

Estimating Loss, Impact and Risk



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Pacific Disaster Center

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Asia-Pacific
Economic Cooperation



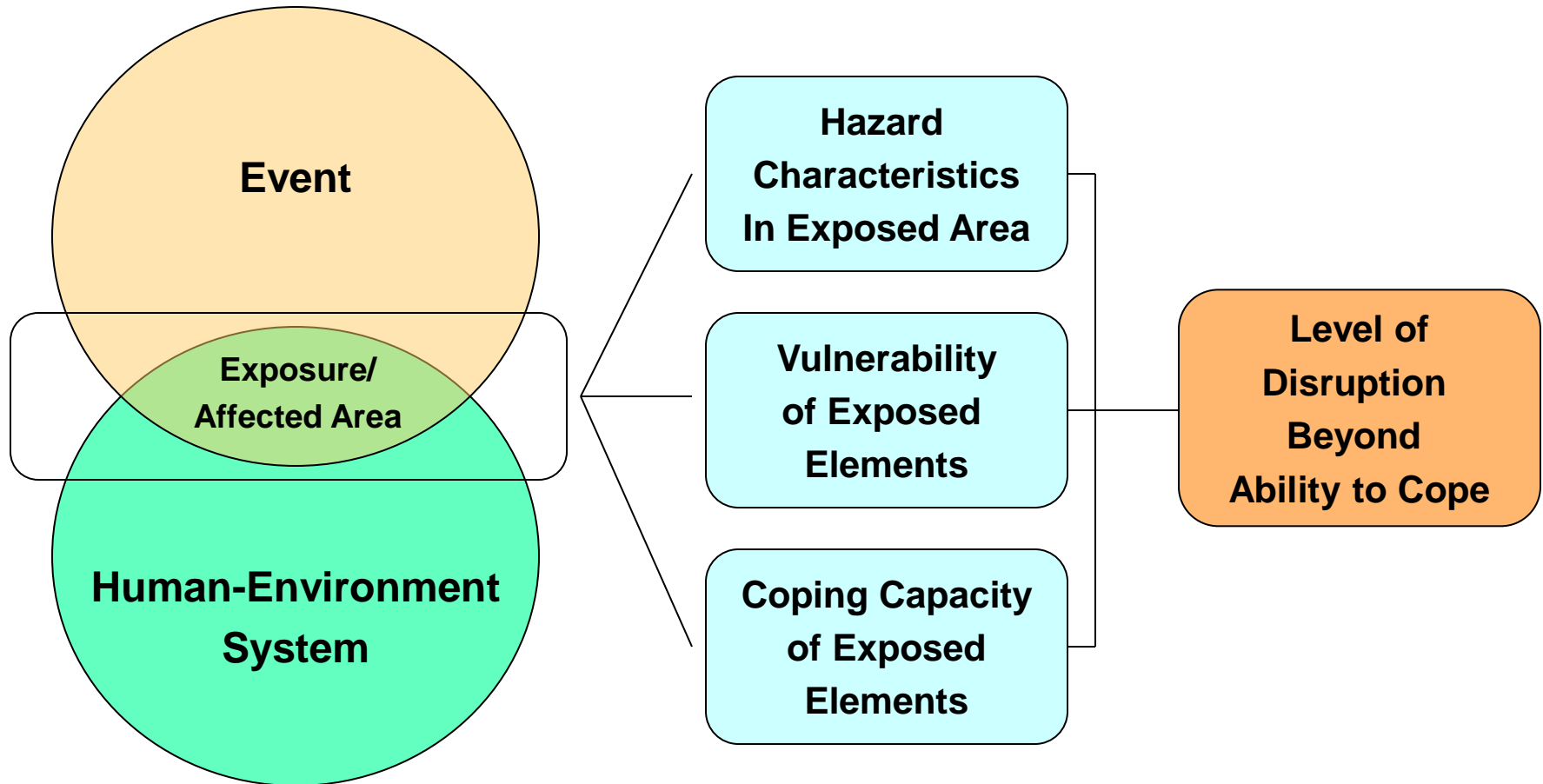
USAID
FROM THE AMERICAN PEOPLE

Understanding Disaster Risk*

The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.

The definition of disaster risk reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, disaster risks can be assessed and mapped, in broad terms at least.

Components of Disaster



Combining the Components

- Basic Loss Estimation for Physical Assets
- Loss Estimation for Communities Based on Assets
- Using Modeling and Simulation to Estimate Impacts and Losses
- Modeling Indirect Losses
- Assets and Consequence to Community
- Estimating and Describing Risk

Basic Loss Estimation for Physical Assets

- Scenario Based
- Physical Damage Relationships
- Monetary Damage Relationships

■ Table 5. Modified Repair Cost Ratio for All Bridges

Damage State	Best Mean Repair Cost Ratio	Range of Repair Cost Ratios
1: No damage (pre-yield)	0	0
2: Slight damage	0.03	0.01 to 0.03
3: Moderate damage	0.08	0.02 to 0.15
4: Extensive damage	0.25	0.10 to 0.40
5: Complete	See Equation 6	0.30 to 1.0

- Replacement Costs

Loss Estimation in American Samoa

County	Village	Name	Function	Number of Employees	Estimated Replacement Cost (\$)	Critical Facilities Ownership	Approx. Value Contents (\$)	1 st -Floor Flood Elevation (feet)
Lealataua	Leone	Leone High School	School/Shelter		\$1,960,000	Gov't.	\$1,960,000	53
Maoputasi	Fagaalu	KSBS Radio Station	Communications	10	\$384,000	Private	\$384,000	15
Maoputasi	Fagaalu	LBJ Tropical Medical	Hospital	500	\$18,836,193	Gov't.	\$28,254,289	17
Maoputasi	Fagatogo	ASG Gov't Bldgs.	Government		\$14,000,000	Gov't.	\$14,000,000	12.5
Maoputasi	Fagatogo	DPS Central Station	Police	230	\$770,414	Gov't.	\$1,155,621	8
Maoputasi	Fagatogo	DPS Fire Division	Fire	25	\$150,000	Gov't.	\$225,000	6
Tualauta	Tafuna	PPG Intl. Airport	Transportation	77	\$69,080,080	Gov't.	\$69,080,080	15.5

