



» Wildfire



» Hurricane



» Tropical Cyclone

» Tsunami



» Flooding

» Earthquake



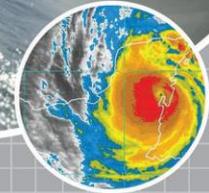
» Pandemic Influenza



Fostering Disaster - Resilient Communities



PACIFIC DISASTER CENTER



MEASURING VULNERABILITY

Christina Finch

International Training Workshop

National Science and Technology Center for Disaster Reduction

May 4-8, 2009

Hazards, Vulnerability & Risk

» Hazard

- Physical Event or Process
- Natural Hazard – Flood, Earthquake
- Technological – Nuclear Explosion
- Probability of Occurrence
- Characteristics: Magnitude, Intensity, Frequency, Duration, Time of Onset

» Disaster

- *“Hazards only become disasters when people’s lives and livelihoods are swept away.”* – UN Secretary-General Kofi Annan

Hazards, Vulnerability & Risk

» Vulnerability

- Potential for Harm
- Likelihood that an individual or group will be exposed to and adversely affected by a hazard
- *“The conditions determined by physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard.” - UNDP*

Hazards, Vulnerability & Risk

» Risk

- Probability of Loss (Likelihood, Frequency)
- Expected Losses (Deaths, Economic Damages)

» Risk Assessment

- Probability of Natural Hazard and Degree of Danger
- *Function of Hazard, Exposure, Vulnerability and Coping Capacity*

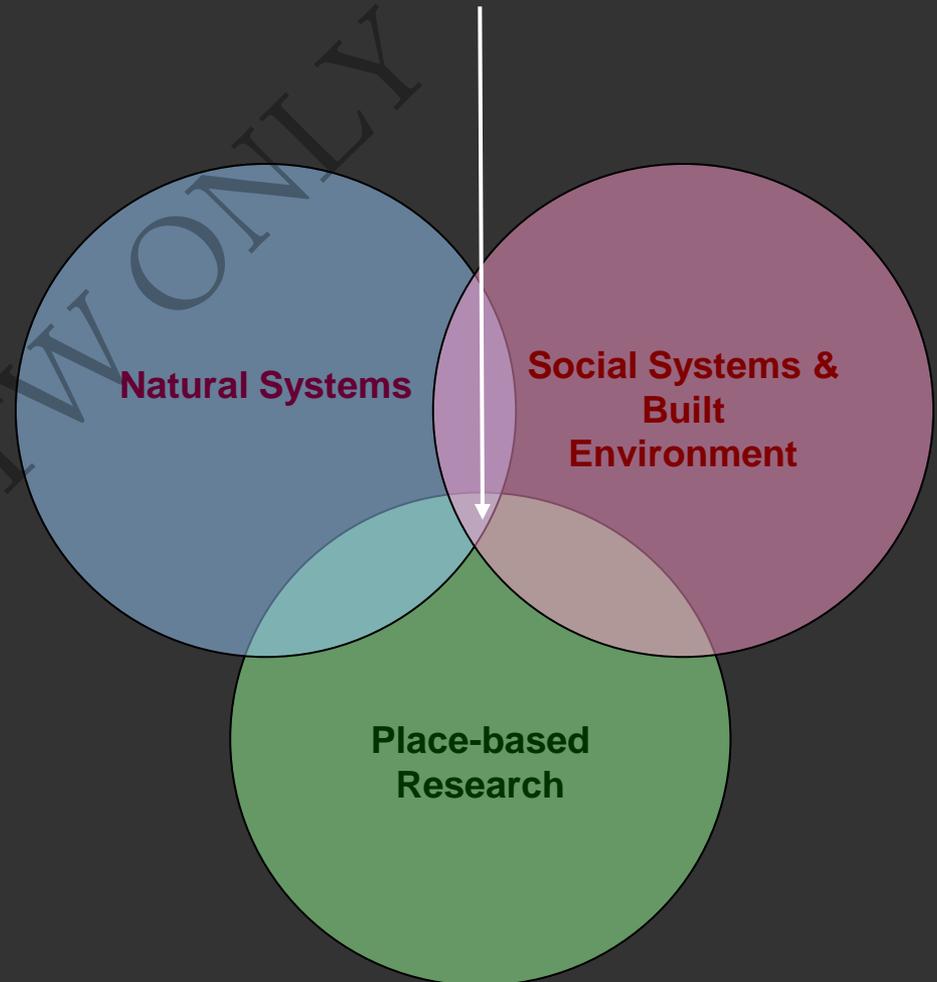
» Risk Reduction

Vulnerability Science

- » What makes people and places vulnerable to environmental threats from natural, technological, and human-induced hazards?
 - What circumstances place people and localities at risk?
 - What enhances or reduces the ability to respond to environmental threats?
- » Development of methods and metrics for analyzing societal vulnerability and resilience to environmental hazards and extreme events

Importance of Spatial Perspective

- » Interaction of Natural Systems, Social Systems, and Built Environment
- » Place-Based Research



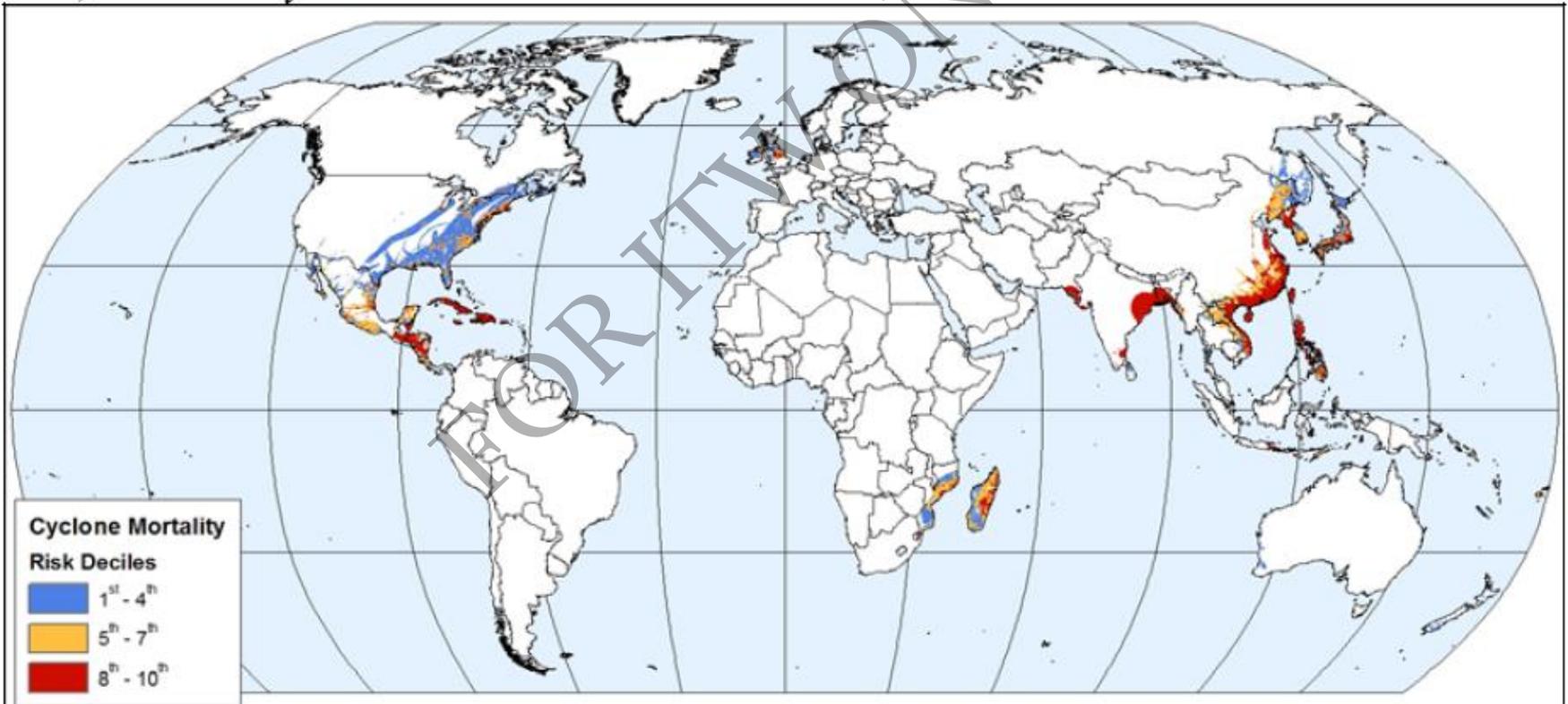
Outline

- » **Global Risk & Vulnerability Assessments**
 - **Global Hotspots** (Columbia University, World Bank)
 - **Disaster Risk Index** (UNDP/UNEP-GRID)
- » **Social Vulnerability Index – SoVI** (Cutter, Boruff and Shirley 2000)
 - **U.S. County**
 - Spatial Patterns and Temporal Trends
 - **Case Study: New Orleans, Louisiana**

