www.usatoday.com/story/news/nation/2021/02/20/texas-ice-storm-blackouts-minorities-hardest-hit-recovery/4507638001/

# Modeling Social Vulnerability

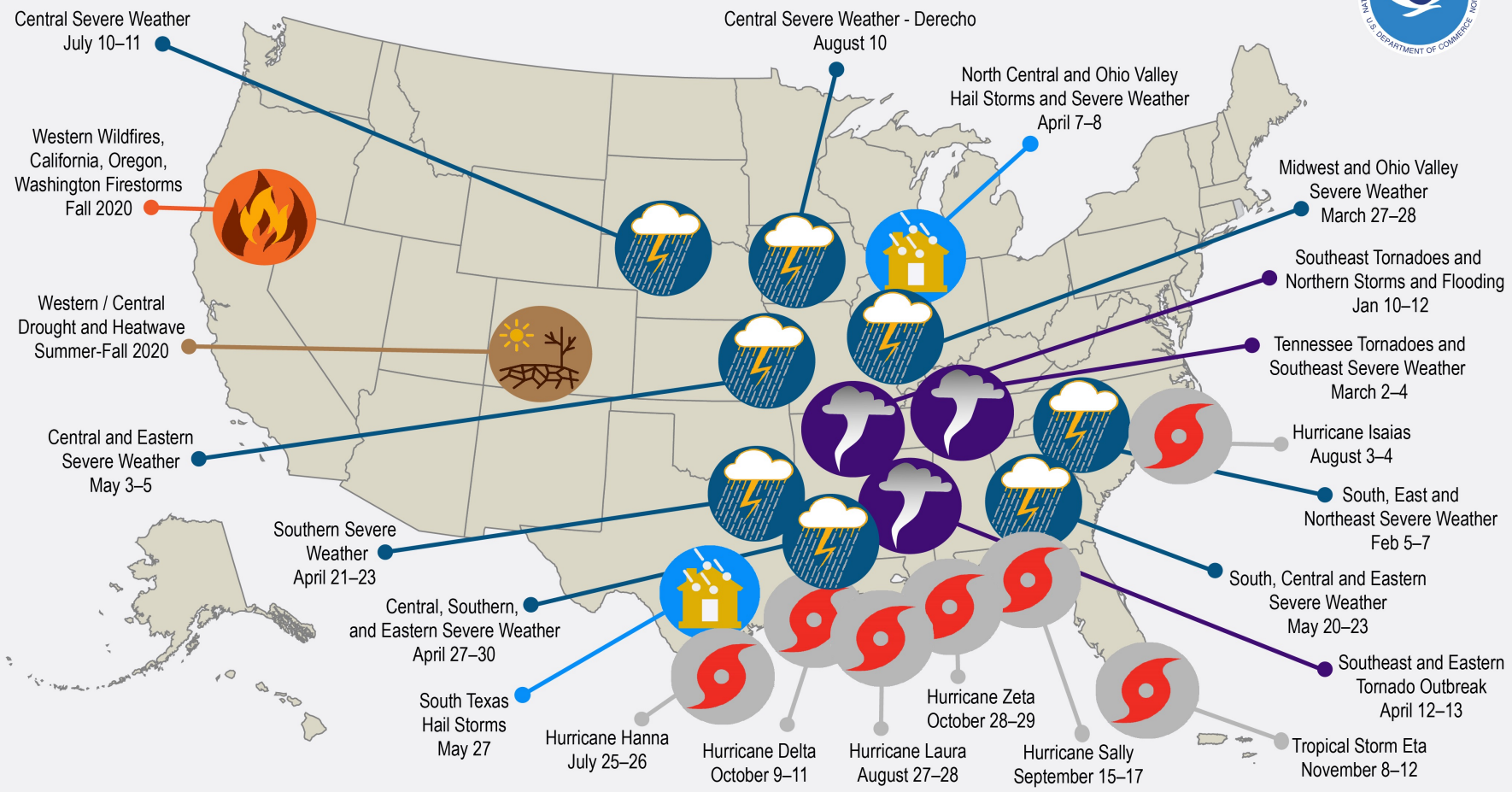
ERIC TATE

UNIVERSITY OF IOWA

MICROGRID & ES APPLICATIONS FOR RESILIENCE & ENERGY EQUITY

NOVEMBER 19, 2021

# U.S. 2020 Billion-Dollar Weather and Climate Disasters




*This map denotes the approximate location for each of the **22 separate billion-dollar weather and climate disasters that impacted the United States during 2020**.*

www.ncdc.noaa.gov/billions/

# There are multiple dimensions of vulnerability to *'natural'* disasters

**Physical**

Infiltration, Depth, Discharge, Frequency, Floodplain, Velocity, Rainfall, Cross-Section, Duration, Runoff

**Social**

Education, Age, Race, Property Ownership, Disability, Perception, Health, Exclusion, Language, Ethnicity, Poverty

**Disaster**

**Management**

Insurance, Mapping, Preparedness, Response, Mitigation, Disaster Assistance, Infrastructure, Recovery

#NoNaturalDisasters

# Social Vulnerability

*"There are no really generalized opportunities & risks in nature, but instead there are sets of **unequal access to opportunities and unequal exposure to risks** which are a consequence of the socio-economic system.*

*It is **more important** to discern how human systems themselves place people in relation to each other and to the environment than it is to interpret natural systems."*

-Terry Cannon

IOWA

# What is social vulnerability to hazards?

- **Higher susceptibility from economic, social, political, institutional processes**
- Some population groups persistently face greater impacts

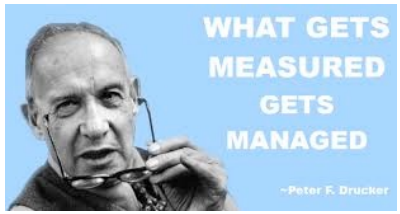
| Dimension | Most Vulnerable | Manifestation |
|---|---|---|
| **Socioeconomic status** | Living in poverty | Less ability to absorb losses and recover<br>Lack transportation for evacuation<br>Lower housing quality<br>High proportional losses |
| **Race and ethnicity** | Non-White<br>Non-Anglo | Cultural barriers<br>Lower acceptance & trust of warnings<br>Reside in high hazard zones |
| **Gender** | Women | Wage gap<br>Care-giving role<br>Domestic violence |
| **Health** | Chronically ill<br>Children | Increased mortality<br>Disease outbreak<br>Post-traumatic stress |