Estimating Community Losses Based on Impacts to Assets

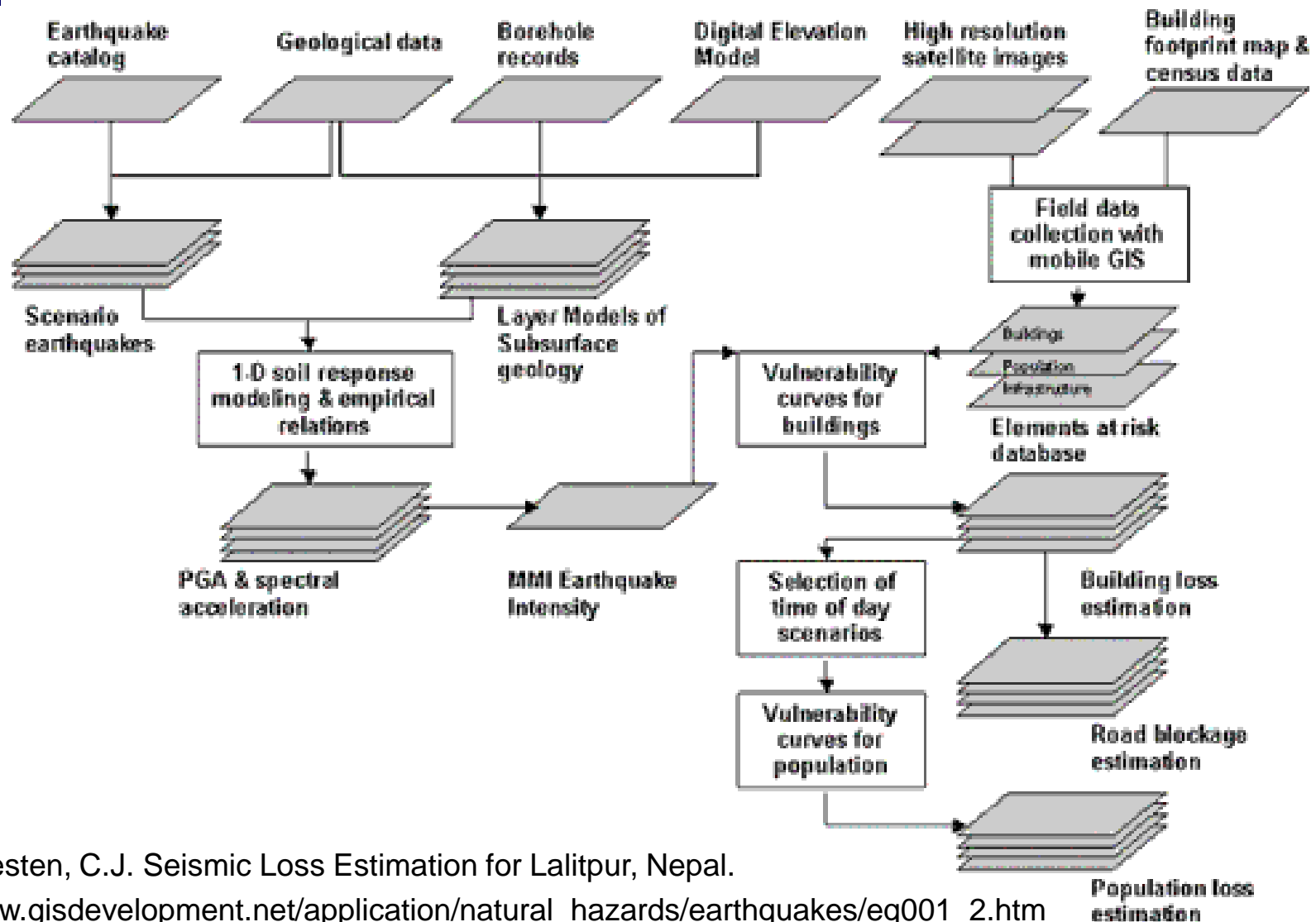
- Requires Building Inventory
- Map Hazard Characteristics
- Use Physical Fragility Curves to Estimate Damage to Structures
- Use Monetary Damage Curves and Cost Information to Estimate Monetary Losses
- Use Casualty Ratios Related to Occupancy and Physical Damage Estimates

Seismic Loss Estimation: Lalitpur, Nepal*

- Remote Sensing and Field Data Used to Generate Building Database
- SHAKE2000 software used to calculate hazard properties for 3 scenarios
- In GIS, Combined EQ MMI class maps and Building data using developed fragility curve
- Casualties estimated based on night and day occupancy estimates

* Van Westen, C.J. Seismic Loss Estimation for Lalitpur, Nepal.

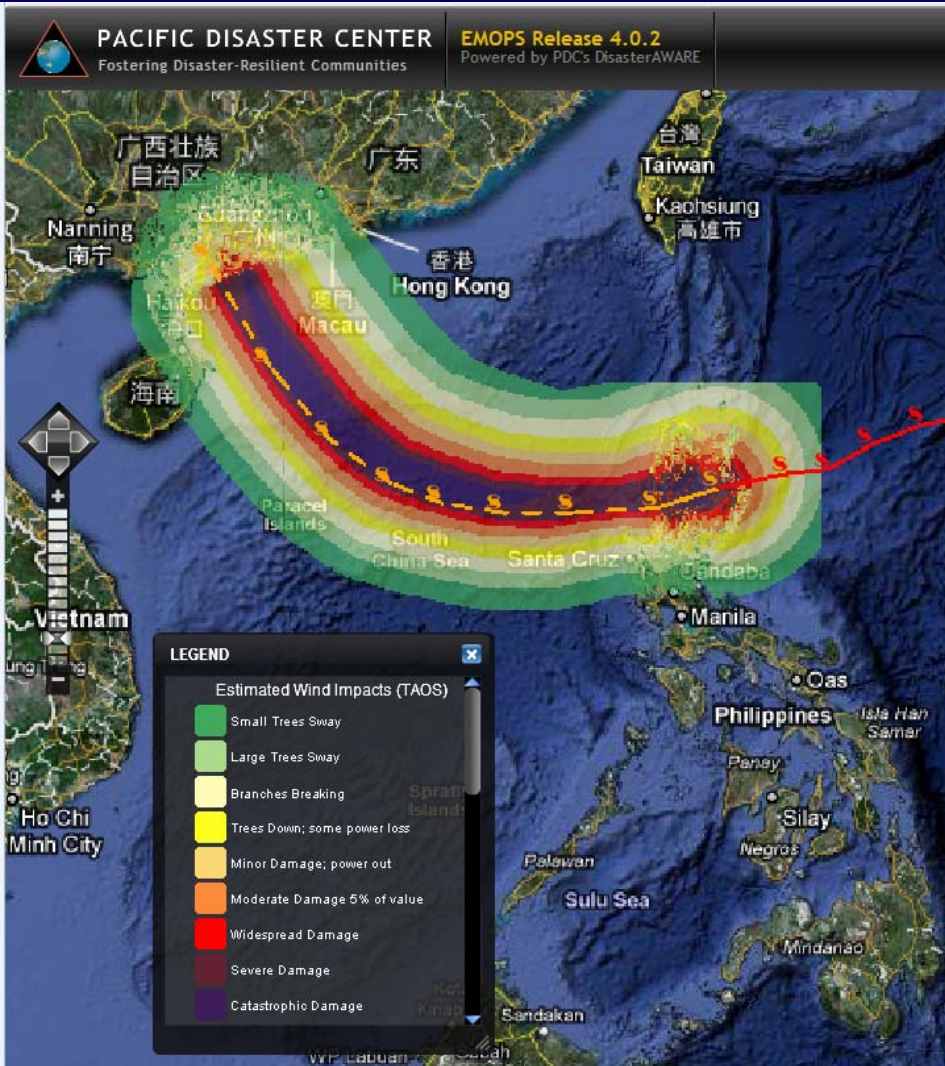
Seismic Loss Estimation: Lalitpur, Nepal*



* Van Westen, C.J. Seismic Loss Estimation for Lalitpur, Nepal.

http://www.gisdevelopment.net/application/natural_hazards/earthquakes/eq001_2.htm

Using Models to Estimate Impacts and Losses

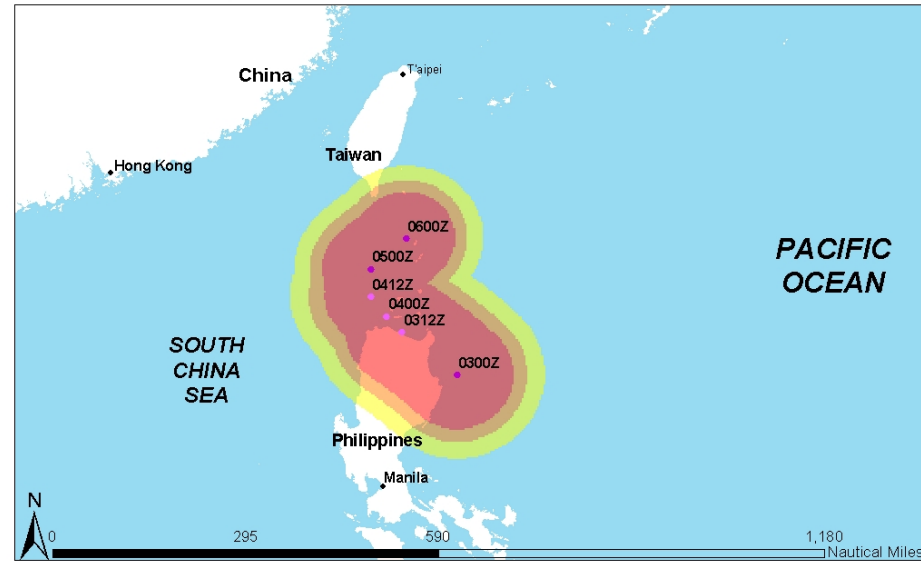
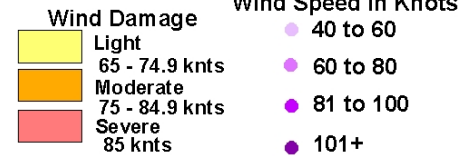