Global Natural Disaster Risk Hotspots

» Tropical Cyclones Based on Mortality

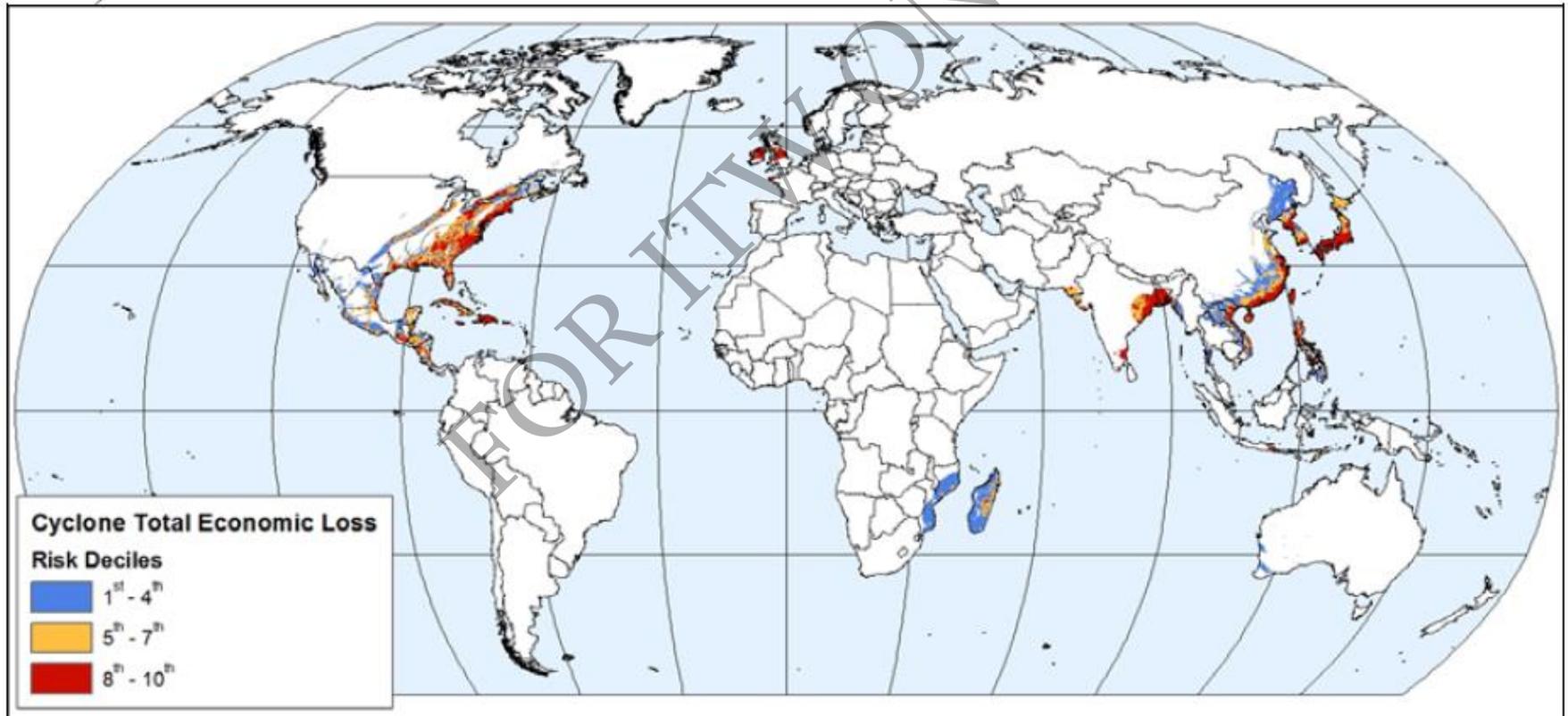
a) *Mortality*



Global Natural Disaster Risk Hotspots

» Tropical Cyclones Based on Economic Losses

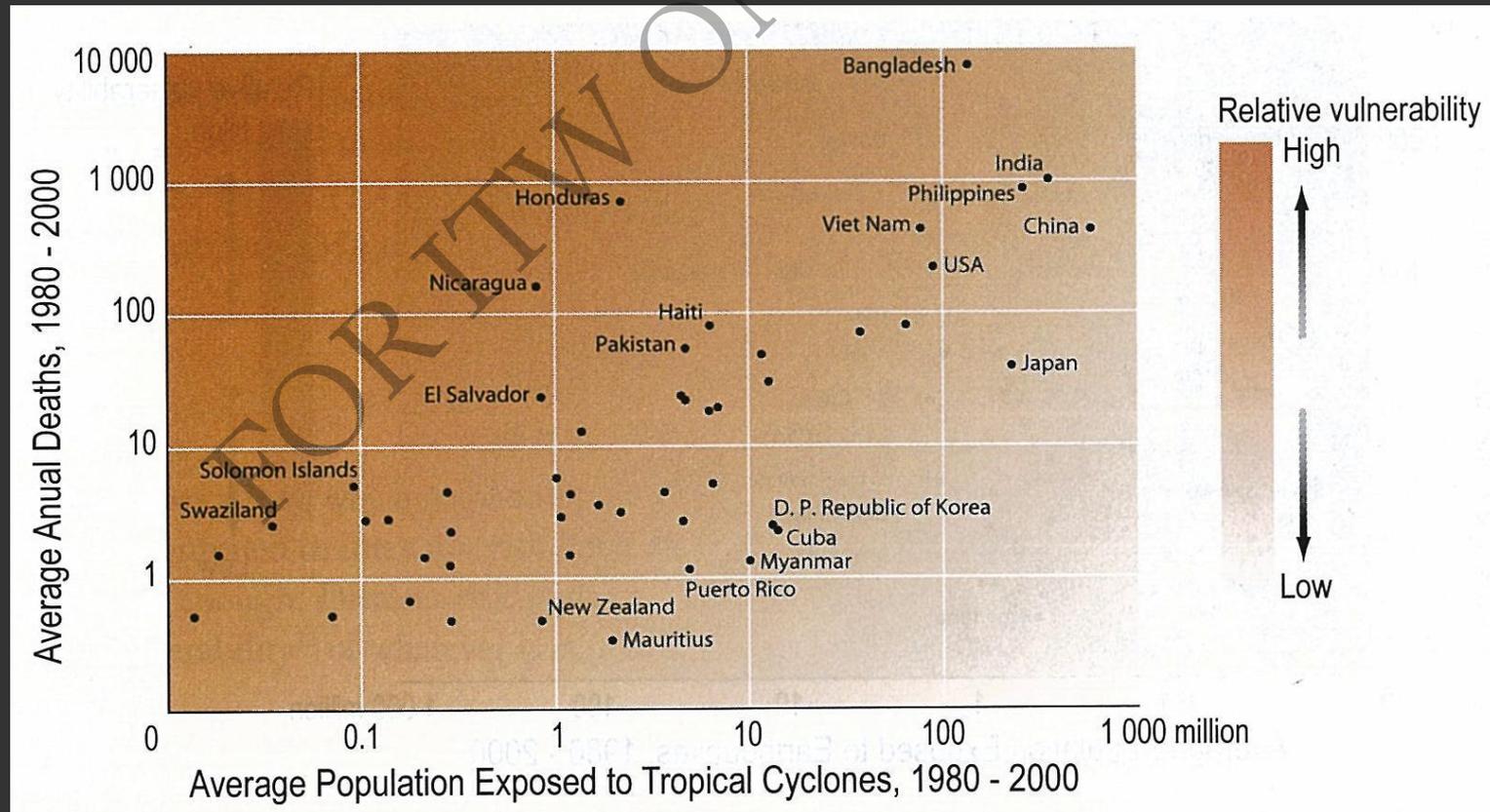
b) *Total economic loss*



Disaster Risk Index

- » Index Based on Mortality
- » “Vulnerability is perceived as the concept that explains why people with the same level of physical exposure can be more or less at risk.”
- » Similar Exposure – Different Human Impacts
 - Least Developed Countries
 - 11% of Physical Exposure
 - 53% of Casualties
 - Most Developed Countries
 - 15% Physical Exposure
 - 1.8% of Casualties

Disaster Risk Index: Tropical Cyclones



Social Vulnerability

- » Characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard

Characteristics of Social Vulnerability

Special Needs Populations

- » Difficult to identify (infirm, transient) let alone measure; invariably left out of recovery efforts; often invisible in communities



Age (Elderly and Children)

- » Affect mobility out of harm's way; need special care; more susceptible to harm



Socioeconomic Status (Rich, Poor)

- » Ability to absorb losses and recover (insurance, social safety nets), but more material goods to lose



Race and Ethnicity (Non-white, Non-Anglo)

- » Impose language and cultural barriers; affect access to post-disaster recovery funding; tend to occupy high hazard zones



Gender (Women)

- » gender-specific employment, lower wages, care-giving role



Social Vulnerability Index (SoVI)