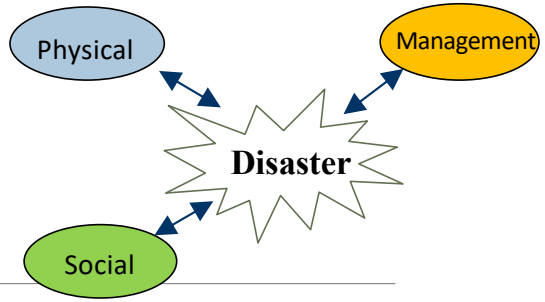
| Dimension | Most Vulnerable | Manifestation |
|---|---|---|
| **Age** | Children<br>Elderly | Reduced evacuation mobility<br>Special care requirements |
| **Home ownership** | Renters | Low control over home disaster resistance<br>Lower rates of insurance<br>Disaster assistance favors homeowners<br>Higher post-disaster rents |
| **Functional needs** | Disabled<br>Institutionalized<br>Homeless | Reduced evacuation mobility<br>Custom shelter needs<br>Lower receipt of warnings |
| **Immigrants** | Non-English speakers<br>Recent arrivals | Language barriers<br>Unfamiliarity with local hazards<br>Less access to disaster assistance |
| **Population distribution** | Urban<br>Rural | Evacuation complications<br>Reduced emergency response capabilities<br>Single-sector economic dependence |

# Why should we focus on the vulnerable?

- At greatest risk
- Fewer resources to cope with impacts
- Cost effective
- Least responsible for increase in extreme floods
- It's morally right

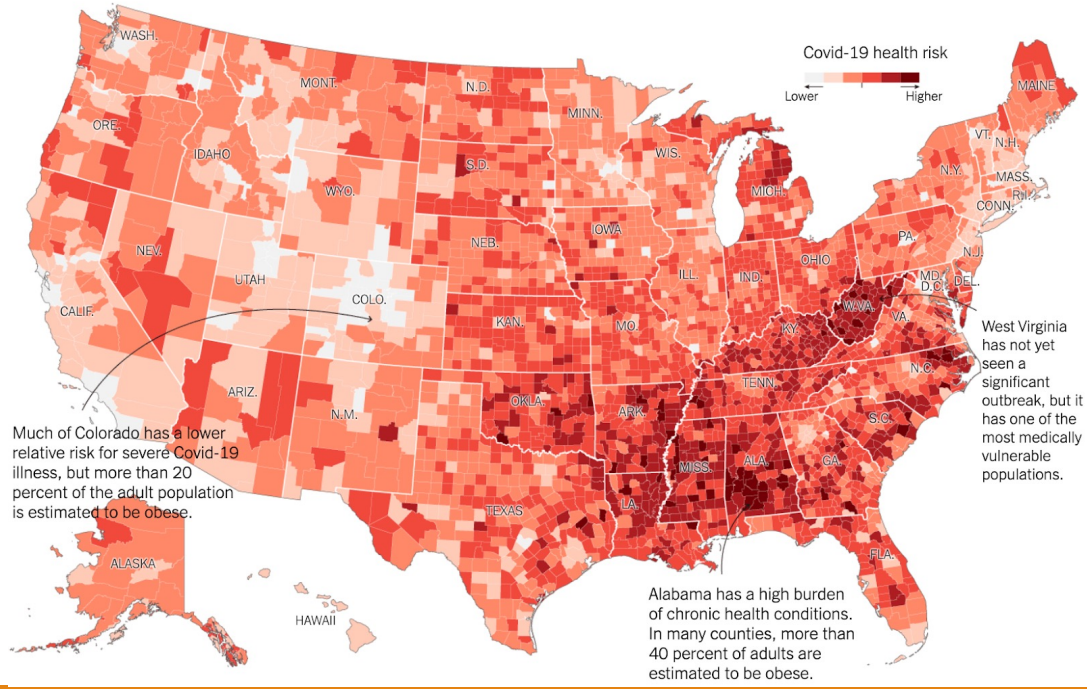
# Spatial indicators can spotlight vulnerable places




## Quantitative geographic measures of a construct

- Simplify complexity
- Identify trouble spots
- Prioritize projects
- Allocate resources
- Communication
- Track trends
- Advocacy
- Research & analysis
- Raise awareness

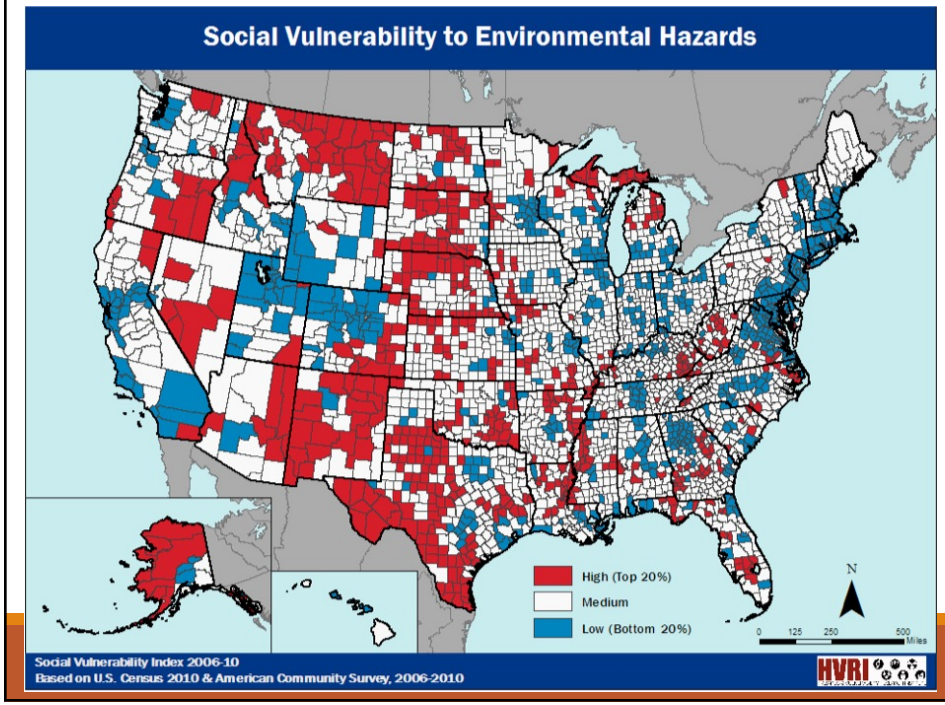



www.agupdate.com/rural_life/index-shows-counties-most-vulnerable-to-covid-19-due-to-underlying-health-issues-many-of/article_5b2151a0-97a7-5b29-b2b5-9f4f64b33182.html

