Socioeconomic data for climate change impacts, vulnerability and adaptation assessment

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Overview

1. Vulnerability definitions
2. Sample applications
   - Population and poverty and current hazards
   - Population and poverty and CC scenarios
3. Data needs for describing population vulnerability
4. Data needs for describing adaptive capacity
5. A proposed Climate Change IVA "collection"
6. Conclusions

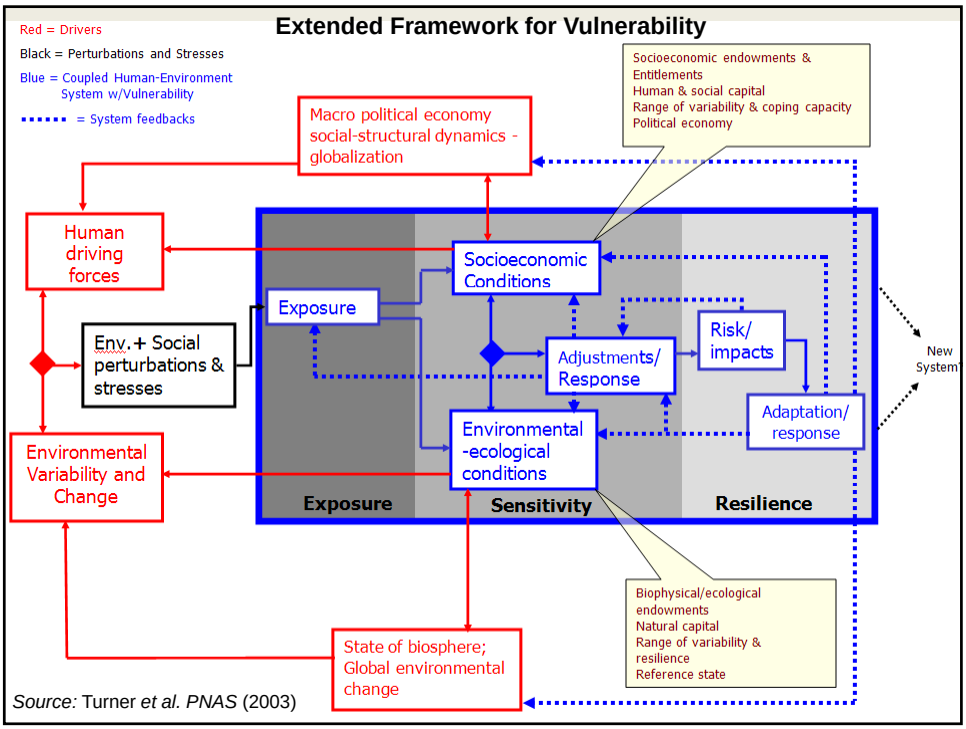
IPCC Working Group 2
Definition of Vulnerability

"Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."

Population's Vulnerability = f (E, S, A)

Where

- E = *exposure* — size of the area and/or population affected (does the event occur there?)
- S = *sensitivity* — the intrinsic (age, sex, SES, ethnicity, livelihood strategies, etc.) and extrinsic (institutions, entitlements, etc.) characteristics of a population
- A = *adaptive capacity* — capacities of the population, place or system to resist impacts, cope with losses, and/or regain functions

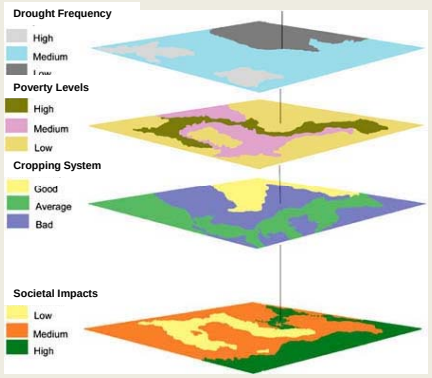


Source: Turner *et al. PNAS* (2003)