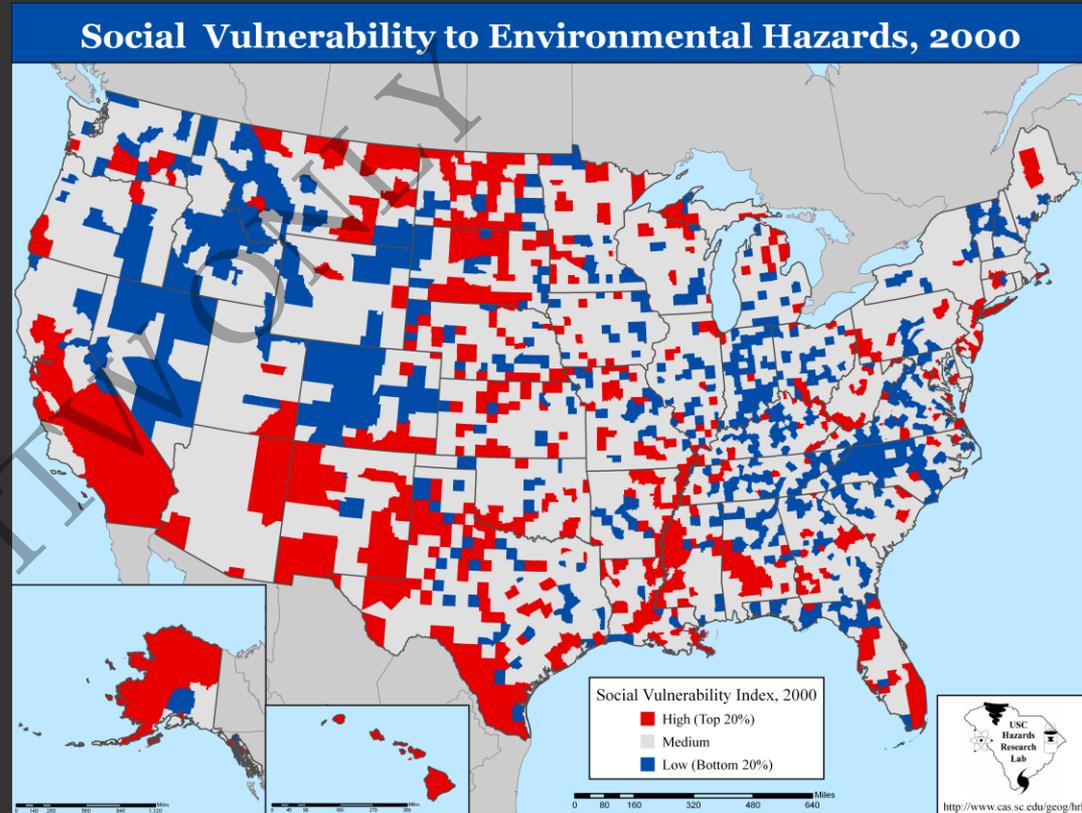
- » Identify Vulnerable Populations
- » Replicate Methodology for Different Time Periods
- » Assess Spatial Patterns and Changes
- » Highlight Temporal Trends
- » Project Future Vulnerability
- » Scale Methodology for Different Levels of Geography

SoVI

- » Socioeconomic Status
(Income, Political Power, Prestige)
- » Gender
- » Race and Ethnicity
- » Age
- » Commercial and Industrial Development
- » Employment Loss
- » Rural/Urban
- » Residential Property
- » Infrastructure and Lifelines
- » Renters
- » Occupation
- » Family Structure
- » Education
- » Population Growth
- » Health Status
- » Medical Services
- » Social Dependence
- » Special-needs Population

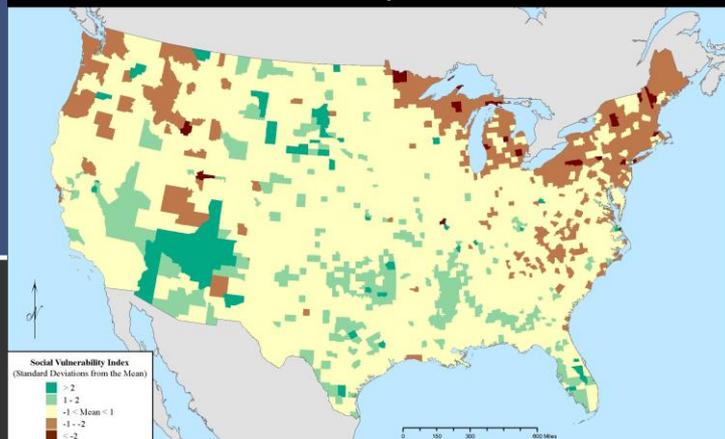
Social Vulnerability Index (SoVI)

- » Relative Index
- » County Level
- » United States
- » Decade - 2000
- » Data Reduction
- » 42 Socioeconomic Variables

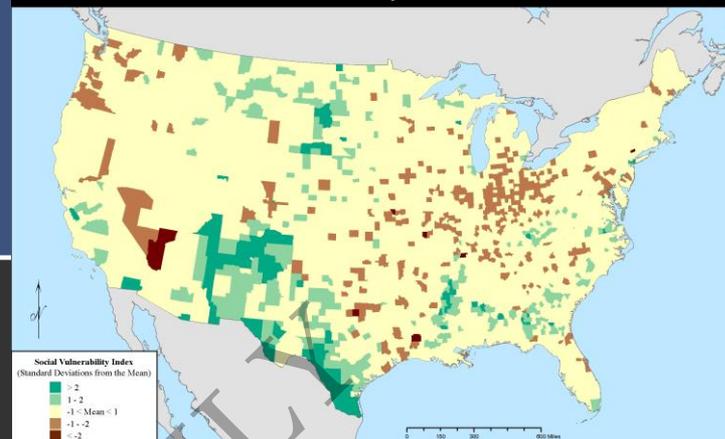


Cutter, S.L., B.J. Boruff, and W.L. Shirley. 2003. "Social Vulnerability to Environmental Hazards." *Social Sciences Quarterly*. 84(2): 242-261.

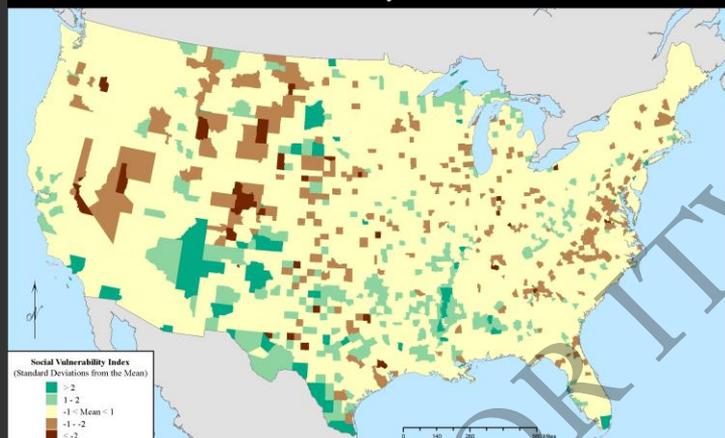
Social Vulnerability Index in 1960



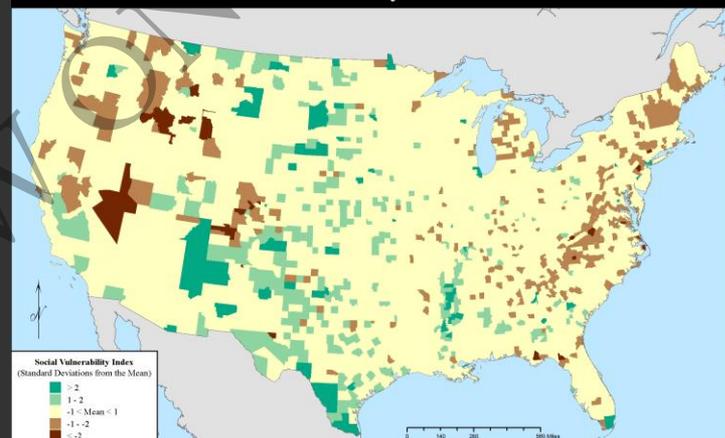
Social Vulnerability Index in 1970



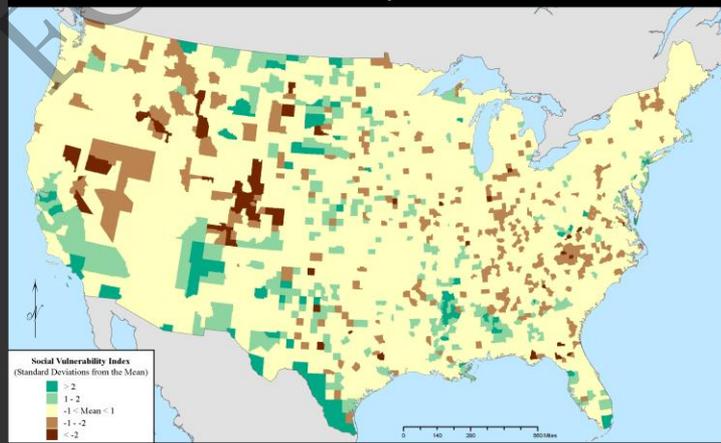
Social Vulnerability Index in 1980



Social Vulnerability Index in 1990



Social Vulnerability Index in 2000



High Social Vulnerability Regional Trends

- » Lower Mississippi River
- » Texas-Mexico Border
- » North Central US/Great Plains

