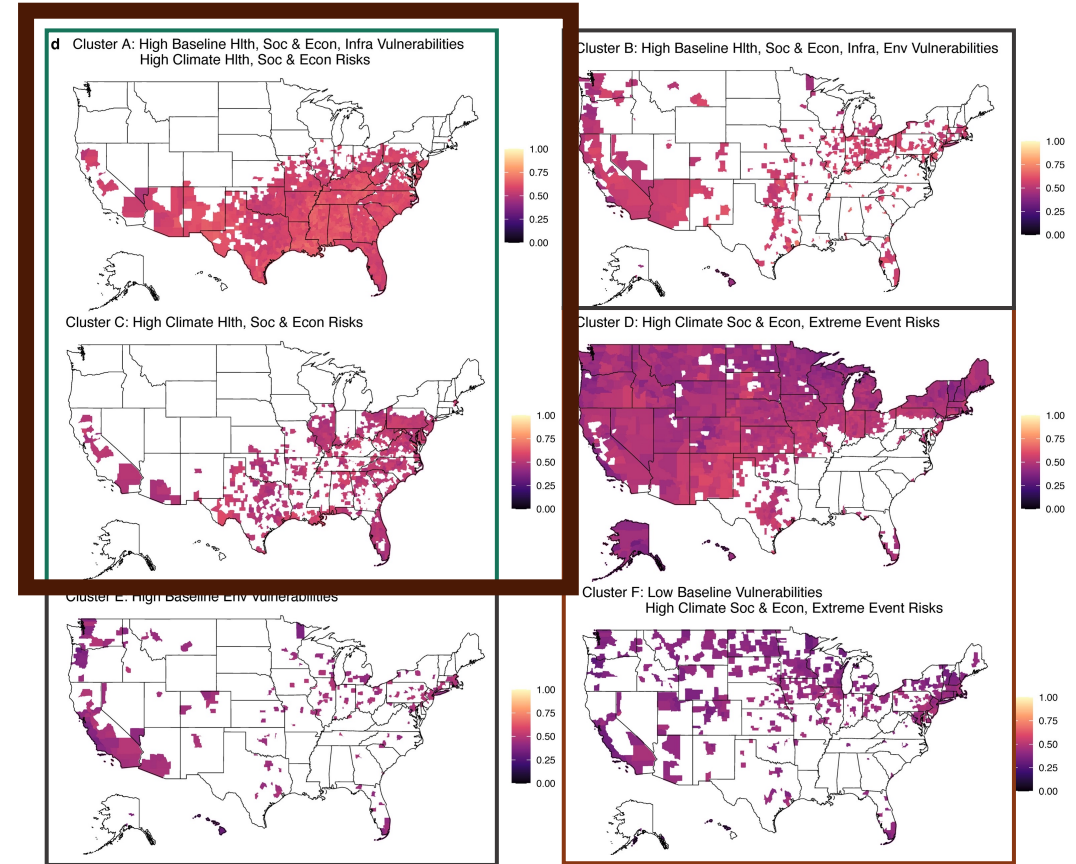
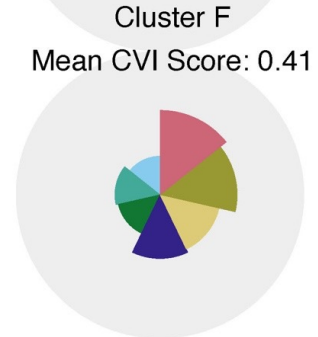
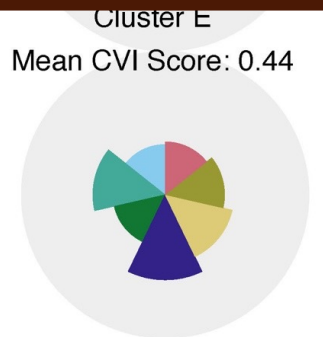
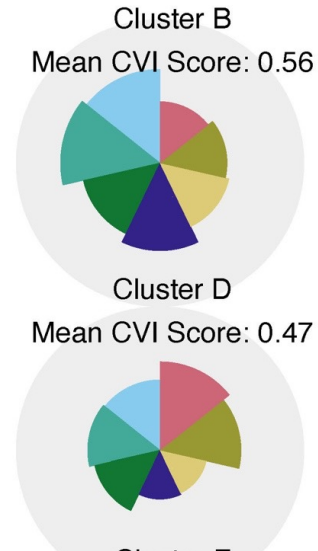
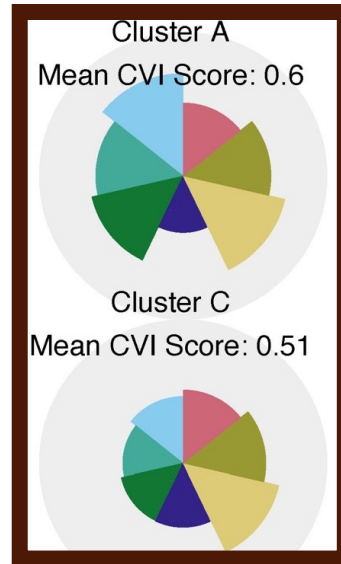