The Main Point

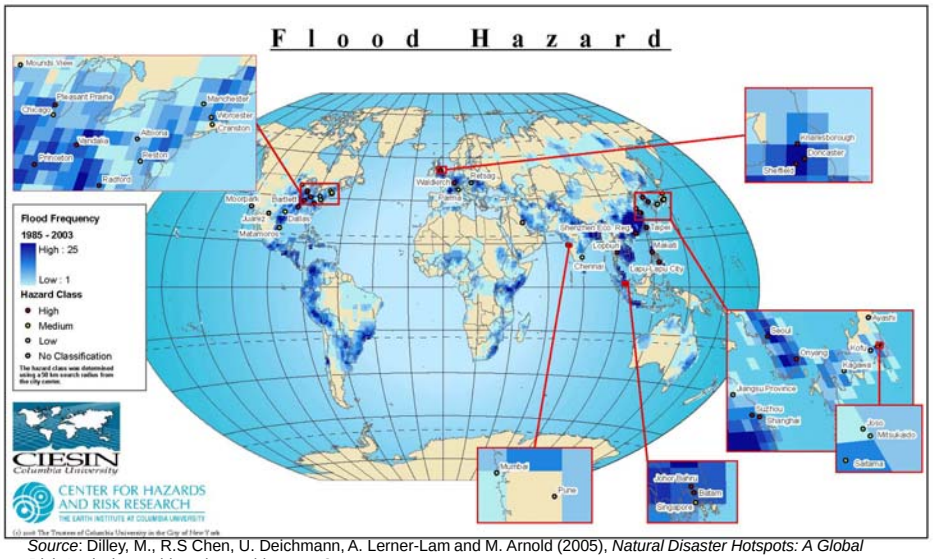
- Climate change impacts are **spatially** differentiated
- Vulnerabilities are **spatially** differentiated
- Adaptive/coping capacities are **spatially** differentiated

Georeferenced data on population, poverty, land use types, hazards, and climate change scenario outputs, together with ancillary biogeophysical data, can help us in our understanding of climate change impacts and vulnerability, and in turn inform where adaptation may be required



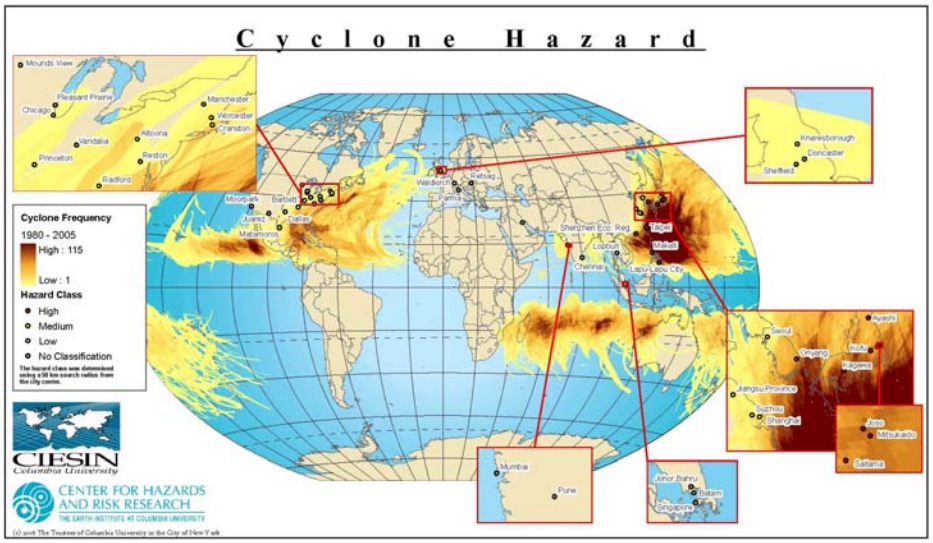
Exposure to Current Hazards as a Way of Understanding Potential Future Vulnerabilities to Climate Change