Low Social Vulnerability Regional Trends

- » Northwest
- » Nevada
- » Colorado

25 Most Vulnerable Counties

1960	1970	1980	1990	2000
New York, NY	New York, NY	New York, NY	New York, NY	New York , NY
Shannon, SD	San Francisco, CA	Yellowstone National Park, MT	San Francisco, CA	Roanoke City, VA
Monroe, WI	Bronx, NY	San Francisco, CA	Washington, DC	Bronx , NY
Todd, SD	Kings, NY	Shannon, SD	Bronx, NY	Webb , TX
Duval, TX	Suffolk, MA	Todd, SD	Kings, NY	Northampton , VA
Jackson, SD	Washington, DC	Kings, NY	Suffolk, MA	Shannon , SD
Apache, AZ	Maverick, TX	Apache, AZ	Shannon, SD	San Francisco , CA
Athens, OH	Queens, NY	Bronx, NY	Benton, WA	Kings , NY
Navajo, AZ	Starr, TX	Starr, TX	Todd, SD	Starr , TX
San Juan, UT	Zavala, TX	Maverick, TX	St. Louis City, MO	Todd , SD
McKinley, NM	Philadelphia, PA	Buffalo, SD	Buffalo, SD	Maverick , TX
Buffalo, SD	Kenedy, TX	Hudson, NJ	Apache, AZ	McKinley , NM
Adams, WA	Webb, TX	Queens, NY	Hudson, NJ	Zavala , TX
Monroe, IL	Dimmit, TX	Falls Church, VA	Baltimore, MD	Buffalo , SD
Rolette, ND	St. Louis City, MO	Suffolk, MA	Philadelphia, PA	Issaquena , MS
Ormsby, NV	Jim Hogg, TX	Menominee, WI	Queens, NY	Clifton Forge City, VA
Dewey, SD	Willacy, TX	Sioux, ND	Sioux, ND	Queens , NY
Sioux, ND	Hudson, NJ	McKinley, NM	McKinley, NM	Hudson , NJ
Brown, NE	Zapata, TX	Rolette, ND	Platte, NE	Brooks , TX
Alpine, CA	Hidalgo, TX	Webb, TX	Webb, TX	Wilcox , AL
Mohave, AZ	Denver, CO	St. Louis City, MO	Big Stone, MN	Cameron , TX
Coryell, TX	Shannon, SD	Dewey, SD	Menominee, WI	Presidio , TX
Coconino, AZ	Santa Cruz, AZ	Corson, SD	Arlington, VA	Apache , AZ
Kings, NY	Presidio, TX	Val Verde, TX	Dewey, SD	Sioux , ND
Stanley, SD	Cameron, TX	Emporia, VA	East Carroll LA	Dimmit , TX

Occurrence Frequency of Most Vulnerable Counties

2 Decades	3 Decades	4 Decades	5 Decades
Cameron, TX ←	Dewey, SD ←	Apache, AZ ←	Kings, NY ←
Dimmit, TX ←	Maverick, TX ←	Bronx, NY ←	New York, NY ←
Menominee, WI ←	St. Louis City, MO ←	Buffalo, SD ←	Shannon, SD ←
Philadelphia, PA ←	Starr, TX ←	Hudson, NJ ←	
Presidio, TX ←	Suffolk, MA ←	McKinley, NM ←	
Rolette, ND ←		Queens, NY ←	
Washington, DC ←		San Francisco, CA ←	
Zavala, TX ←		Sioux, ND ←	
		Todd, SD ←	
		Webb, TX ←	

Main Themes

Development - Urban

Race/Ethnicity – Native American

Race/Socioeconomic Status – Lack of Education, Poverty, Diversity

Spatial Variations and Patterns

- » Measures of Spatial Autocorrelation
 - Global Moran's I
 - Measure of Association - Similar/Dissimilar
 - Similar (+1), Random (0), Dissimilar (-1)
 - Local Moran's I (LISA)
 - Influence of Local Neighbors
 - Identify Significant Clusters of Similar Values
 - *High-High* and *Low-Low*

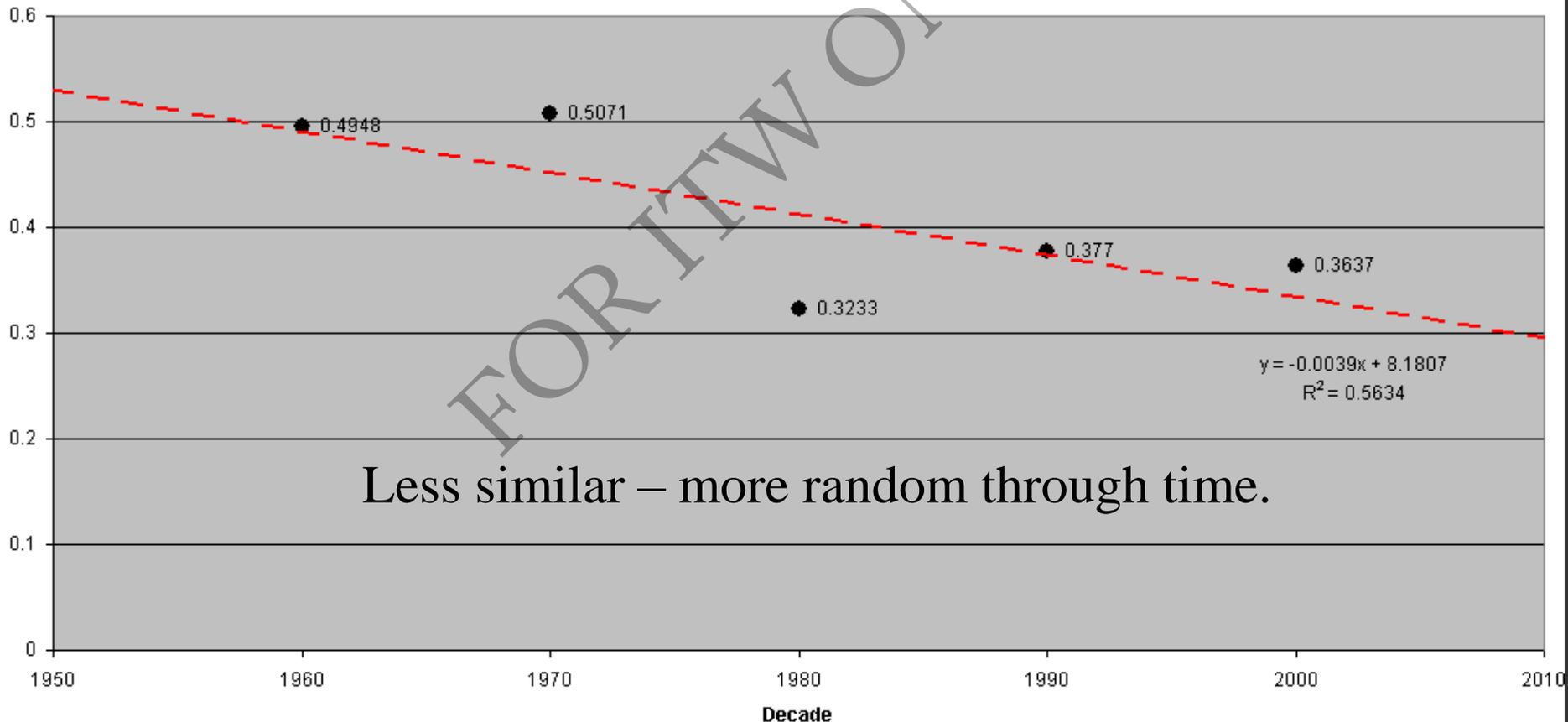
Global Moran's I

There was significant positive spatial autocorrelation in all decades.