TYPHOON PARMA (19W)



CATS - Damage Prediction
Mobile Homes
(CONUS BUILDING CODE)

Based on JTWC Advisory 22
1700 HST (0300Z) FRI 10/02/2009

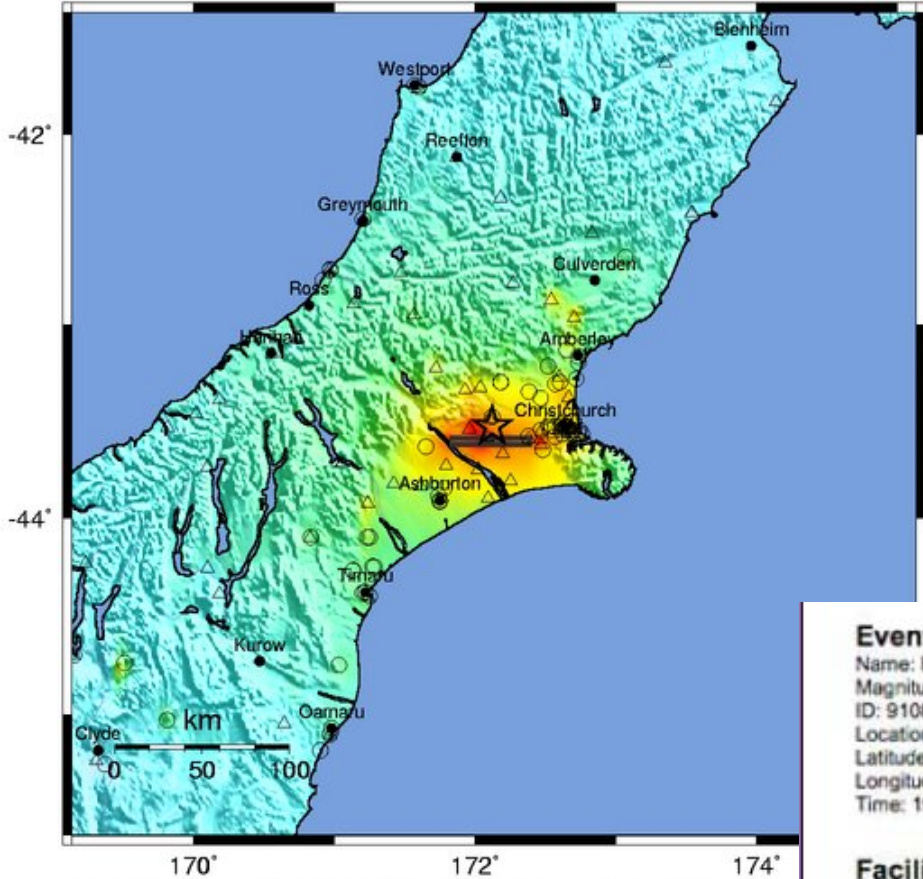


CATS

TAOS

USGS ShakeMap : SOUTH ISLAND OF NEW ZEALAND

Fri Sep 3, 2010 16:35:46 GMT M 7.0 S43.53 E172.12 Depth: 5.0km ID:2010atbj



Map Version 9 Processed Wed Sep 8, 2010 08:02:40 AM MDT – NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	V
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	H
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	6
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	6
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	



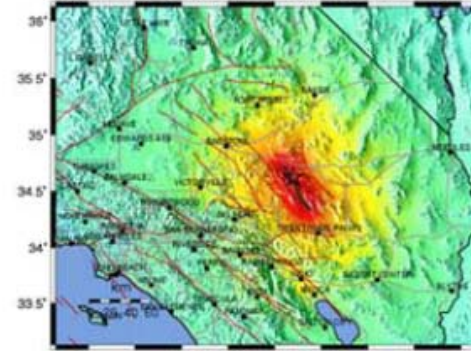
Caltrans ShakeCast Server
 <loren_tumer@dot.ca.gov>
 03/24/2006 09:41 AM

To: loren_tumer@dot.ca.gov
 cc:
 bcc:
 Subject: DAMAGE ASSESSMENT: Hector Mine, 7.1, (9108645_scte-1)

Caltrans ShakeCast Preliminary Earthquake Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by a Caltrans Engineer or Seismologist. Information about the epicenter, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an initial [ShakeMap](#) (unverified) and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from HAZUS and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.

CISN Rapid Instrumental Intensity Map for Hector Mine Earthquake
 Sat Oct 15, 1999 03:54:53 AM PDT M 7.1 N34.63 W116.36 Depth: 33.6km ID:9108645



Event Summary

Name: Hector Mine, Version 1
 Magnitude: 7.1
 ID: 9108645_scte
 Location: 33.8 mi N of Joshua Tree, CA
 Latitude: 34.626
 Longitude: -116.303
 Time: 1999-10-16 10:04:53

Estimated Bridge Damage Summary

Maximum Peak 1.0 sec Spectral Acceleration (PSA): 56.4714 (1/100 g)
 Maximum Acceleration: (not measured)
 Number of bridges evaluated: 7
RED: 2
YELLOW: 1
GREEN: 4

Facility Damage Estimates from ShakeMap

Bridges presented in the table below are sorted in order of potential damage level.

Bridge Name	Bridge No	Dist-Cty-Rte-PM	Damage Level	Value	Exceedance Ratio
Pisgah Overhead	54 0689L	08-SBD-040-R37.41	RED	47.6856	1.163
Pisgah Overhead	54 0689R	08-SBD-040-R37.44	RED	47.6856	1.163
Lavic Road OC	54 0734	08-SBD-040-R41.91	YELLOW	56.4714	0.867
Ash Hill Wash	54 0758L	08-SBD-040-R54.75	GREEN	25.5495	0.887
Ash Hill Wash	54 0758R	08-SBD-040-R54.77	GREEN	25.5495	0.887
Argos Wash	54 0737L	08-SBD-040-R43.84	GREEN	48.8524	0.053
Argos Wash	54 0737R	08-SBD-040-R43.84	GREEN	48.8524	0.053

ShakeMap and ShakeCast

Figure 3 – Email generated by ShakeCast

Using Models to Estimate Impacts and Losses

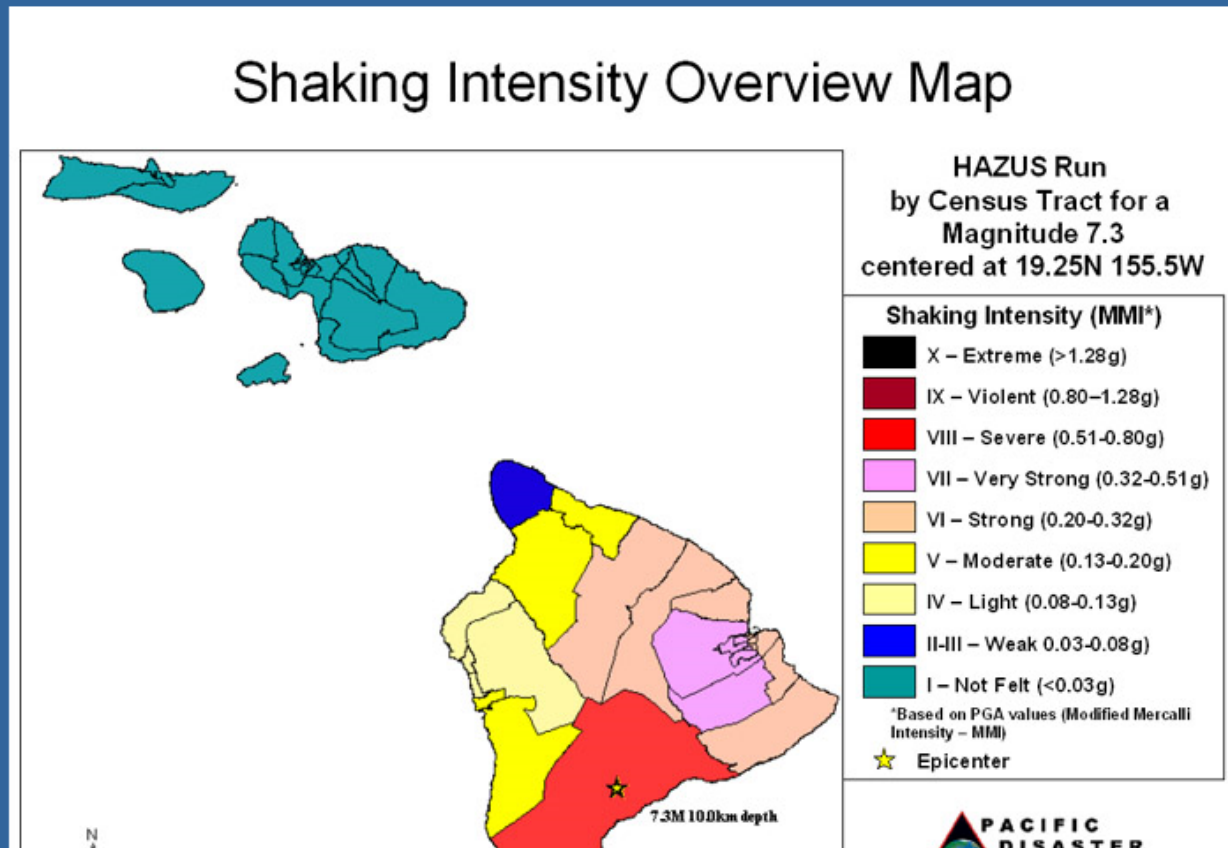
- Software Links Hazard Model to Asset and Population Inventory
- Software then Applies Damage Curves
- Some Apply Additional Financial, Casualty, and Indirect Loss Functions
- HAZUS-MH
 - Earthquake, Tropical Cyclone, Flooding
 - Developed by FEMA for US, but Is Beginning to Be Applied Elsewhere