Exposure to Current Climate Hazards

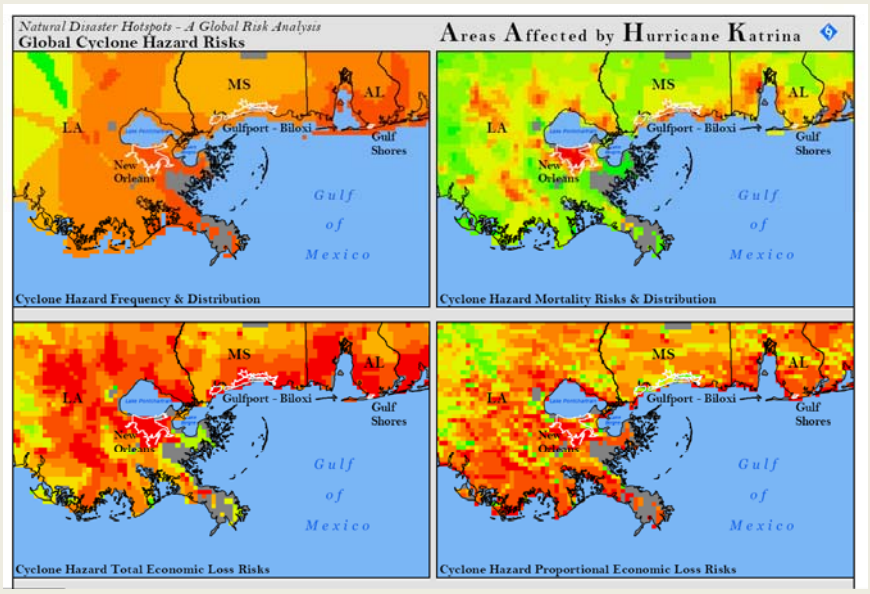


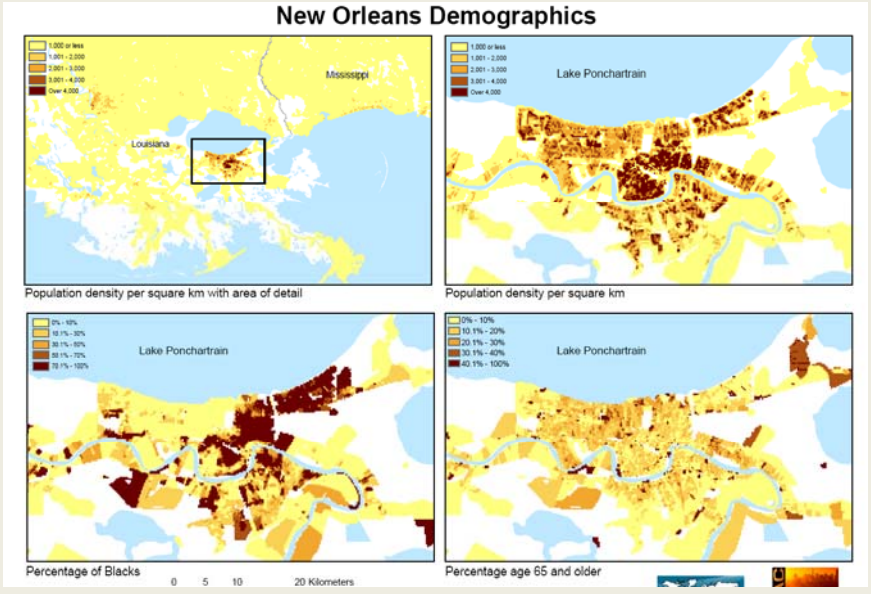
Source: Dilley, M., R.S Chen, U. Deichmann, A. Lerner-Lam and M. Arnold (2005), *Natural Disaster Hotspots: A Global Risk Analysis*, World Bank, Washington DC.

Exposure to Current Climate Hazards



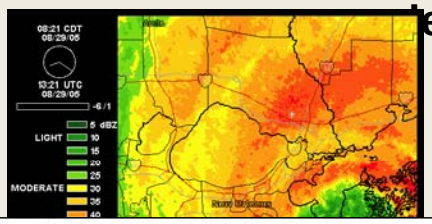
Source: Dilley, M., R.S Chen, U. Deichmann, A. Lerner-Lam and M. Arnold (2005), *Natural Disaster Hotspots: A Global Risk Analysis*, World Bank, Washington DC.