Decade	Moran's I
1960	0.4948
1970	0.5071
1980	0.3233
1990	0.377
2000	0.3637

Moran's I of SoVI Through Time

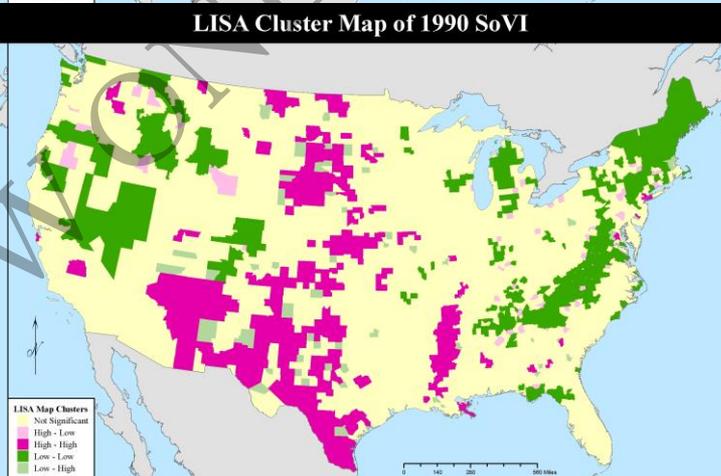
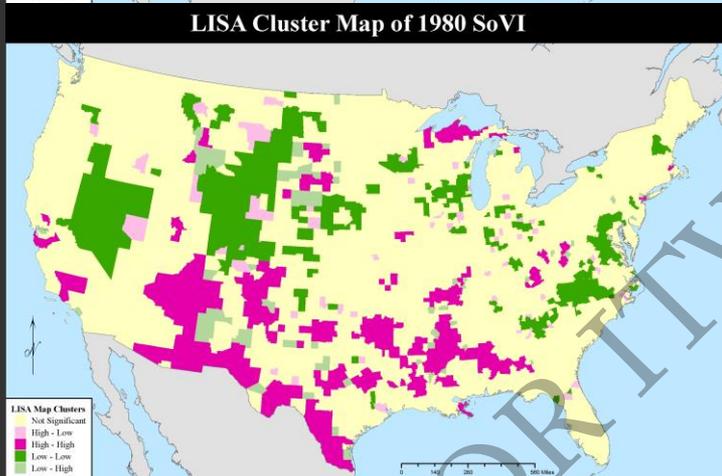
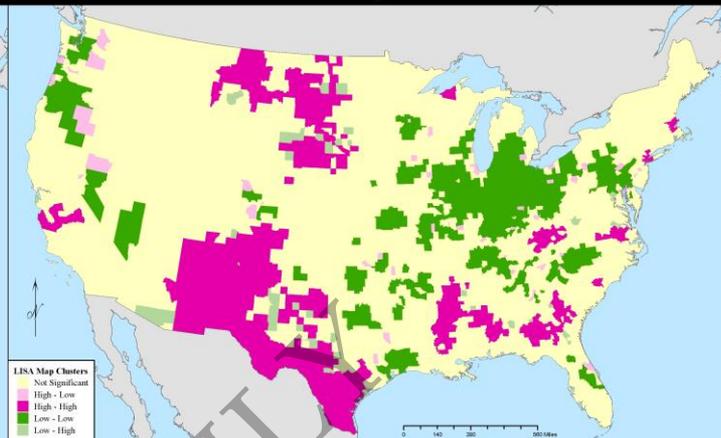
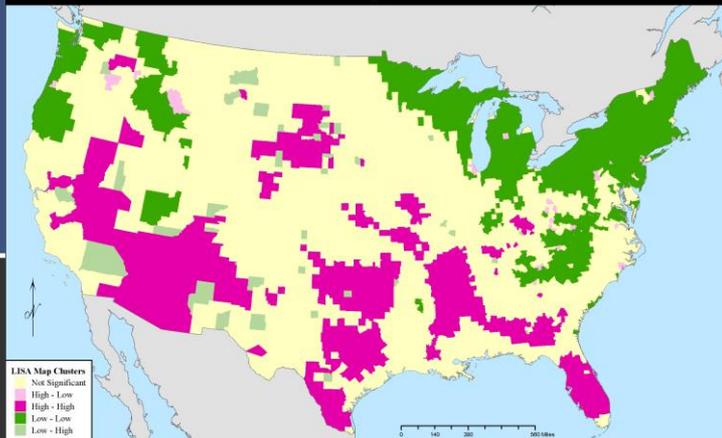
● Series1 - - Linear



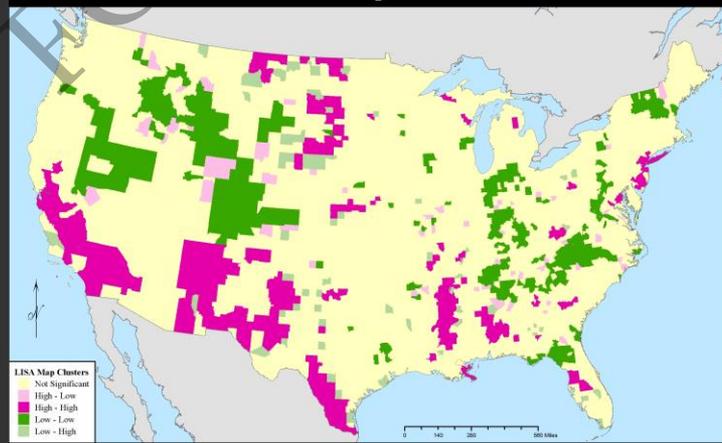
Less similar – more random through time.

LISA Cluster Map of 1960 SoVI

LISA Cluster Map of 1970 SoVI



LISA Cluster Map of 2000 SoVI



High-High
517
Low-Low
636

High-High
355
Low-Low
597

High-High
293
Low-Low
344

High-High
344
Low-Low
448

High-High
239
Low-Low
342

Spatial Pattern and Variations

- » Significant Positive Spatial Autocorrelation for ALL Decades (Moran's I)
- » Number of Counties with Significantly Similar Neighbors Decreased Through Time
- » **Spatial Pattern is More Random and Less Similar Through Time**

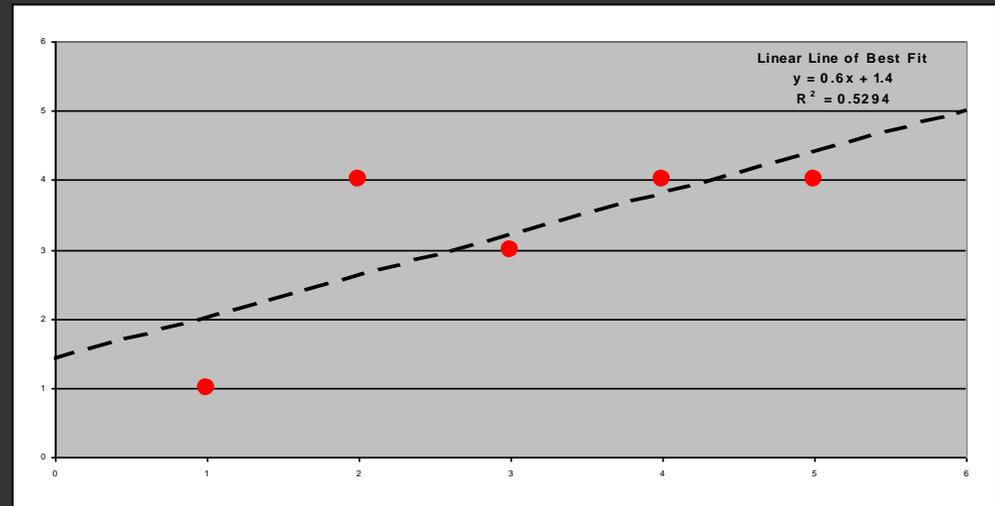
Temporal Trends

» Linear Regression for Each County

- Line of Best Fit
 - Slope (Direction of Trend)
 - R^2 (Strength of the Trend)
 - F-Statistic (Level of Significance)

» Identify Counties with Significant Trends in SoVI

- Predict 2010 SoVI Based on Linear Trend through Time

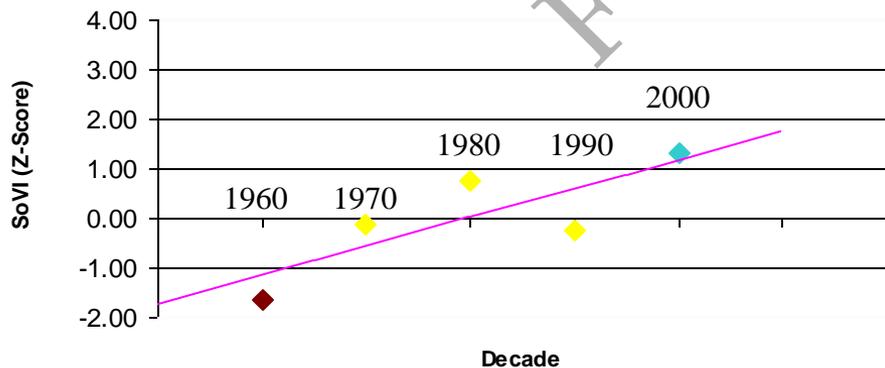


Significant Increase in Social Vulnerability

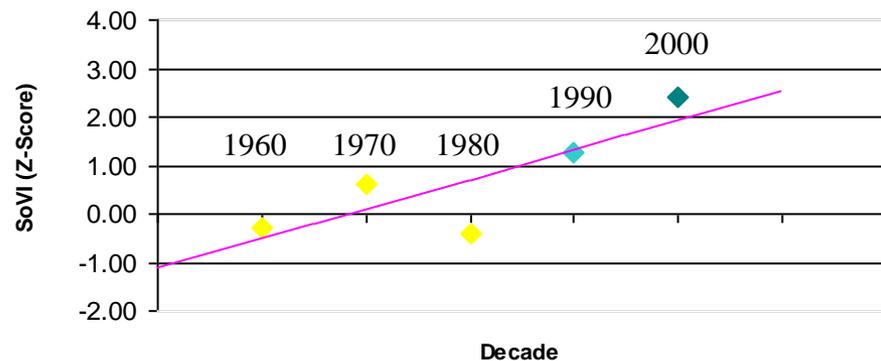
» 46 Counties
 » 25 Counties Shown in Table