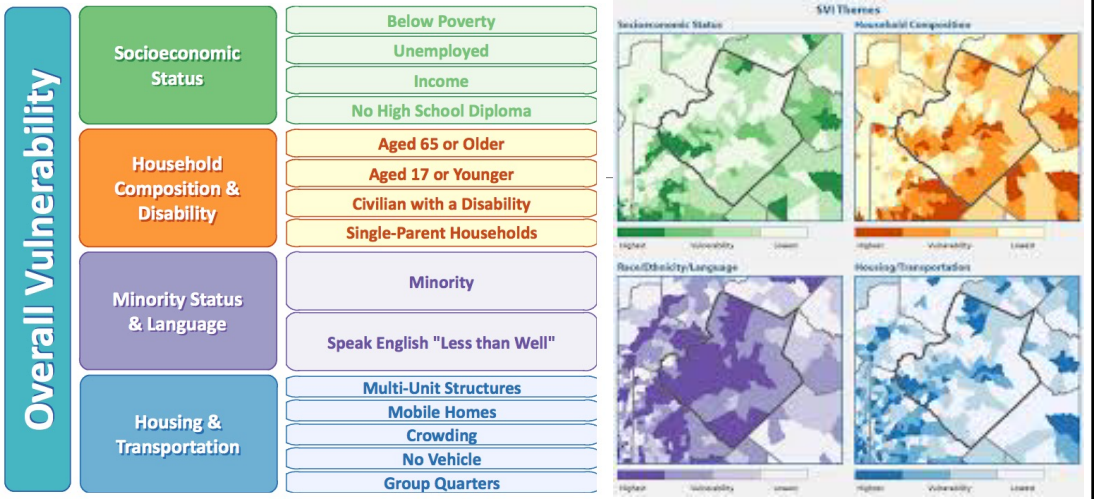
IOWA

# Describing the vulnerable: prominent spatial indicators

## 1. Social Vulnerability Index (SoVI)
## University of South Carolina




## 2. Social Vulnerability Index (SVI)
## Centers for Disease Control



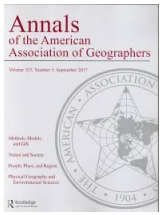

## 3. Low-to-Moderate Income (LMI) populations
## Community Development Block Grant Program

CDBG

Building Better Neighborhoods

IOWA

# 1. Are the leading indexes suitable for all hazards? Disaster phases?



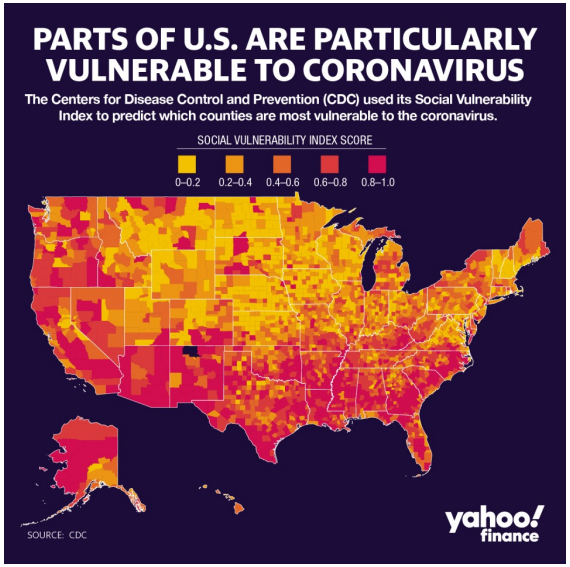

Articles

**How Valid Are Social Vulnerability Models?**

Samuel Rufat, Eric Tate, Christopher T. Emrich & Federico Antolini

Pages 1131-1153 | Received 01 Apr 2018, Accepted 01 Sep 2018, Published online: 01 Mar 2019

| Index/ Indicator | Descriptive | Explanatory | Flood focused | Mitigation focused |
|---|---|---|---|---|
| SoVI (USC) | ✓ | ? | X | X |
| SVI (CDC) | ✓ | ? | X | X |
| LMI (CDBG) | ✓ | ? | X | X |




**What is CDC's Social Vulnerability Index?**

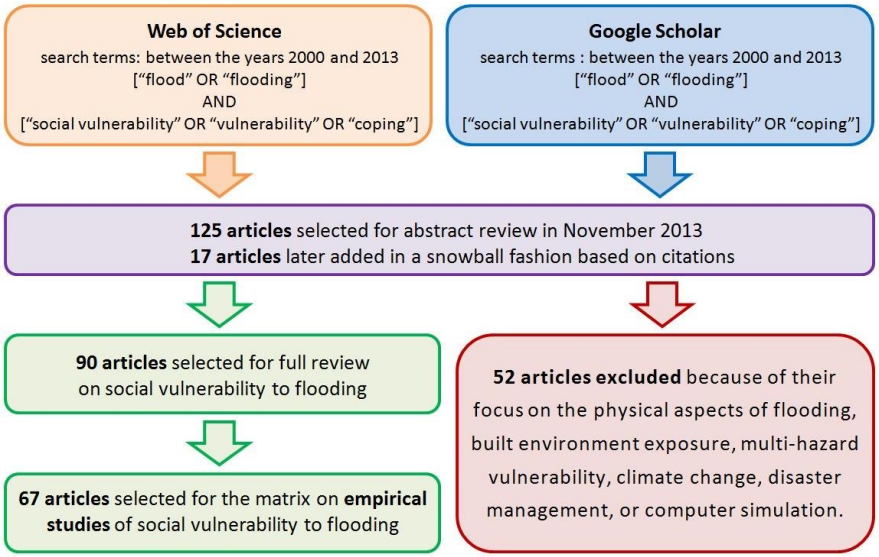
"ATSDR's Geospatial Research, Analysis & Services Program (GRASP) created databases to help emergency response planners and public health officials identify and map communities that will most likely need support before, during, and after a hazardous event."

IOWA

# 2. Which indicators reflect vulnerability processes?

Review qualitative case studies of flood disasters

Which characteristics associated with higher vulnerability?



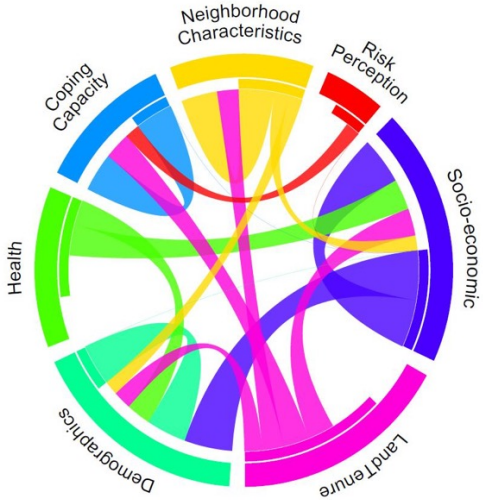
Rufat, S., E. Tate, C. G. Burton, and A. S. Maroof. 2015. Social vulnerability to floods: Review of case studies and implications for measurement. *International Journal of Disaster Risk Reduction* 14:470-486.