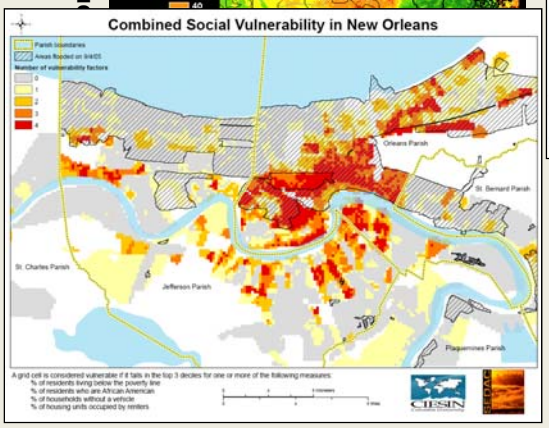

Natural Disaster Hotspots - A Global Risk Analysis
Global Cyclone Hazard Risks
Areas Affected by Hurricane Katrina
MS
AL
LA
Gulfport - Biloxi
Gulf Shores
New Orleans
Gulf of Mexico
Cyclone Hazard Frequency & Distribution
Cyclone Hazard Mortality Risks & Distribution
Cyclone Hazard Total Economic Loss Risks
Cyclone Hazard Proportional Economic Loss Risks


New Orleans Demographics
Mississippi
Louisiana
Lake Ponchartrain
Population density per square km with area of detail
Population density per square km
Percentage of Blacks
Percentage age 65 and older
0 5 10 20 Kilometers

Integrating data to assess vulnerability: An e

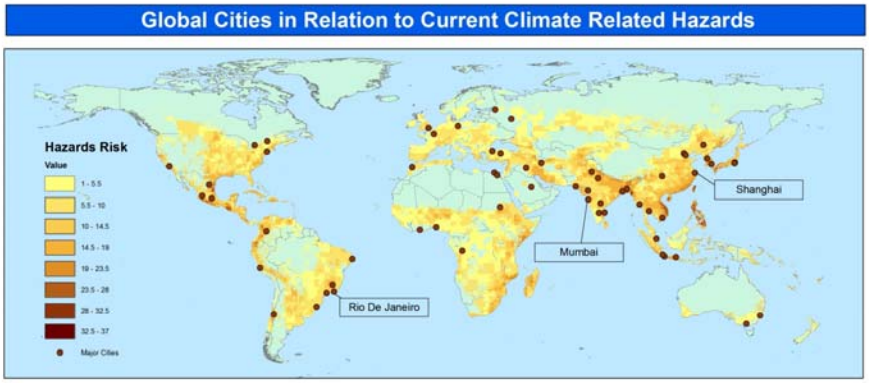
nmental Hazard





Exposure (location) and **sensitivity** (individual, household and community characteristics)