Hawaii

HAZUS

Atlas

pdc.org/hha



Hospital Availability

Before the earthquake, the region had 833 hospital beds available for use.

- On the day of the earthquake, the model estimates that only 456 - 558 hospital beds (55% - 67%) are available for use by patients already in the hospital and those injured by the earthquake
- After one week, 63% - 76% of the beds will be back in service
- By 30 days, 78% - 89% will be operational



What Loss Estimation
Models Are in Use in Your
Area?

Assets and Consequences to Community

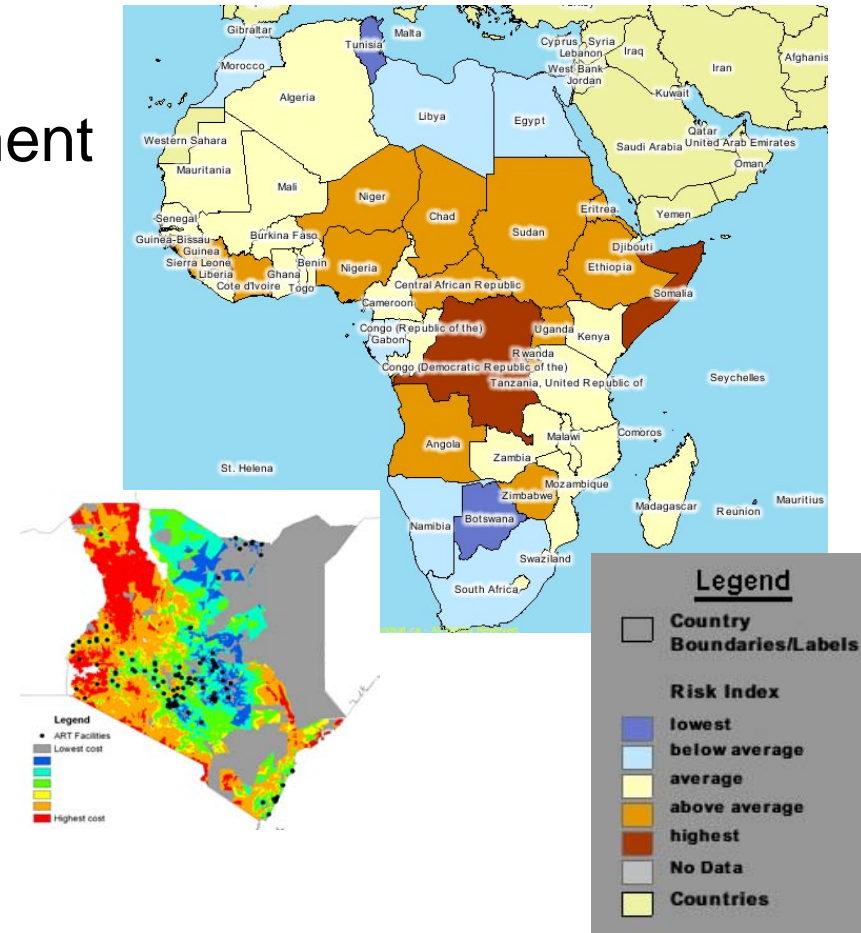
- In some calculations of risk to assets like critical infrastructure, consequence is considered part of the risk function.
- If a particular asset were damaged or lost, how badly would the surrounding community suffer?
- Losses are one aspect, but how do you represent the potential for broader disruption to society?

Estimating and Describing Community Risk

- Comparative Composite Indicator Approaches
 - National Level Example
 - Local Level Example
- Risk Profiles, or Community Profiles
 - Can Contain Results from a Variety of Vulnerability, Capacity, or Risk Assessments
 - Likely Contain Qualitative and Quantitative Information

Example 1: National Level Risk Assessment for Continent of Africa

- Project Overview
 - National Level Risk Assessment for Continent of Africa Using Publicly Available Data
 - Interactive Map Viewer
 - Demonstrate Applicability for Familiarization and Decision Making
 - Sub-National Analysis



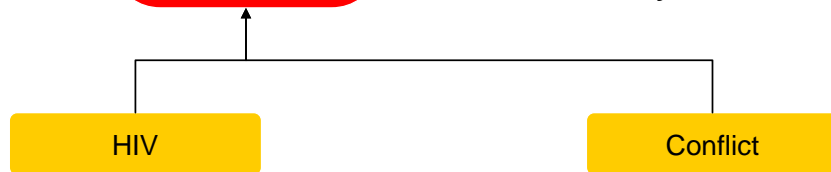
* Colvin, Peter, Heather M. Bell, Margaret Roth. 2009. *PDC Support of Humanitarian Assistance and Disaster Relief Information Needs in Africa*. PDC: Maui, Hawaii.

Assessment Approach

- Composite Index Relative to Africa
 - Three Components: Hazard; Vulnerability; Capacity
 - Vulnerability and Capacity Treated as Hazard Independent
 - Equally Weighted
 - Range from 0 to 1
 - Components Created from Sub-Indices
- Sub-Indices
 - Combination of Indicators
 - Indicator Values Scaled from 0 to 1

Assessment Approach

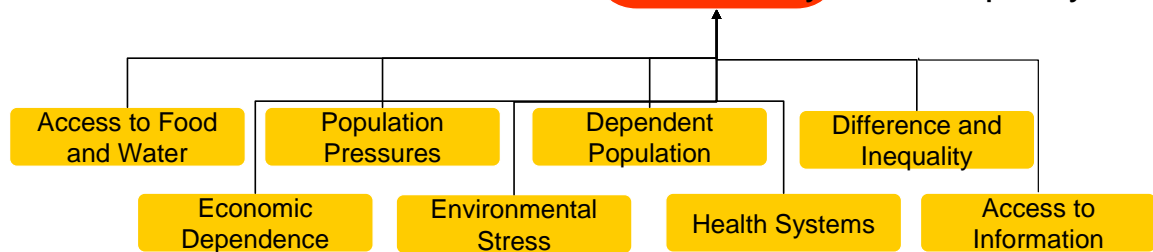
$$\text{RISK} = \text{Hazard} + \text{Vulnerability} - \text{Capacity}$$