| Thematic Indicators | Specific Indicators |
|---|---|
| Coping capacity | Individual capacity |
| | Household capacity |
| | Social capital |
| Demographic characteristics | Age |
| | Race & ethnicity |
| | Family structure |
| | Gender |
| | Functional needs |
| | Language proficiency |
| Health | Access |
| | Stress |
| | Disease |
| | Mortality |
| | Sanitation |
| Land tenure | Owners |
| | Renters |
| | Squatters |
| Neighborhood characteristics | Transportation |
| | Population density |
| | Housing |
| | Resource dependency |
| Risk perception | Awareness |
| | Prior experience |
| | Knowledge of flood protection measures |
| | Risk denial/acceptance |
| | Trust in officials |
| Socioeconomic status | Income |
| | Wealth |
| | Education |
| | Occupation |

# 2. Which indicators reflect vulnerability processes?

Phase-oriented approach to indicator selection.

| Potential indicators | Pre-flood/ mitigation | During flood/ response | Post flood/ recovery |
|---|---|---|---|
| Children | ± | + | − |
| Young adults | + | + | − |
| Elderly | − | + | + |
| ..... | | | |



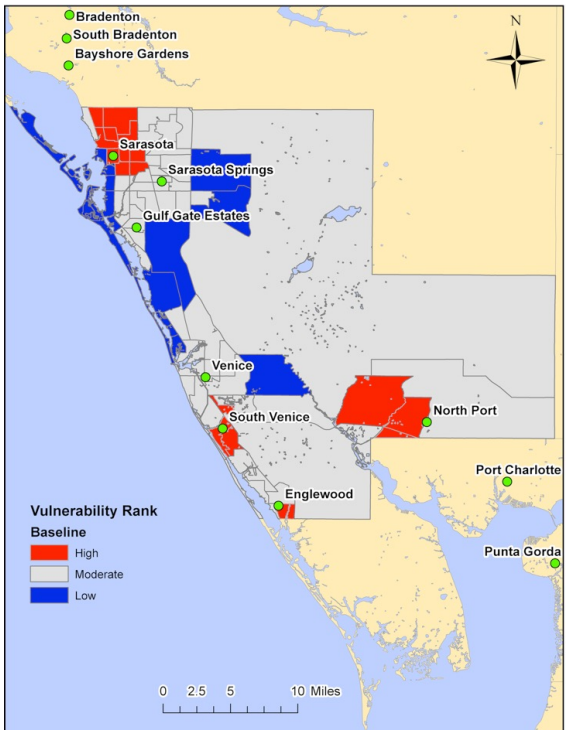

- Some drivers reported more often
- Some interact with others
- Disaster stage matters
- National income matters

| Driver | Overall Frequency (%) | Disaster Stage (%) | | | Development Context (%) | |
|---|---|---|---|---|---|---|
| | | Mitigation | Response | Recovery | Less Developed | More Developed |
| Demographic characteristics | 58 | 32 | 66 | 58 | 32 | 76 |
| Socioeconomic status | 55 | 17 | 53 | 42 | 39 | 61 |
| Health | 47 | 19 | 52 | 42 | 32 | 68 |
| Coping capacity | 39 | 16 | 48 | 48 | 54 | 46 |
| Risk perception | 36 | 46 | 54 | 21 | 33 | 67 |
| Neighborhood Quality of life | 30 | 25 | 45 | 35 | 35 | 65 |
| Land tenure | 30 | 15 | 30 | 45 | 35 | 65 |

Rufat, S., **Tate, E.**, Burton, C. G., & Maroof, A. S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International journal of disaster risk reduction*, *14*, 470-486.

IOWA

# Social Vulnerability Questions




Which places are most socially vulnerable?

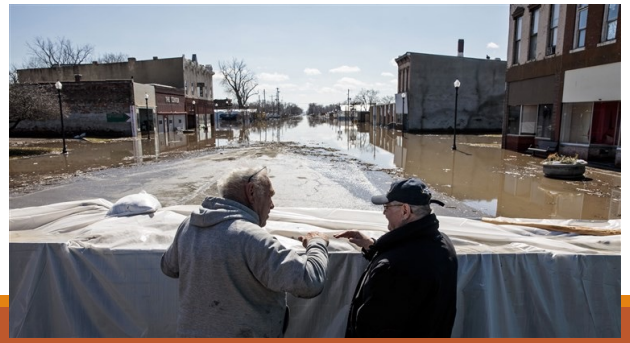
Who are the most vulnerable?

How equitable is disaster management?

How do social and physical dimensions of floods interact?

Easier, Less Revealing

Harder, More Revealing



# How to integrate social equity into hazard programs and planning? – High Policy Relevance

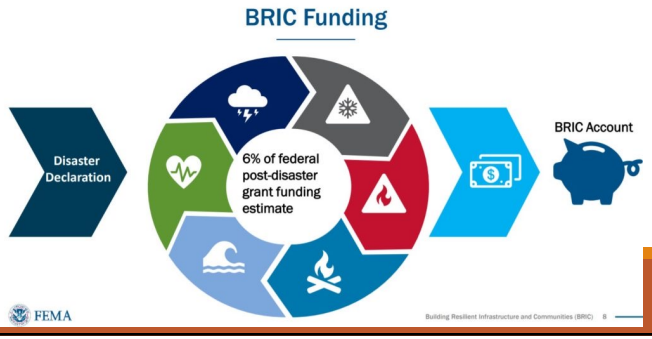
American Property Casualty Insurance Association
INSURING AMERICA apci.org