COUNTY	ZSOVI_1960	ZSOVI_1970	ZSOVI_1980	ZSOVI_1990	ZSOVI_2000	SLOPE	R_SQUARED
Roanoke city, VA	-0.38	1.15	1.83	1.58	6.41	1.40	0.75
Northampton, VA	-0.26	2.02	1.01	1.50	4.95	0.99	0.66
Beaver, PA	-1.89	-0.69	0.08	1.54	1.59	0.92	0.95
Clifton Forge city, VA	0.26	0.22	2.89	2.38	3.62	0.89	0.81
McIntosh, ND	-0.43	1.79	0.30	2.23	2.95	0.72	0.66
Box Butte, NE	0.55	-0.03	1.60	2.46	2.85	0.71	0.84
Delaware, PA	-1.87	-0.29	0.66	0.56	1.23	0.71	0.85
Wyandotte, KS	-0.56	-0.52	1.82	2.10	1.65	0.70	0.71
Bergen, NJ	-1.95	0.52	-0.25	0.34	1.56	0.68	0.70
San Mateo, CA	-1.30	-0.07	1.60	0.24	1.82	0.65	0.65
Salem, NJ	-1.46	-0.93	-0.11	0.58	0.97	0.64	0.99
Jefferson, OH	-1.35	-0.76	0.70	0.42	1.23	0.63	0.88
Brooke, WV	-1.86	-0.73	-0.19	-0.23	1.02	0.63	0.91
Moore, TX	-0.57	-0.39	0.43	0.89	1.92	0.63	0.96
Towner, ND	-0.76	0.25	-0.33	0.89	2.02	0.62	0.81
Norton city, VA	-0.10	0.01	2.07	2.04	1.95	0.61	0.73
Divide, ND	-0.29	0.59	-0.42	1.28	2.41	0.61	0.67
Mahoning, OH	-1.64	-0.27	0.74	0.57	0.99	0.61	0.81
Middlesex, NJ	-1.55	-0.18	-0.39	-0.19	1.47	0.60	0.78
Hancock, WV	-1.81	-0.65	0.07	0.19	0.78	0.60	0.92
Boyd, KY	-0.98	-1.71	0.67	0.65	0.81	0.59	0.66
DuPage, IL	-1.68	-0.90	-0.71	0.13	0.72	0.58	0.98
Barnstable, MA	-1.63	-0.10	0.75	-0.23	1.32	0.58	0.66
St. Louis, MO	-2.17	-0.87	-0.22	-0.24	0.39	0.58	0.87
Orange, CA	-0.33	-0.28	-0.28	0.65	2.07	0.57	0.76

Barnstable County, MA



Divide County, ND

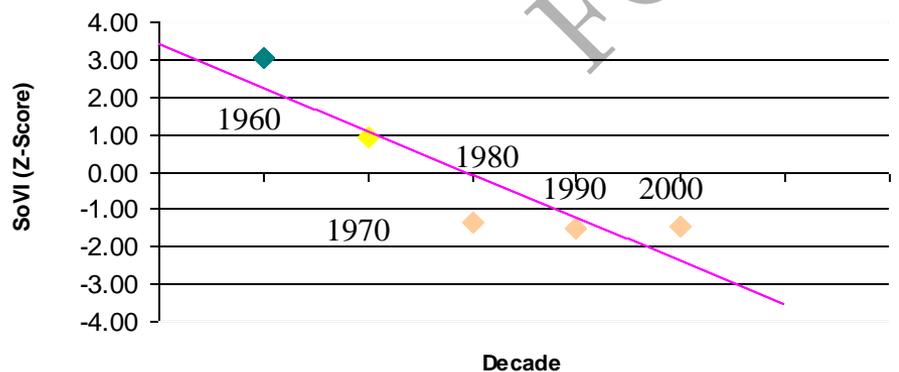


Significant Decrease in Social Vulnerability

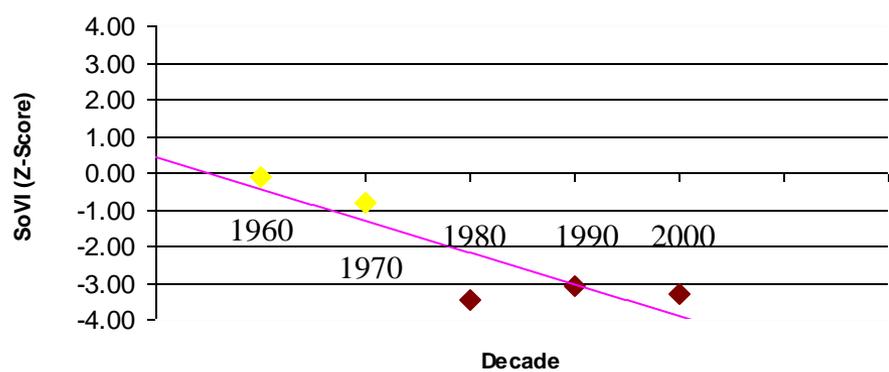
COUNTY	ZSOVI_1960	ZSOVI_1970	ZSOVI_1980	ZSOVI_1990	ZSOVI_2000	SLOPE	R_SQUARED
San Miguel, CO	0.80	0.38	-1.41	-2.77	-3.72	-1.22	0.97
Alpine, CA	3.07	0.95	-1.34	-1.50	-1.46	-1.15	0.80
Daggett, UT	1.98	2.22	-0.11	-0.70	-2.18	-1.12	0.91
Stanley, SD	2.95	0.14	-0.75	-0.71	-2.23	-1.12	0.86
King, TX	0.50	1.05	-2.33	-1.53	-3.30	-1.02	0.75
Pitkin, CO	-0.13	-0.80	-3.48	-3.07	-3.29	-0.86	0.75
Mono, CA	1.15	-0.69	-2.06	-0.93	-2.98	-0.85	0.74
Lafayette, FL	0.04	0.81	-0.74	-2.36	-2.61	-0.85	0.81
Gilpin, CO	0.15	-0.73	-2.31	-2.61	-3.04	-0.83	0.93
Roberts, TX	0.52	-0.19	-1.15	-1.49	-2.85	-0.80	0.97
Union, FL	1.08	-1.01	-1.46	-1.20	-2.71	-0.78	0.81
Brown, IL	0.25	0.07	-0.02	-1.35	-2.83	-0.76	0.84
Grand, CO	-0.30	-0.36	-2.67	-1.85	-3.23	-0.73	0.76
Liberty, FL	-0.22	0.24	-0.24	-2.61	-2.41	-0.72	0.72
Teton, WY	-1.08	-0.18	-2.44	-2.50	-3.52	-0.72	0.75
Echols, GA	-0.15	1.15	-0.64	-1.00	-2.51	-0.69	0.67
Bandera, TX	0.77	-0.05	-0.23	-1.56	-1.88	-0.68	0.95
Pershing, NV	0.46	0.71	-0.35	-0.66	-2.23	-0.68	0.85
Grant, NE	1.46	0.39	-0.48	-0.46	-1.41	-0.66	0.93
James City, VA	0.21	-0.24	-1.39	-1.97	-2.22	-0.66	0.95
Blaine, ID	-0.14	-0.14	-1.93	-2.32	-2.28	-0.65	0.82
Granville, NC	0.78	0.56	-0.91	-0.73	-1.78	-0.64	0.90
Carroll, MS	1.20	1.37	0.07	-0.09	-1.19	-0.62	0.89
Lafayette, MS	1.19	-0.64	0.14	-0.93	-1.76	-0.62	0.77
Baldwin, GA	1.49	-0.02	0.26	-0.35	-1.41	-0.61	0.85