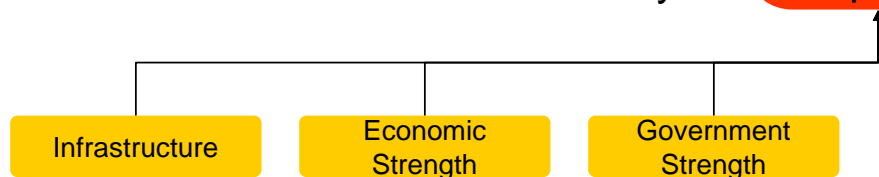
Hazard Is Modular, Includes Exposure and Specific Vulnerability And Capacity

Vulnerability and Capacity Components Are Hazard Independent

$$\text{RISK} = \text{Hazard} + \text{Vulnerability} - \text{Capacity}$$



$$\text{RISK} = \text{Hazard} + \text{Vulnerability} - \text{Capacity}$$



Composite Index Allows Drill Down into Drivers of Hazard, Exposure, Vulnerability, And Capacity

Indicators of Vulnerability

Access to Food and Water

% Undernourished

% Without Improved Water Source

Population Pressures

Urban Population Growth Rate

Population Growth Rate

Dependent Population

% Refugees & Internally Displaced

% Age Dependent (Over 65; Under 15)

Difference and Inequality

Secondary School Gender Ratio

Maximum Minority Discrimination

Economic Dependence

Debt (% of GDP)

Development Assistance (% GDP)

Trade Deficit (% of GDP)

Environmental Stress

% Forest Change

Freshwater Stress

Agricultural Density

Health Systems

Life Expectancy

Infant Mortality

Ratio of Physicians

% With Improved Sanitation

Health Expenditure (per capita)

Health Expenditure (% of GDP)

Access to Information

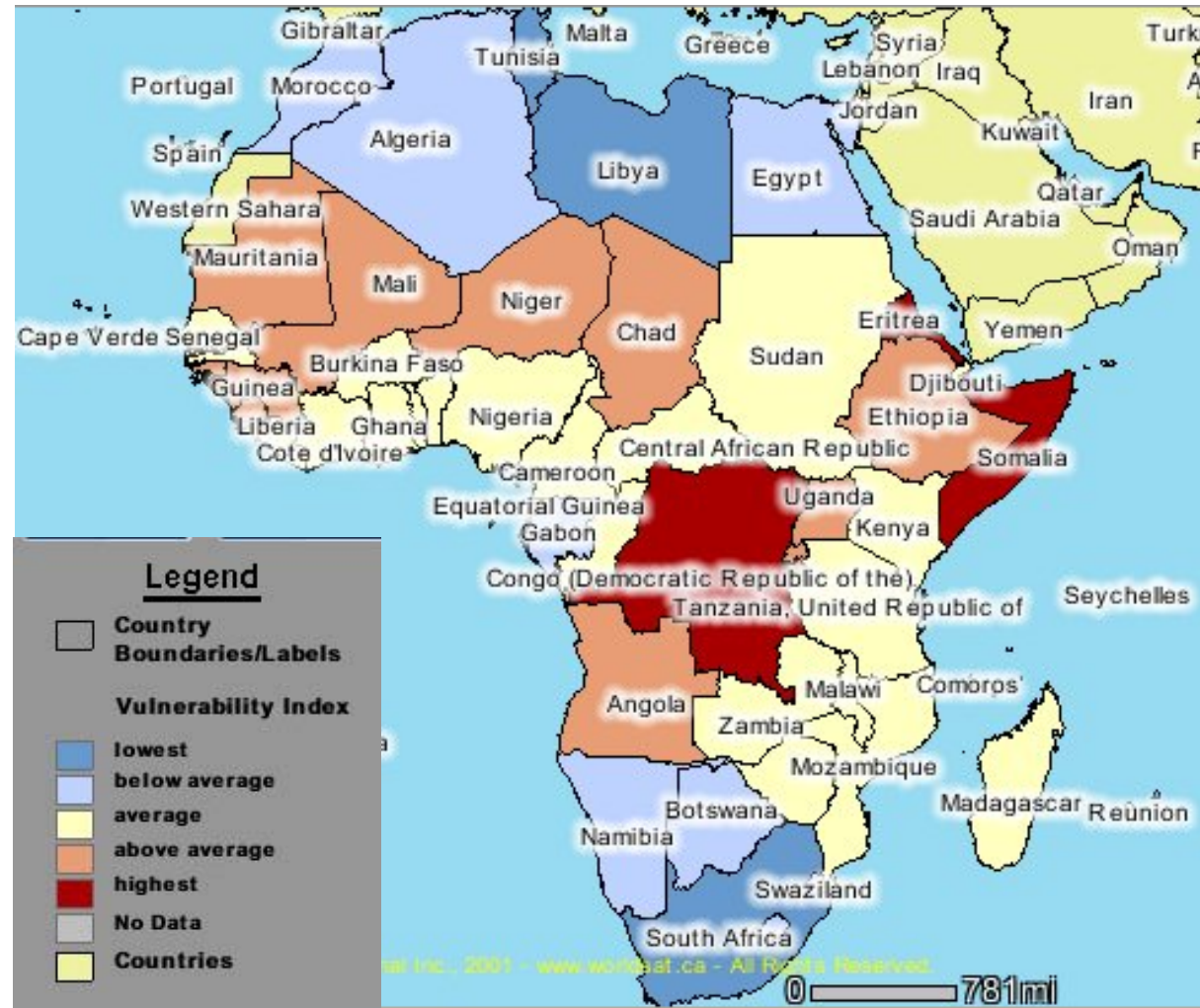
Adult Literacy Rate

Gross Enrollment Ratio

Internet Users

Representing Vulnerability

- Vulnerability Index
- Top Ten Countries:
 - Somalia
 - Eritrea
 - Congo (DRC)
 - Chad
 - Burundi
 - Sierra Leone
 - Ethiopia
 - Guinea-Bissau
 - Niger
 - Guinea



Sub-Indices and Indicators of Capacity

- Economic Strength
- Governance
- Infrastructure

Economic Strength

GDP per capita

Average
Growth of GDP

Governance

Voice and
Accountability

Government
Effectiveness

Control of Corruption

Political Stability

Rule of Law

Infrastructure

Telephone Mainlines
and Cell Subscribers

Road Density

Runway Density

Representing Capacity

■ Capacity Index

■ Top Eleven Countries:

- Mauritius
- Cape Verde
- Botswana
- Seychelles
- South Africa
- Tunisia
- Namibia
- Sao Tome and Principe
- Equatorial Guinea
- Morocco
- Ghana



Representing Capacity

- Mauritius
 - Higher Capacity in All Aspects
- Equatorial Guinea
 - Weak Governance, High Economic Strength
- Ghana
 - Strong Governance, Relatively Weak Infrastructure