FEMA
Federal Insurance and Mitigation Administration

URBAN INSTITUTE
ELEVATE · THE · DEBATE

The National Academies of SCIENCES · ENGINEERING · MEDICINE

Community Development Block Grant
CDBG
Disaster Recovery

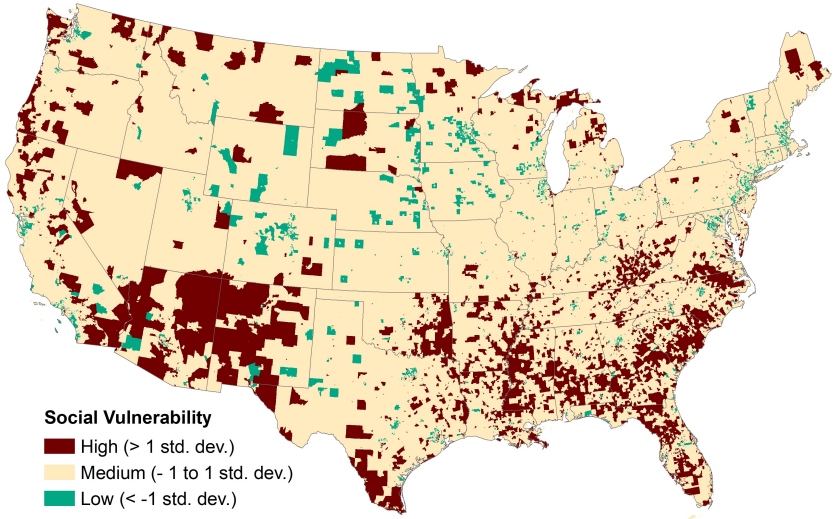


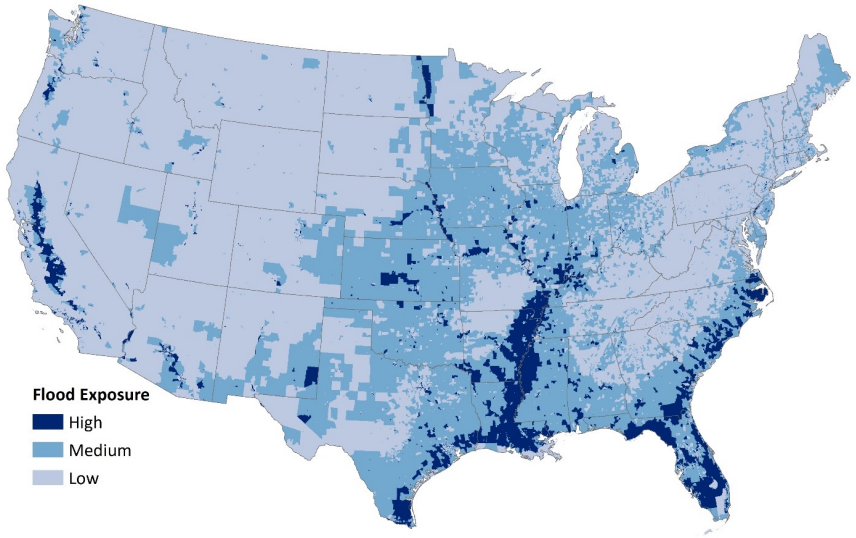

Texas Water Development Board

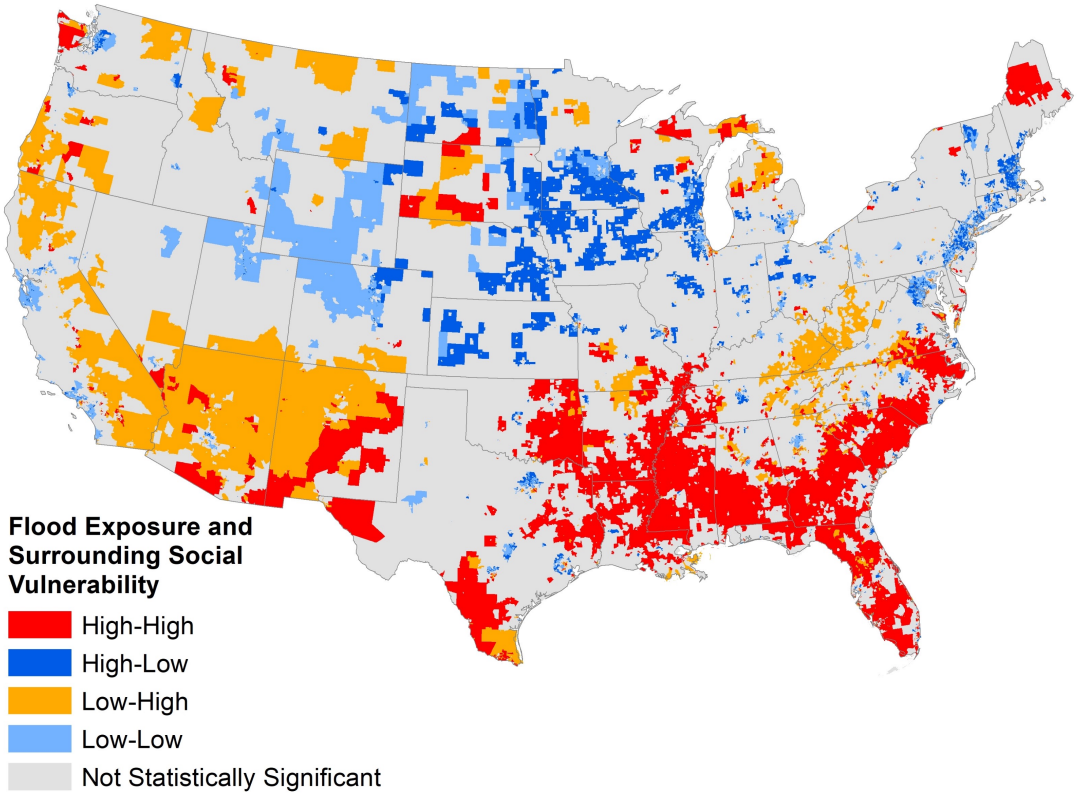
COUNCIL on FOREIGN RELATIONS

IOWA

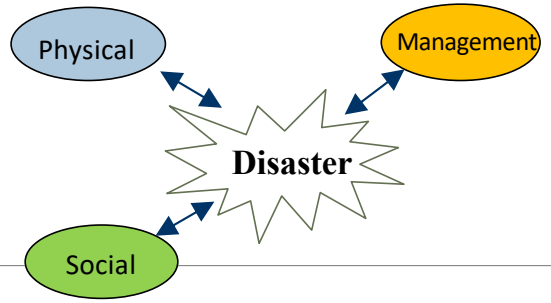
# Where do high physical & social vulnerability coincide?