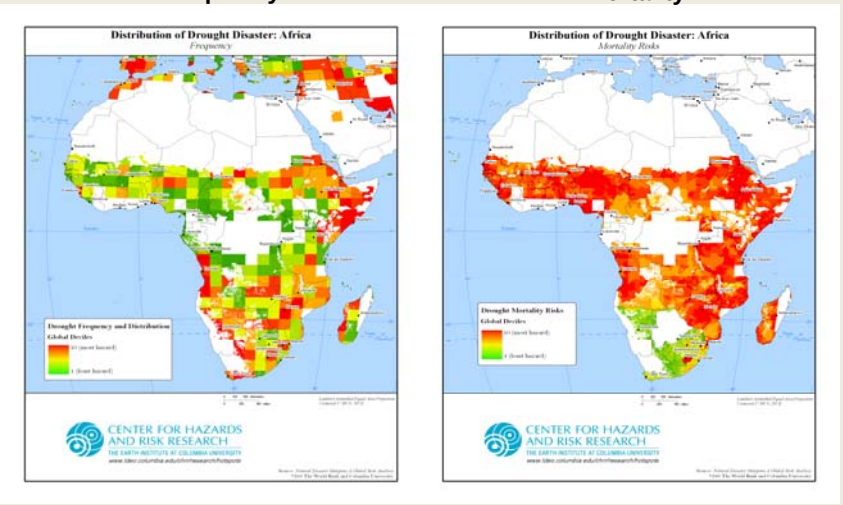
Exposure to hazards

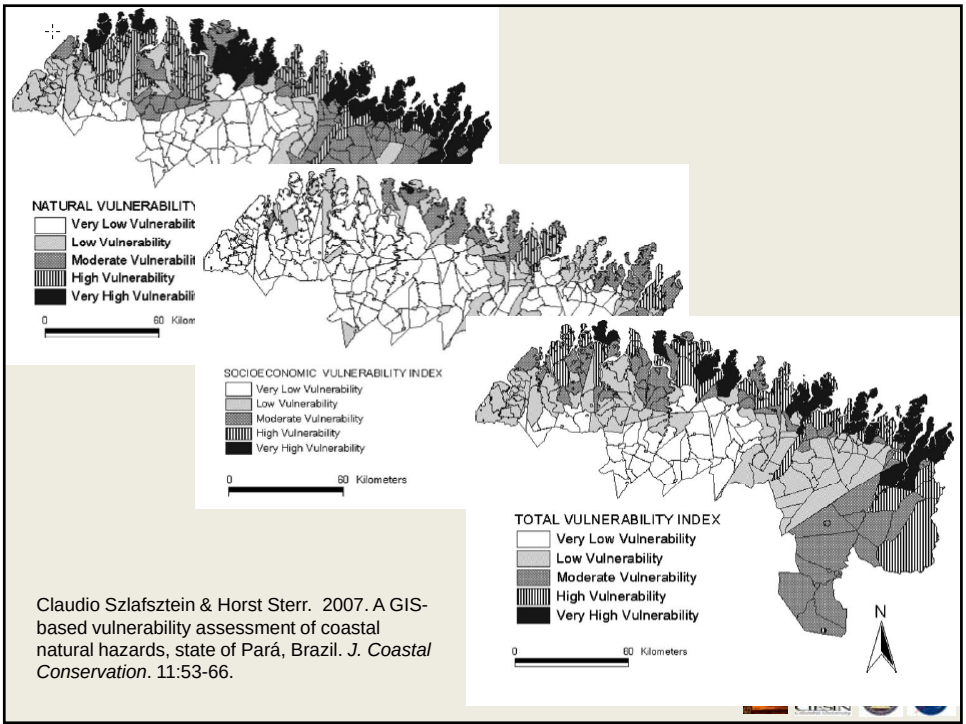


Hazard risk represents a cumulative score based on risk of cyclones, flooding, landslides and drought. *Source*: de Sherbinin *et al.* (2007). The vulnerability of global cities to climate hazards. *Environment & Urbanization.* 19(1): 39-64.

Vulnerability to Drought: Exposure + Sensitivity

Frequency **Mortality**





Claudio Szlafsztein & Horst Sterr. 2007. A GIS-based vulnerability assessment of coastal natural hazards, state of Pará, Brazil. *J. Coastal Conservation*. 11:53-66.