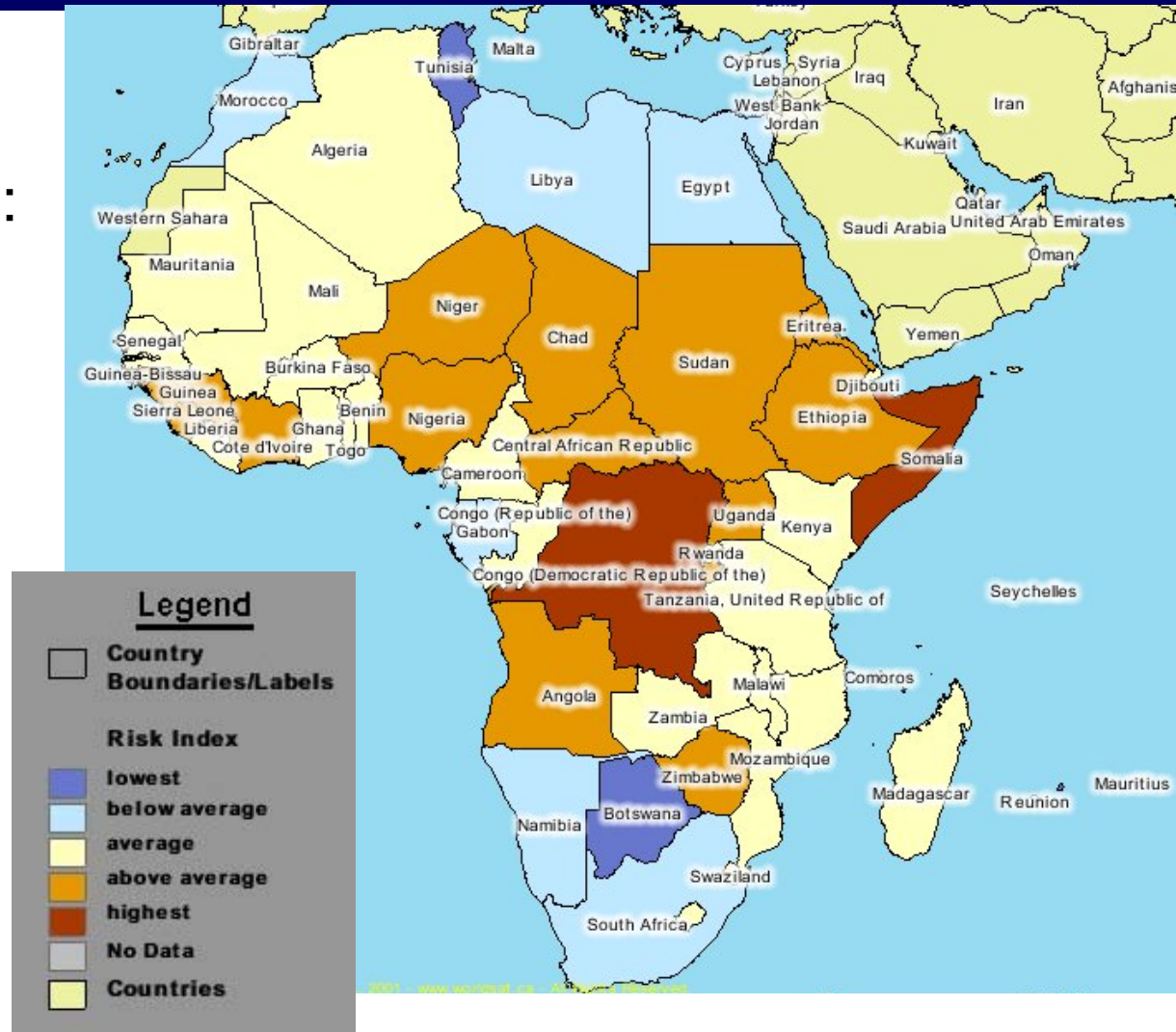
Top 10	Capacity		Governance		Infrastructure		Economic Strength	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Country	(Range 0-1)	(Rank x of 53)	(Range 0-1)	(Rank x of 53)	(Range 0-1)	(Rank x of 53)	(Range 0-1)	(Rank x of 53)
Mauritius	0.90	1	0.93	3	0.89	1	0.89	2
Cape Verde	0.76	2	0.94	1	0.78	2	0.56	7
Botswana	0.73	3	0.93	3	0.26	10	0.99	1
Seychelles	0.71	4	0.78	6	0.71	3	0.65	6
South Africa	0.61	5	0.83	5	0.51	6	0.49	8
Tunisia	0.55	6	0.64	8	0.36	7	0.66	5
Namibia	0.48	7	0.84	4	0.19	20	0.43	10
Sao Tome and Principe	0.46	8	0.57	13	0.70	4	0.11	32
Equatorial Guinea	0.39	9	0.15	45	0.24	13	0.80	3
Morocco	0.38	11	0.56	14	0.27	9	0.31	16
Ghana	0.38	11	0.72	7	0.14	32	0.28	17

RISK = Hazard + Vulnerability - Capacity

■ Risk Index

■ Top Ten Countries:

- Somalia
- Congo (DRC)
- Chad
- Sudan
- Burundi
- Ethiopia
- Angola
- Eritrea
- Sierra Leone
- Central African Republic



Viewer Example: Linking to Qualitative Information

Powered By **PACIFIC DISASTER CENTER** **Disaster Resilience Visualization and Assessment Tool II (DRVAT2)**

PDC Home Feedback Disclaimer Help Case Study

Tools
 DisasterAWARE
 Legend/Layers
 Overview
 Zoom In
 Zoom Out
 Full Extent
 Zoom Last
 Pan
 Identify
 Identify All
 Hyperlink
 Bookmark
 Print
 Regional Reporter

Legend
Atrocities 2007
 1 - 2
 3 - 4
 5
 5 - 13
 No Reported Data
 Countries

Kenya KEN

A

Event Type	Region	District	Locality	Number of Deaths	Weapon Types	Description	More
Incident		Turkana district	Nakambeit	5-24	Primitive Weapons	Twenty "Sudanesse livestock-raiders" crossed the border into Kenya and killed six people, including f...	see more
Incident	North		Moite	5-24	Unclear/Other	Livestock rustlers have killed at least 11 people in Kenya's remote north where clashes over scant r...	see more
Incident	Western		Matisi	5-24	Firearms	Armed robbers killed 10 people in an attack on a village in Kenya's western region on May 3, police ...	see more
Incident	Turkana Region		Lokwamosing	5-24	Firearms	Livestock raiders in a remote part of northwestern Kenya have killed 14 people, including eight chil...	see more
Incident			Athi River township	5-24	Firearms	Five blood-soaked bodies riddled with bullet holes were also found in a thicket near Athi River town...	see more

Atrocities 2007

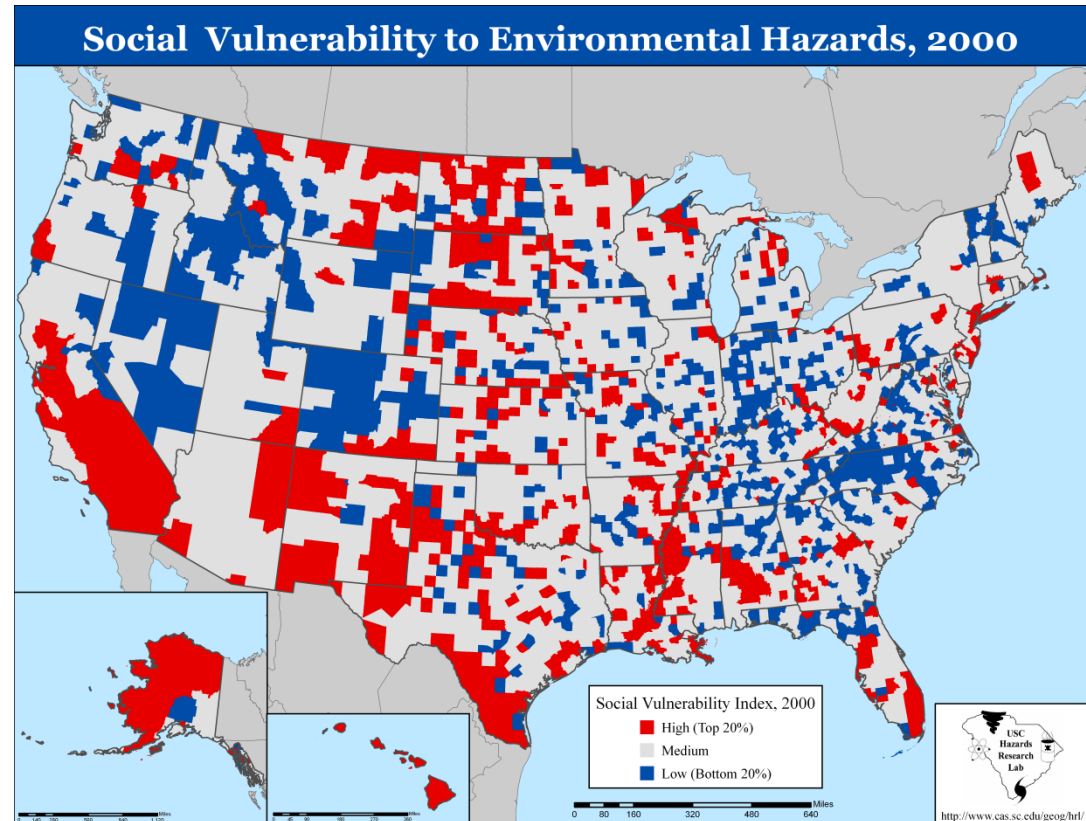
Rec	DATA LINK	ISO 3 DIGIT	COUNTRY NAME	NUMI
1	Click for Atrocities Report	KEN	Kenya	5