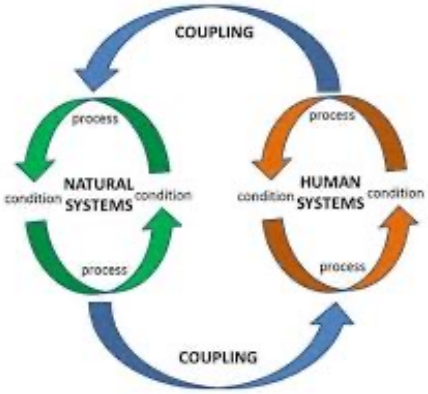


# Indicators Are Only Vulnerability Proxies



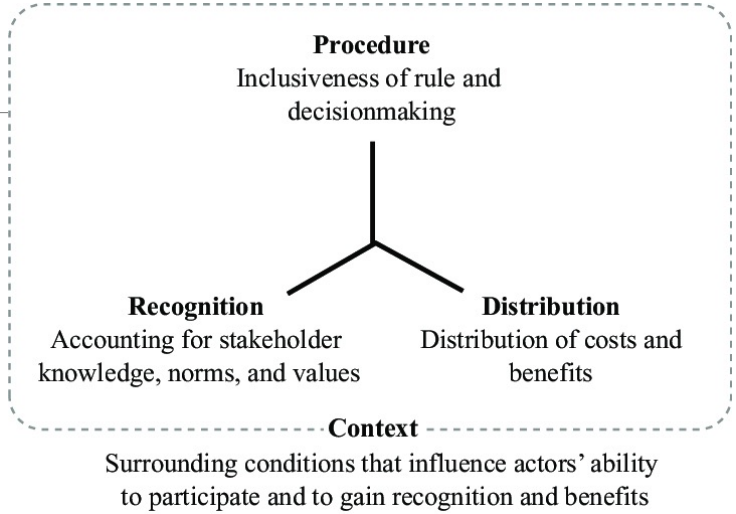

| Avg. % Change | Indicator | Relationship w/ Social Vulnerability | Social Vulnerability Dimension |
|---|---|---|---|
| 156.7 | Mobile Homes (%) | + | Housing |
| 115.3 | Asian (%) | - | Race |
| 102.4 | Black (%) | + | Race |
| 95.0 | Households Earning > $200,000 annually (%) | - | Income |
| 84.0 | Native American (%) | + | Race |
| 64.8 | Less than 12th Grade Education (%) | + | Education |
| 53.7 | Median Housing Value | - | Wealth |
| 50.6 | Female Headed Households (%) | + | Family structure |
| 50.5 | Poverty (%) | + | Income |
| 48.6 | Employment in Extractive Industries (%) | + | Employment |
| 44.4 | Per Capita Income | - | Income |
| 42.6 | Population without health insurance (%) | + | Health |

- Peril in focusing only on variables & disparities
- What about underlying processes?
- What are the system interactions?
- Need qual-quant integration

***"The prominence of housing and race indicators highlights the multidimensionality of social vulnerability, in that its leading causes extend beyond the common focus on income."***

# Research needs to integrate equity

1. Understand vulnerability processes
   - Which disaster impacts most create unmet needs?
   - Who and where are the most affected populations?
2. Select empirically-supported indicators
   - Which demographic variables?
   - Which program outcomes? Program processes?
   - Local scale indicators of race, ethnicity, program metrics
   - Data access for non-government researchers
3. Enhance local capacity
4. Evaluate performance: spatial econometric, qualitative, qual-quant




United States® Census Bureau

Pascual, U., Phelps, J., Garmendia, E., Brown, K., Corbera, E., Martin, A., ... & Muradian, R. (2014). Social equity matters in payments for ecosystem services. *Bioscience*, *64*(11), 1027-1036.

frontiers

Flood Recovery Outcomes and Disaster Assistance Barriers for Vulnerable Populations

Bradley Wilson[1*], Eric Tate[2], Christopher Emrich[3]

# Integrate Equity:
# 1. Understand vulnerability processes

- Renters
  - Underprioritized vs. homeowners
  - Assistance programs underestimate demand
  - Flood disasters disrupt rental housing markets & can permanently displace renters
  - Rental housing slower to rebuild and recover pre-storm values

- Racial & ethnic minorities
  - Federal assistance may be harder to access
  - Access constrained by longstanding discriminatory housing policies
  - Limited recovery support for populations with low English proficiency
  - Amplified negative financial outcomes

Wilson, B., **Tate, E.**, and Emrich, C.T. (in press). "Flood Recovery Outcomes and Disaster Assistance Barriers for Vulnerable Populations." *Frontiers in Water*.

frontiers

Flood Recovery Outcomes and Disaster Assistance Barriers for Vulnerable Populations

Bradley Wilson[1*], Eric Tate[2], Christopher Emrich[3]

# Integrate Equity:
# 1. Understand vulnerability processes

- Low Income
  - Barriers submitting & completing assistance applications
  - Disproportionately high assistance rejection rates, independent of damage levels
  - Less federal assistance relative to damage levels
  - Persistent negative impacts on financial health
  - Fewer relocation options & are impacted by post-disaster housing shortages
- Intersectionality
  - Low-income renters and low-income minorities are unique populations
  - Disproportionate number of minorities are low-income, renters, or both
  - Low data availability & transparency

Wilson, B., **Tate, E.**, and Emrich, C.T. (in press). "Flood Recovery Outcomes and Disaster Assistance Barriers for Vulnerable Populations." *Frontiers in Water*.

# The Derecho had outsized impacts to the most vulnerable

- Low income
- Uninsured:  lack of funds for repairs to homes
- Underinsured:  can lose what you own
- Renters:  no control over landlord resources in loss of electricity, walls
- Refugees
  - lack of trust in shelter system
  - language difficulties communicating with landlords & insurance
- Children:  some students still displaced from homes

www.press-citizen.com/story/weather/2020/08/12/iowa-derecho-cedar-rapids-storm-damage-power-outages/3349746001/

https://iowastartingline.com/2020/08/18/from-covid-to-derecho-iowas-refugee-community-struggles-to-hang-on/

# 1. Understand vulnerability processes

National

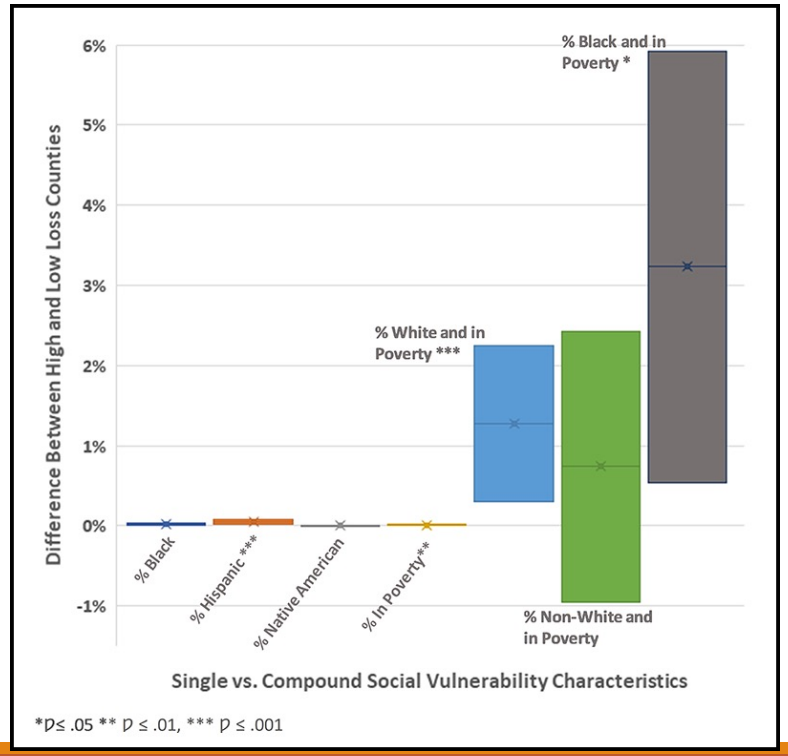
The Washington Post

## Freezing temperatures and power outages hurt Texas's most vulnerable yet again

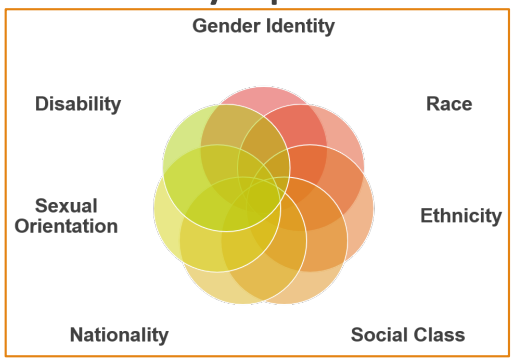
www.texastribune.org/2021/02/18/texas-power-outages-ercot/