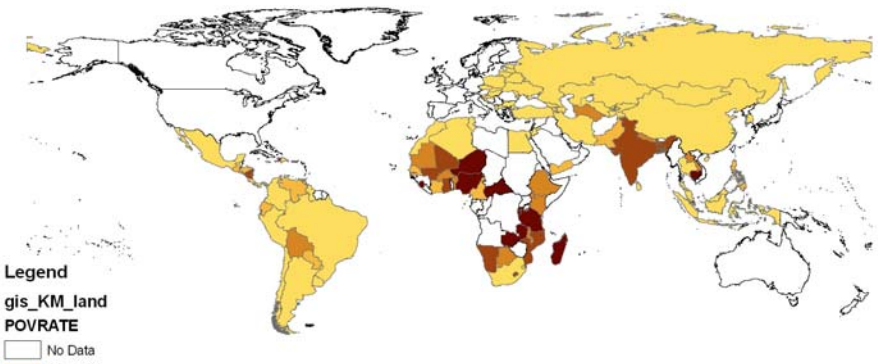
Poverty as a proxy for vulnerability

- Poverty refers to lack of physical requirements, assets and income; while vulnerability focuses on the exposure to shocks, stress and risks, and on the lack of means to face the damage or loss.
- Poverty is a relatively static, unidimensional concept, while vulnerability is more dynamic, multi-dimensional, and a better concept for measuring change.
- Poverty contributes to vulnerability through three mechanisms: (a) the narrowing of coping and resistance strategies, (b) the loss of diversification and the restriction of entitlements, and (c) the lack of empowerment.

Difficult to measure vulnerability at global/regional level

- Very place-specific and multi-dimensional
- Internal or intrinsic vulnerability a function of:
  - Socioeconomic status
  - Household characteristics
  - Gender and age
  - Social networks
  - Historic inequalities
  - Institutional inequalities
  - Building codes
  - National or local preparedness (e.g. early warning systems)

National Poverty Rate



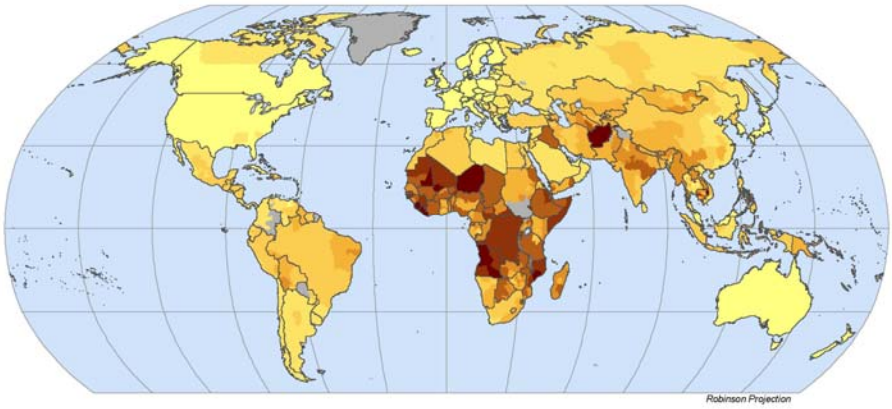
Legend

gis_KM_land

POVRATE

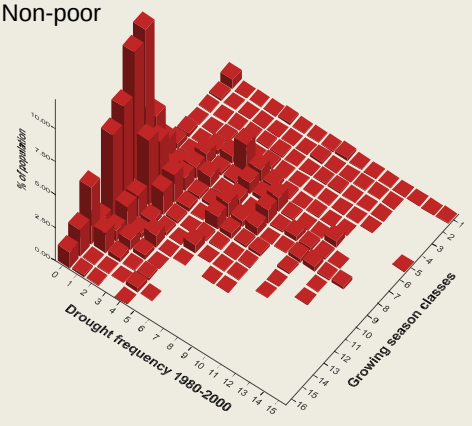
- No Data
- 0.1 - 10.8
- 10.9 - 19.0
- 19.1 - 30.9
- 31.0 - 45.1
- 45.2 - 70.8
- km_gis

percentage of the population having per capita consumption of less than $1.08 a day