Example 2: Local Level Assessment of New Orleans

- Project Overview
 - Tract Level Assessment of Orleans Parish, Louisiana
 - Public Data
 - Combine with Event-Based Hazard Information
 - Validate against Recovery Measures
 - Demonstrate Applicability

Assessment Approach

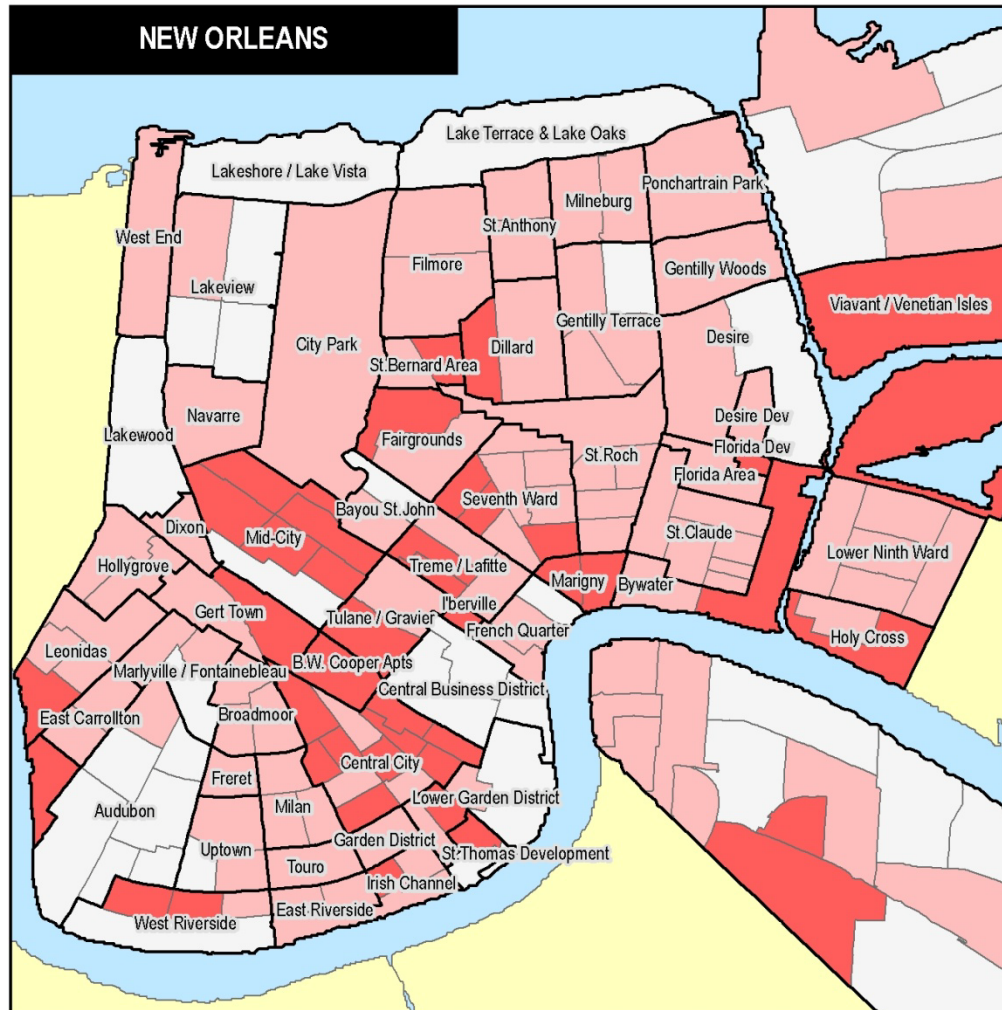
- Vulnerability Estimation Based on SoVI* Method
- Social Vulnerability Treated as Hazard Independent
- Relative Index
- Uses Principal Components
- Equal Weighting
- Additive



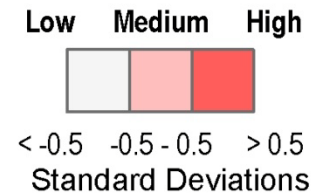
SoVI: Dimensions Captured

- Socioeconomic Status
- 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

New Orleans Social Vulnerability

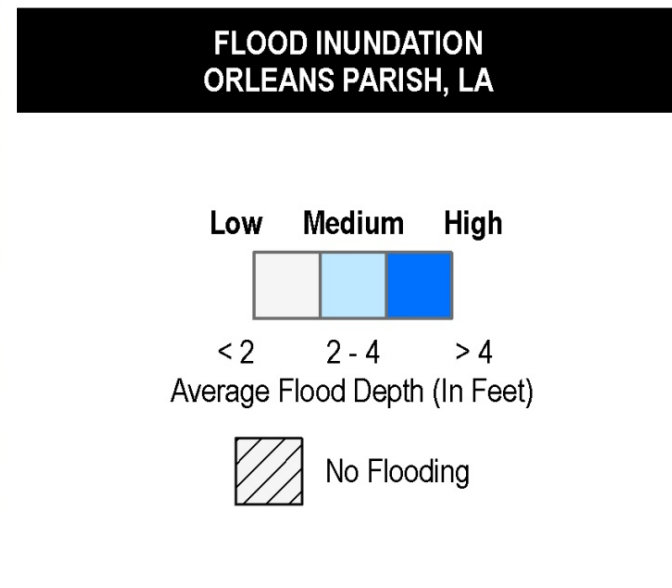
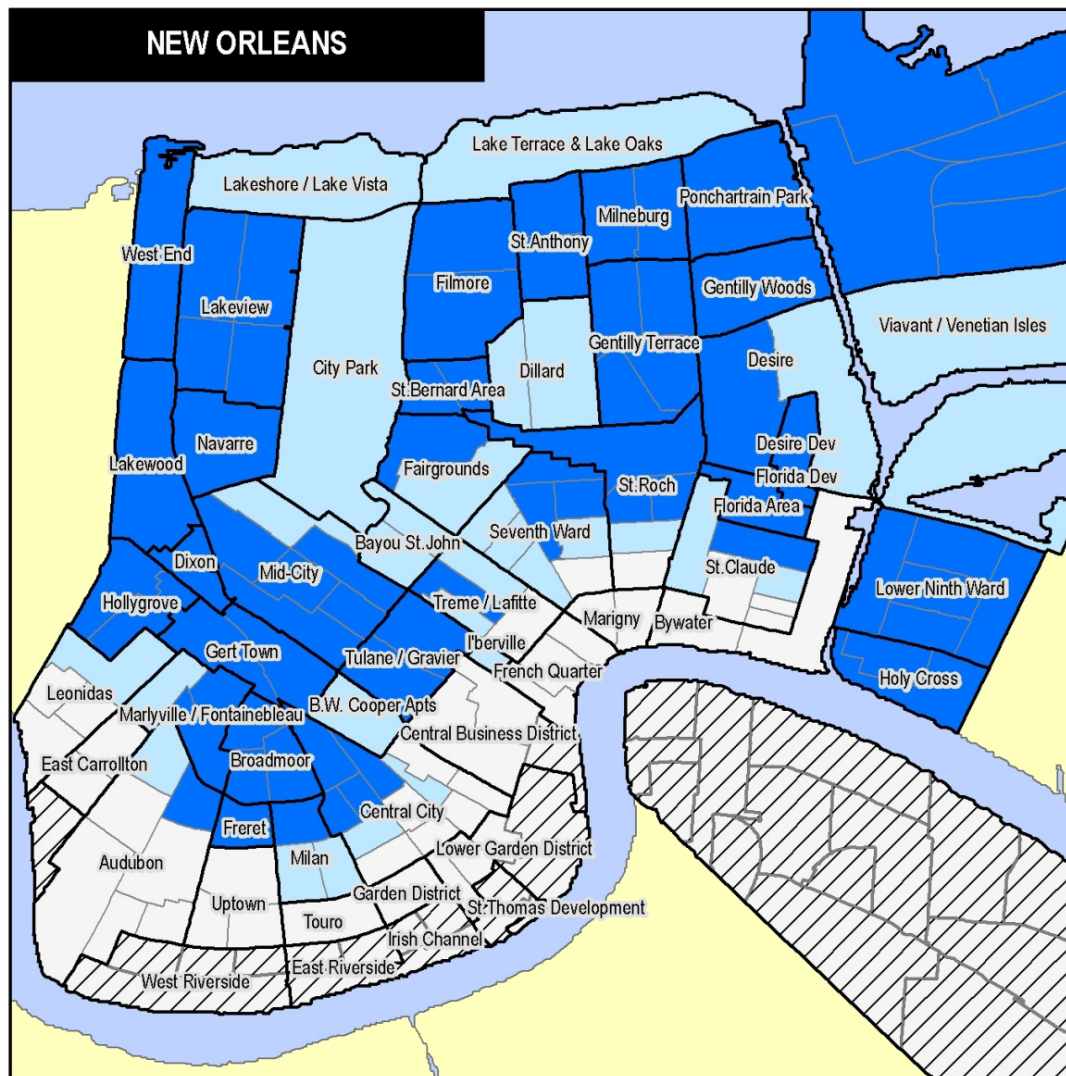