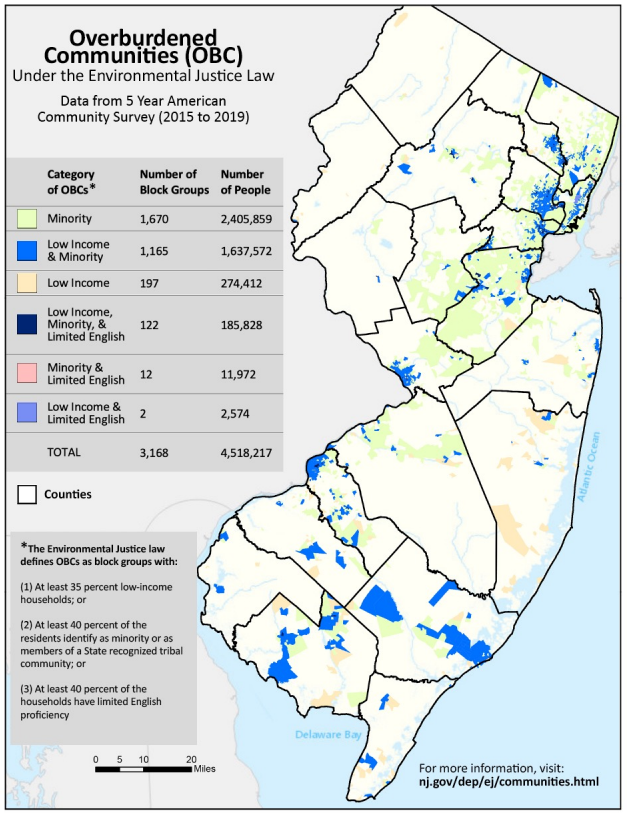
- Lower quality housing
  - Insulation, leaky roofs, pipes
- Low income
  - Hotels, generators, supplies, gas, lost wages, insurance
- Low wealth – limited safety net
- Food insecurity
  - Spoiled food, food deserts
- Transportation access to warming/cooling centers
- Language proficiency
  - translation of conditions, resources, actions
- Disability
  - Reliance on powered medical & mobility devices, socially isolation
- All: disaster planning inclusionary of greatest needs

# Integrate Equity:
# 2. Consider Intersectional Indicators




Disaster vulnerability is multidimensional, intersectional, inherently spatial



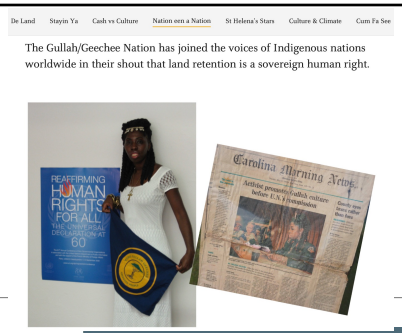



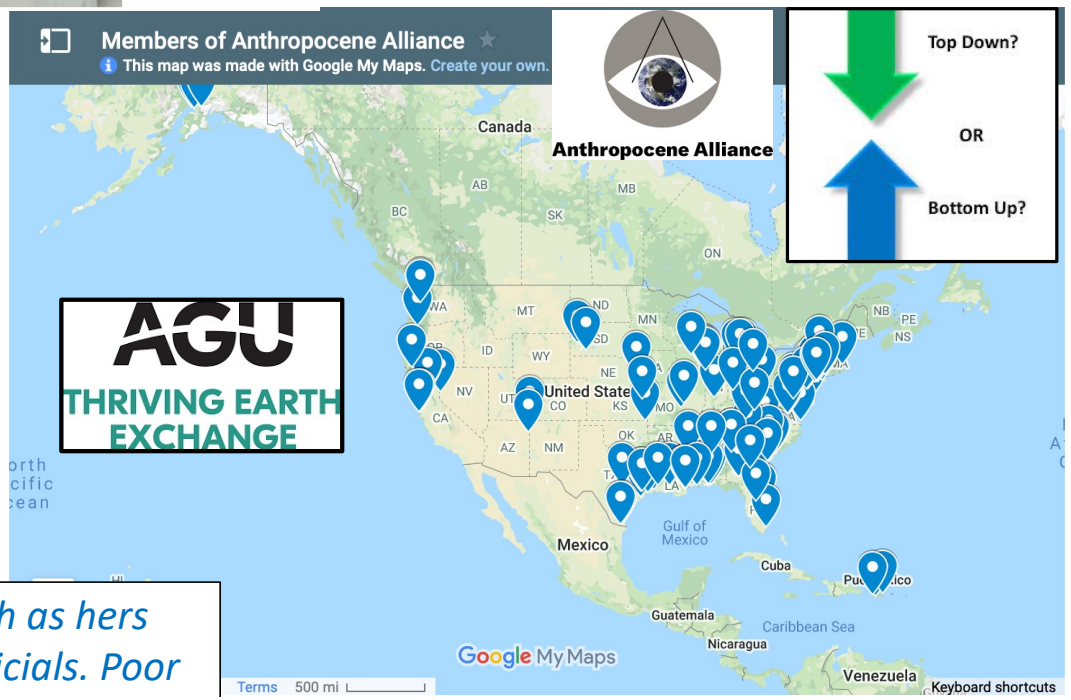

Which population characteristics available or used for EJ analysis? For EJ-based policy?

Tate, E., and C. Emrich (2021). "Assessing social equity in disasters." Eos, 102.

# Integrate equity:
# 3. Enhance local capacity

- Connect grassroots groups
- Prioritize frontline communities
- Collaborative grant writing
- Build links w/ agencies, pro-bono scientists & attorneys
- Introduce new city ordinances
- Pilot nature-based solutions






*a lack of government services in neighborhoods such as hers contributes to residents' deep distrust in elected officials. Poor flood protection contributes to a belief that local leaders sacrifice Halls to protect nearby, wealthier watersheds.*

Harris County's gamble on flood control bond leaves projects in poorest communities underfunded

Zach Despart, Staff writer
Updated: April 24, 2021 3:40 p.m.