» 40 Counties
 » 25 Counties Shown in Table

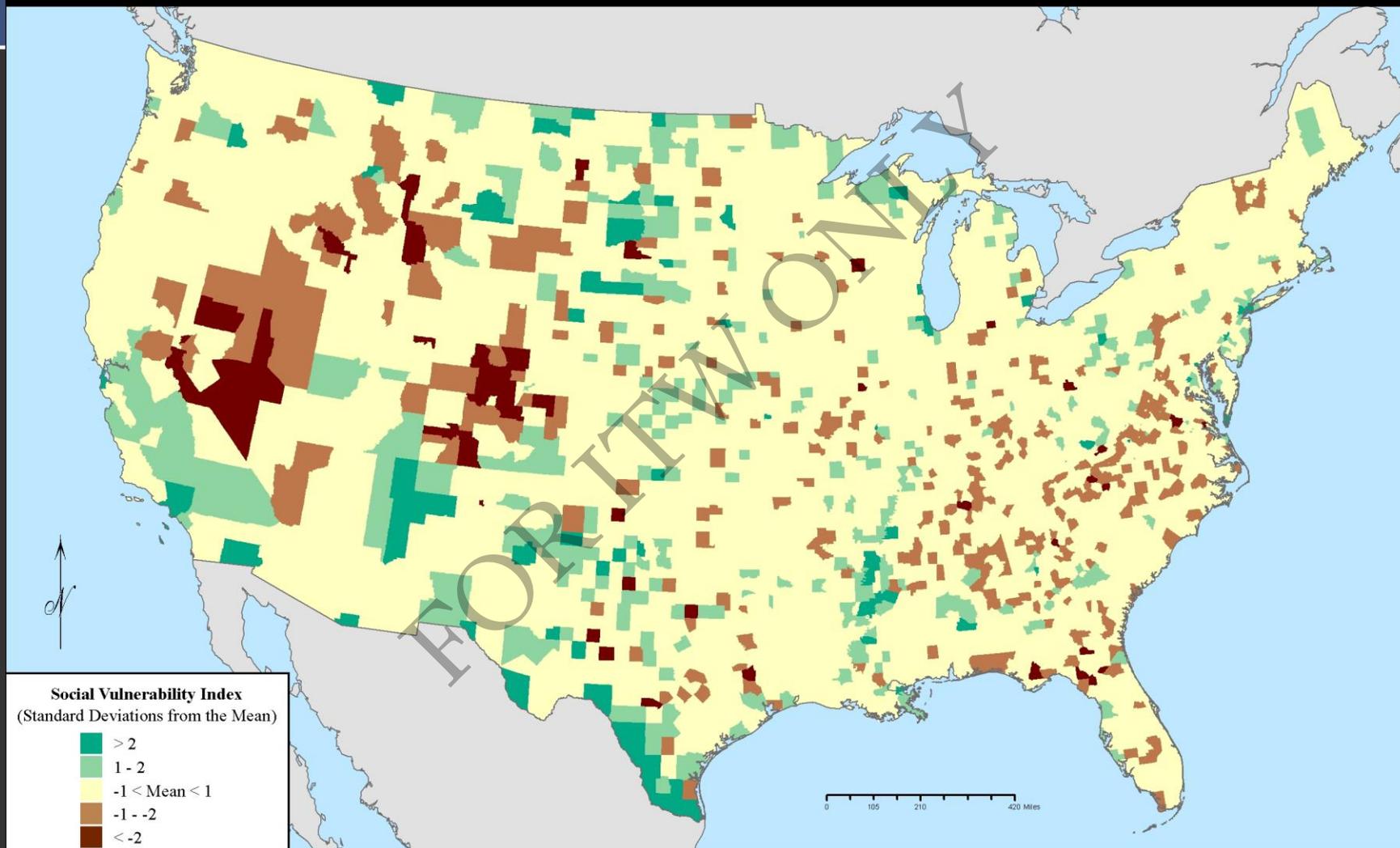
Alpine County, CA



Pitkin County, CO



Projected Social Vulnerability Index in 2010



Temporal Trends

- » Identified Significant Changes in Social Vulnerability
- » Increasing Vulnerability
 - Depopulation
 - Development
- » Decreasing Vulnerability
 - Increasing Wealth
- » SoVI in 2010
 - Significant Positive Spatial Autocorrelation
 - Moran's I Supports Decreasing Trend
 - Decrease also Apparent in LISA Clusters

Benefits and Impacts

- » Identification of socially vulnerable counties and regions, and their associated socio-economic characteristics is **beneficial for mitigation planning, immediate response and long-term recovery.**
- » The spatial pattern of social vulnerability is becoming more dispersed and less clustered in similar geographic regions, and therefore **more counties will need to plan for a broad spectrum of social vulnerability characteristics.**

Benefits and Impacts

- » Many counties in the United States are experiencing significant increases or decreases in social vulnerability; these counties should have **more emphasis on current mitigation plans**, as their demographics and resilience to environmental hazards have changed.
- » The projected future of social vulnerability in 2010 **identifies priority areas** that should be addressed in the present to increase the resilience of those communities.

Hurricane Katrina

- » August 23, 2005
- » **Damage:** \$81 billion total; \$40.6 billion in insured losses
- » **Deaths:** 1,833
 - LA: 1,577, MS: 238, FL: 14, GA: 2, AL: 2
- » **Storm Surge**
 - Mississippi: 17-28 ft
 - Louisiana: 5-15ft
 - Alabama: 8-15ft
- » **Evacuees:** 1.2 million people



Mississippi

Pass Christian, MS



Long Beach, MS



Highway I-90 Bridge
Biloxi, MS



Gulfport, MS

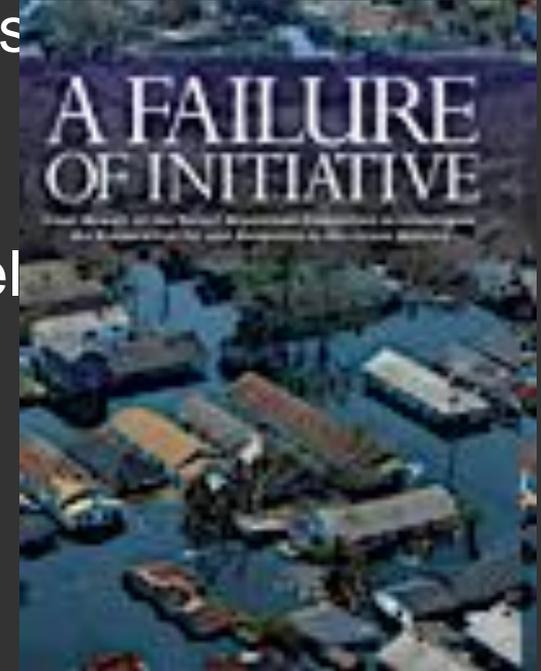


New Orleans, Louisiana



A Failure of Initiative

- » Imagination and initiative – in other words leadership – require good information. And a coordinated process for sharing it. And a willingness to use information – however imperfect or incomplete – to fuel action.
- » A national emergency management system that relies on state and local governments to identify needs and request resources is adequate for most disasters, a catastrophic disaster like Katrina can and did overwhelm most aspects of the system.
- » Response plans at all levels of government lacked flexibility and adaptability.