# Clustering Analysis

Clusters group into pairs with similar climate risks but differing baseline vulnerabilities

**A (higher baseline) and C (lower baseline):**

- Heightened health and social/economic climate risks but differing baseline vulnerabilities
- South, Lower Midwest, Mid-Atlantic

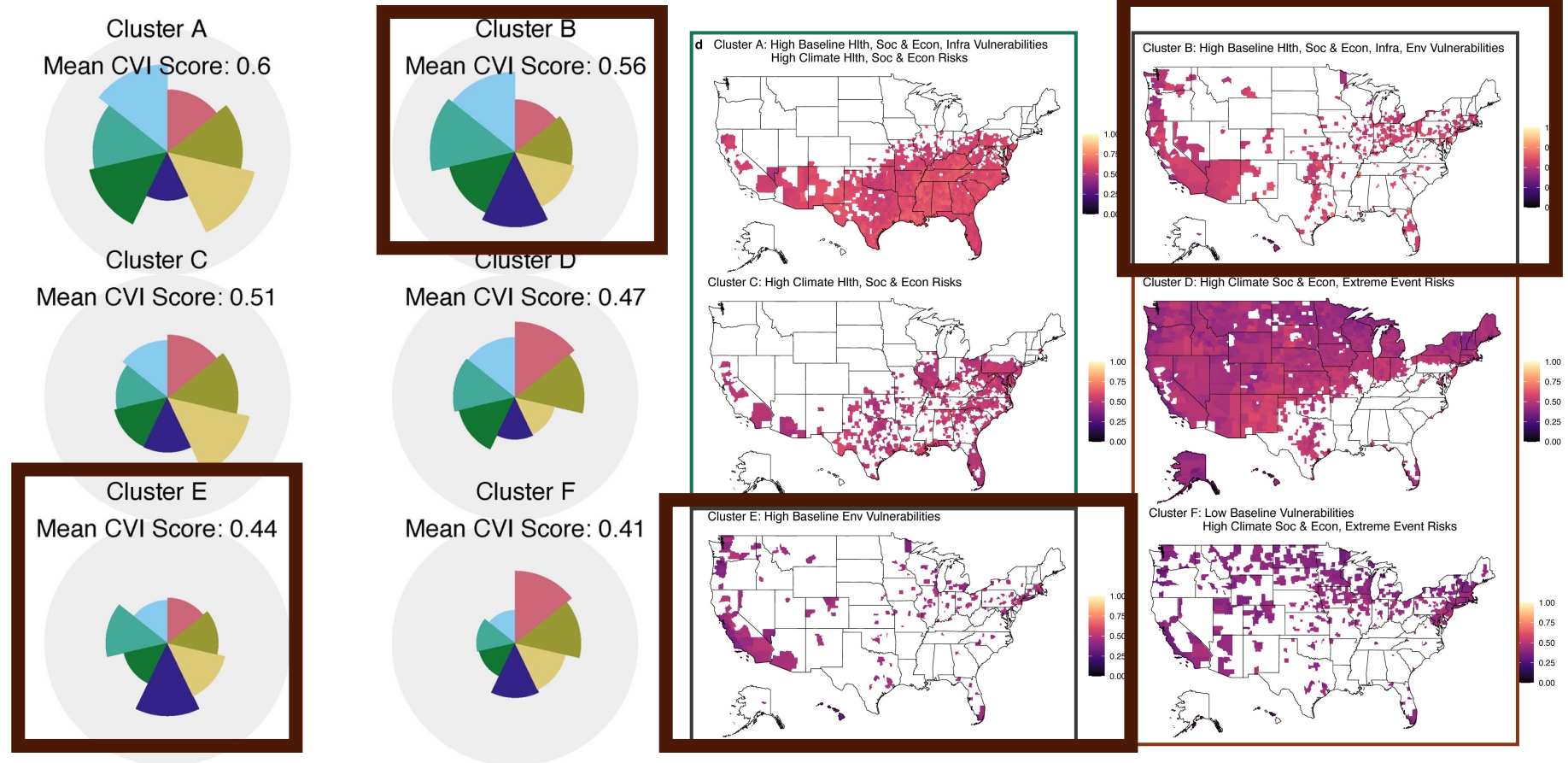


# Clustering Analysis

Clusters group into pairs with similar climate risks but differing baseline vulnerabilities

**B (higher baseline) and E (lower baseline):**

- Without heightened climate risk but with higher baseline environmental vulnerabilities, while differing in other baseline vulnerabilities
- West and urban centers



# Clustering Analysis

Clusters group into pairs with similar climate risks but differing baseline vulnerabilities

**D (higher baseline) and F (lower baseline):**

- Heightened social/economic and extreme event climate risks but differing baseline vulnerabilities
- Northeast, Upper Midwest, West and Mountain west