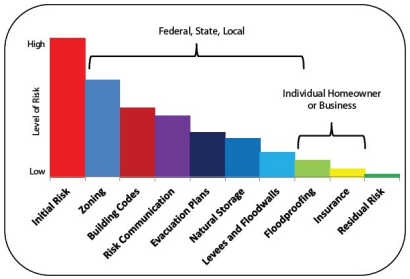
# Integrate equity:
# 4. Evaluate performance at local scales

Community Development Block Grant
Disaster Recovery

NATIONAL FLOOD INSURANCE PROGRAM

Help After a Disaster
Low-Interest Disaster Loans
SBA FEMA

- Disaster outcome data increasingly available spatially
- We're only beginning to understand who has highest unmet needs
- Gaps: how equitable are current programs?
  - Processes?
  - Eligibility measures?
  - Outcomes?
- Status quo investments likely to perpetuate inequities



An Affordability Framework for the National Flood Insurance Program

*April 17, 2018*

Homeland Security

SOCIUS
Original Article

**Racial Inequities in the Federal Buyout of Flood-Prone Homes: A Nationwide Assessment of Environmental Adaptation**

James R. Elliott, Phylicia Lee Brown, and Kevin Loughran

ASA
SAGE

HOUSING RECOVERY IN THE NINTH WARD

*Disparities in Policy, Process, and Prospects*

*Lisa K. Bates and Rebekah A. Green*

E&E NEWS

<< Back to E&E News index page.

INVESTIGATION

**Disaster loans foster disparities in Black communities**

Thomas Frank, E&E News reporter • Published: Tuesday, June 30, 2020

# Integrate equity:
# 4. Evaluate programs w/ spatial indicators

- Equity – allocate resources based on:
  - Equal protection; and
  - Satisfying human needs
- Potential approach:
  - Model context-specific social vulnerability
  - Use results to assess mitigation equity
  - Adjust programs, priorities
- Need to develop best practices!
  - Are current indicators suitable?
- Will the status quo rebel?

**FINAL**

**Prioritization Framework for the Implementation of the Harris County Flood Control District 2018 Bond Projects**

HARRIS COUNTY FLOOD CONTROL DISTRICT

August 27, 2019

**Weighted Factors Analysis**

The Weighted Factors analysis allows criteria to be weighted based on percentages that sum to 100 percent. Each of the criteria was given a percentage weighting based on a holistic view of the District's priorities. The District's mission is to provide flood damage reduction projects that work, with appropriate regard for community and nature-driven values; therefore, flood risk reduction is the most heavily weighted factor, with the remaining factors weighted in decreasing order of priority: infrastructure and community equity, cost effectiveness, and other factors that influence the long-term value of the project.

| | |
|---|---|
| Flood Risk Reduction Weighting Factor | 25% |
| Existing Conditions Drainage Level of Service Weighting Factor | 20% |
| Social Vulnerability Index Weighting Factor | 20% |
| Project Efficiency Weighting Factor | 10% |
| Partnership Funding Weighting Factor | 10% |
| Long Term Maintenance Costs Weighting Factor | 5% |
| Minimizes Environmental Impacts Weighting Factor | 5% |
| Potential for Multiple Benefits Weighting Factor | 5% |
| | 100% |

The New York Times

***A Climate Plan in Texas Focuses on Minorities. Not Everyone Likes It.***

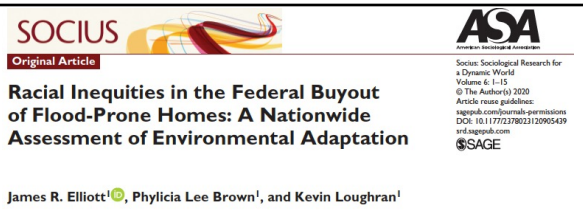
For years, money for flood protection in the Houston area went mostly to richer neighborhoods. A new approach prioritizes minority communities, and it's stirring up resentments.

HOUSTON CHRONICLE

With disaster recovery funding in turmoil, Harris County flood control chief resigns

Zach Despart, Staff writer

June 12, 2021 | Updated: June 12, 2021 8:34 p.m.


SOCIUS
Original Article
Racial Inequities in the Federal Buyout of Flood-Prone Homes: A Nationwide Assessment of Environmental Adaptation
James R. Elliott, Phylicia Lee Brown, and Kevin Loughran
ASA
SAGE

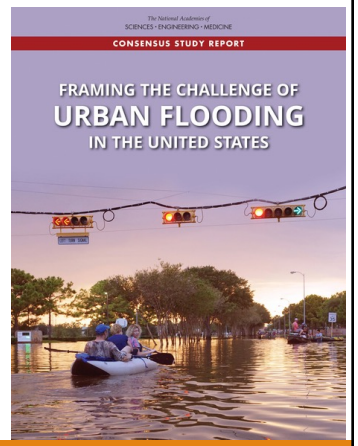
Environmental Research
Volume 179, Part A, December 2019, 108772
ELSEVIER
Environmental injustice and Hurricane Harvey: A household-level study of socially disparate flood exposures in Greater Houston, Texas, USA
Timothy W. Collins, Sara E. Grineski, Jayajit Chakraborty, Aaron B. Flores

Journal of Environmental Management
Volume 232, 15 February 2019, Pages 295-304
ELSEVIER
Research article
Disparities of population exposed to flood hazards in the United States
Yi Qiang

# Social vulnerability to hazards: where do we stand?

- Significant social inequities in hazard exposure & recovery: status quo investments likely to perpetuate them
- Can model social vulnerability using demographic indicators
- Can use resulting metrics to evaluate equity in mitigation

An Affordability Framework for the National Flood Insurance Program
April 17, 2018
Homeland Security


The National Academies of SCIENCES • ENGINEERING • MEDICINE
CONSENSUS STUDY REPORT
FRAMING THE CHALLENGE OF URBAN FLOODING IN THE UNITED STATES

RAND CORPORATION
Research Report
MELISSA L. FINUCANE, LINNEA WARREN MAY, JOAN CHANG
A Scoping Literature Review on Indicators and Metrics for Assessing Racial Equity in Disaster Preparation, Response, and Recovery

Support Strategies for Socially Marginalized Neighborhoods Likely Impacted by Natural Hazards
Coastal Resilience Center
The University of North Carolina at Chapel Hill

THE INFRASTRUCTURES OF EQUITY AND ENVIRONMENTAL JUSTICE
A Dissertation
by
MARCCUS D HENDRICKS
Submitted to the Office of Graduate and Professional Studies of Texas A&M University
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY

IOWA

# Thank You!

Eric Tate

University of Iowa

Department of Geographical & Sustainability Sciences

eric-tate@uiowa.edu