SoVI for New Orleans, LA

» Methods

- Orleans Parish, LA
- Tract Level (181)
- 31 Variables

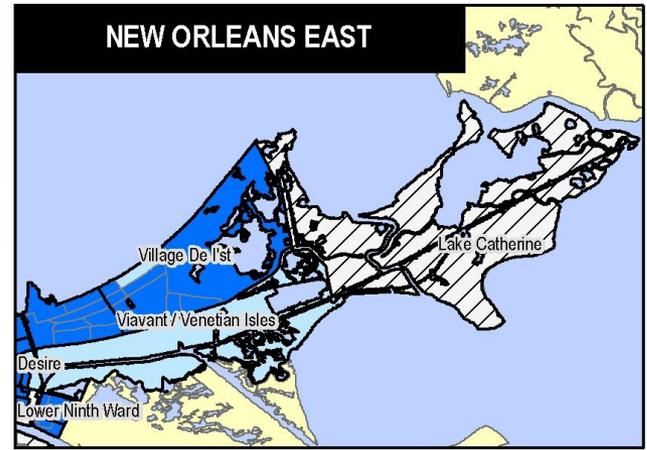
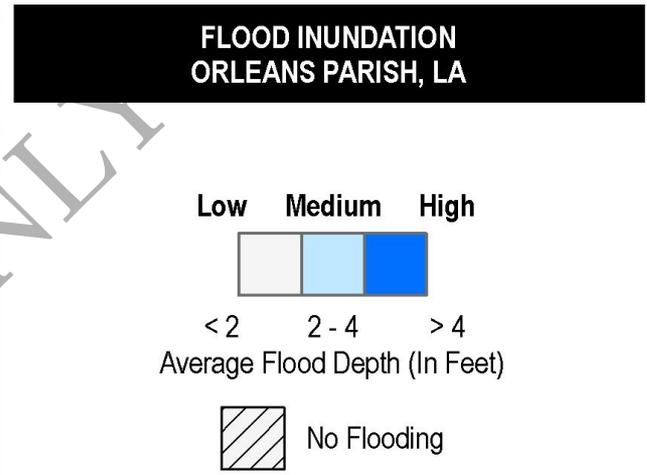
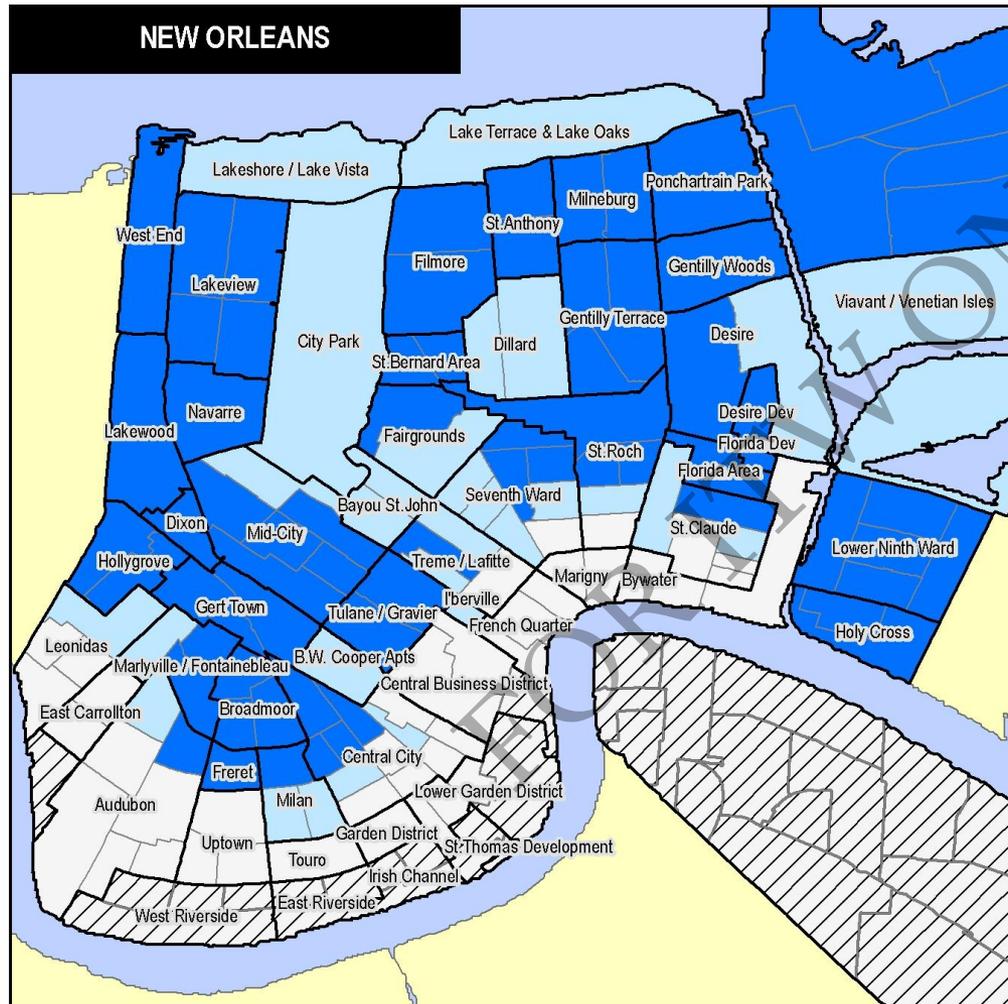
» Results

- Explained 76.57% of the Variance
- 8 Components

» Dominant Variables

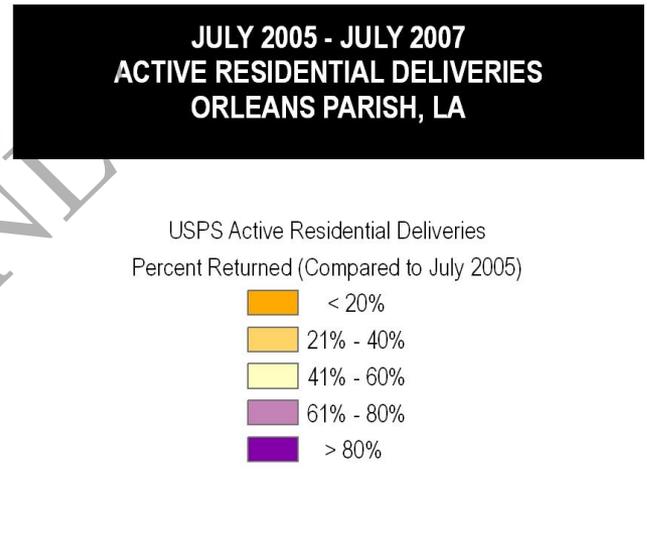
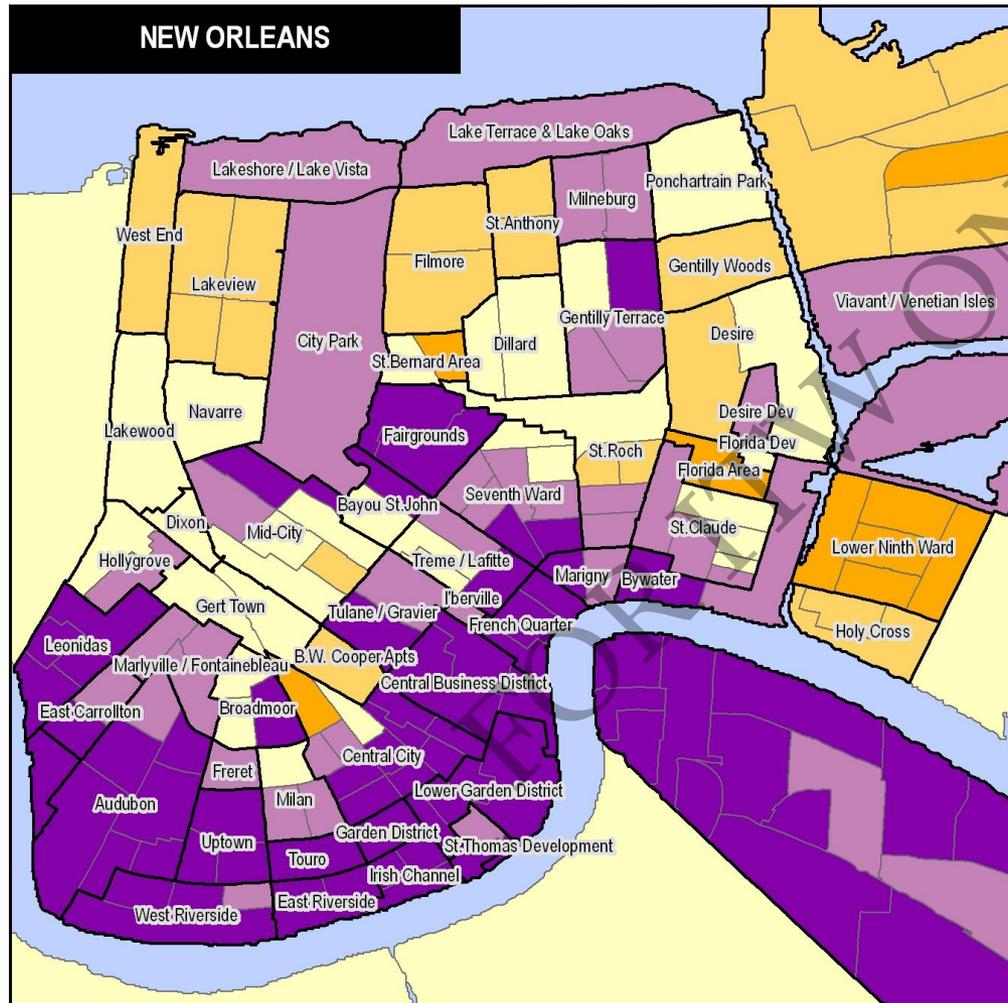
- Socioeconomic Status
- Age and Gender
- Poverty and Unemployment

Neighborhood Disparities Hazard (Flooding)



Finch, C., C. Emrich, and S. L. Cutter. 2008. Disaster Disparities and Differential Recovery in New Orleans. [Publication in Progress].

Neighborhood Disparities Uneven Recovery



Finch, C., C. Emrich, and S. L. Cutter. 2008. Disaster Disparities and Differential Recovery in New Orleans. [Publication in Progress].

Vulnerability and Emergency Management

- » Social vulnerability influences all phases of the emergency management cycle
- » Aggregation of all social and economic characteristics
- » Identify of vulnerable areas
- » Application to different scales and areas

Prevention

Preparation

Mitigation

Response

Recovery

End-to-end Disaster Management

Thoughts and Discussion Topics

- » What is the current status of risk assessment in your country?
 - Hazard Identification
 - Vulnerability Assessment
 - Risk Assessment
 - Mitigation Planning
 - Education and Outreach
- » Risk Reduction



Fostering Disaster - Resilient Communities

» Wildfire



» Hurricane



» Tropical Cyclone

» Tsunami

» Flooding



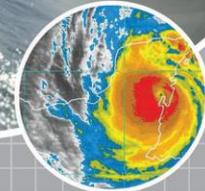
» Earthquake



» Pandemic Influenza



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Any Questions?

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