SOCIAL VULNERABILITY INDEX ORLEANS PARISH, LA

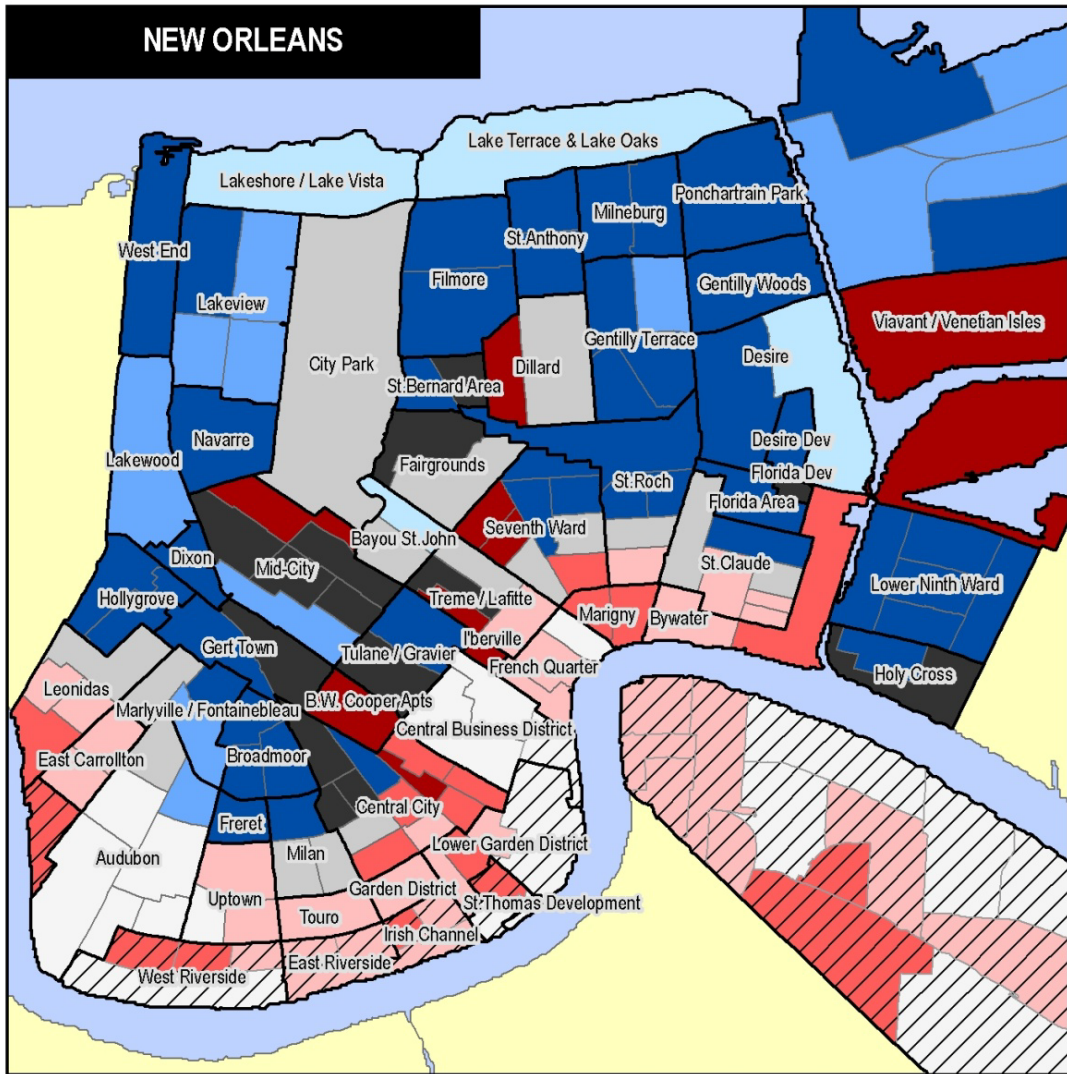


*Following slides from Finch, C., C. Emrich, and S. L. Cutter. 2010. Disaster Disparities and Differential Recovery in New Orleans. *Population and Environment*. DOI 10.1007/s11111-009-0099-8.

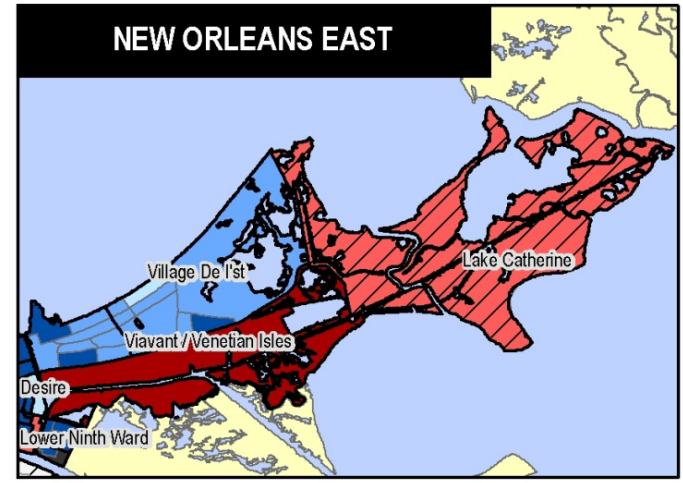
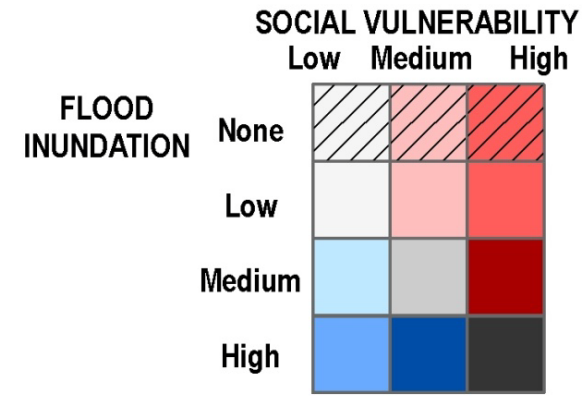
New Orleans Flooding during Katrina



Combining Hazard and Vulnerability



**VULNERABILITY & HAZARD
ORLEANS PARISH, LA**





QUESTIONS?



Group Activity

Acknowledgements

Estimating Loss, Impact and Risk

- **Contributing Authors**

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- **Published Source Materials**

- Pacific Disaster Center. 2010. Course materials developed for the Ministry of Agriculture and Rural Development (MARD) Natural Disaster Risk Management Project: Education and Training Program. Hanoi, Vietnam, March-May 2010.
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- Finch, C., C. Emrich, and S. L. Cutter. 2010. “Disaster Disparities and Differential Recovery in New Orleans.” *Population and Environment*. DOI 10.1007/s11111-009-0099-8
- Cutter, S.L., B.J. Boruff, and W.L. Shirley. 2003. “Social Vulnerability to Environmental Hazards.” *Social Sciences Quarterly*. 84(2): 242-261.