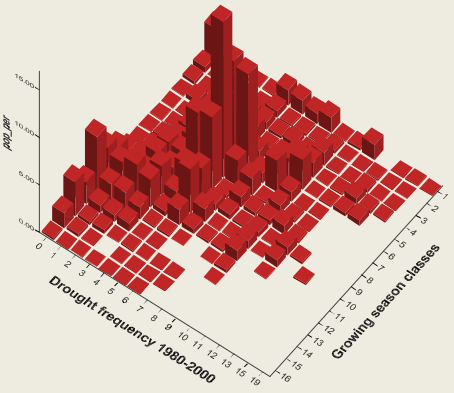


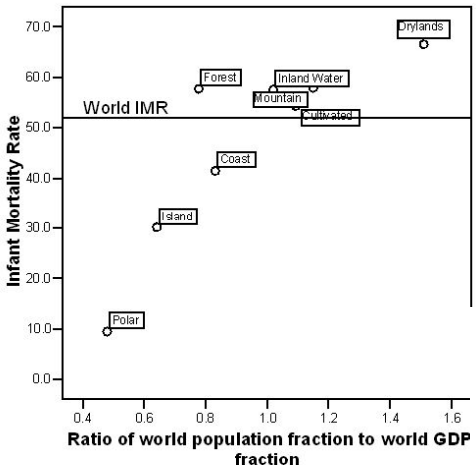
Compared with the non-poor, poor people are more likely to be found in drought-prone areas with shorter growing seasons

Non-poor



Poor





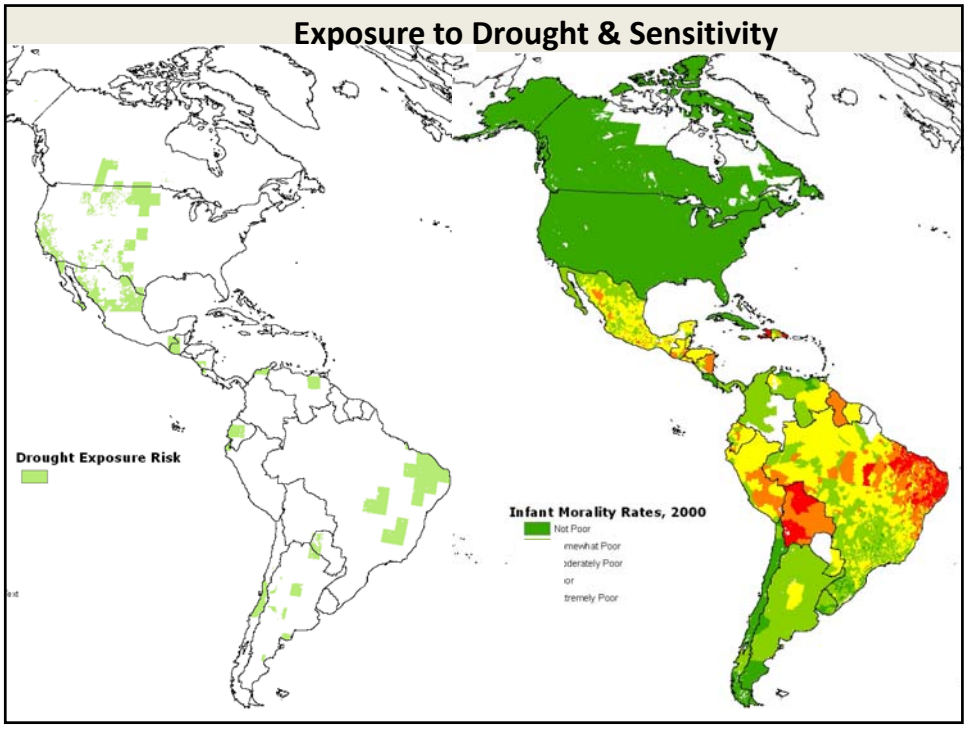
For the Millennium Ecosystem Assessment CIESIN calculated average IMR within each MA ecosystem. We also calculated another measure of well-being, the ratio of the share of world population to share of world GDP. The drylands are the most disadvantaged. We further calculated rates of population growth within each ecosystem unit, and noted that the drylands had the highest rate of growth. To have fragile ecosystems with low levels of well-being experience the highest population growth is bound to make challenges more difficult in these regions.

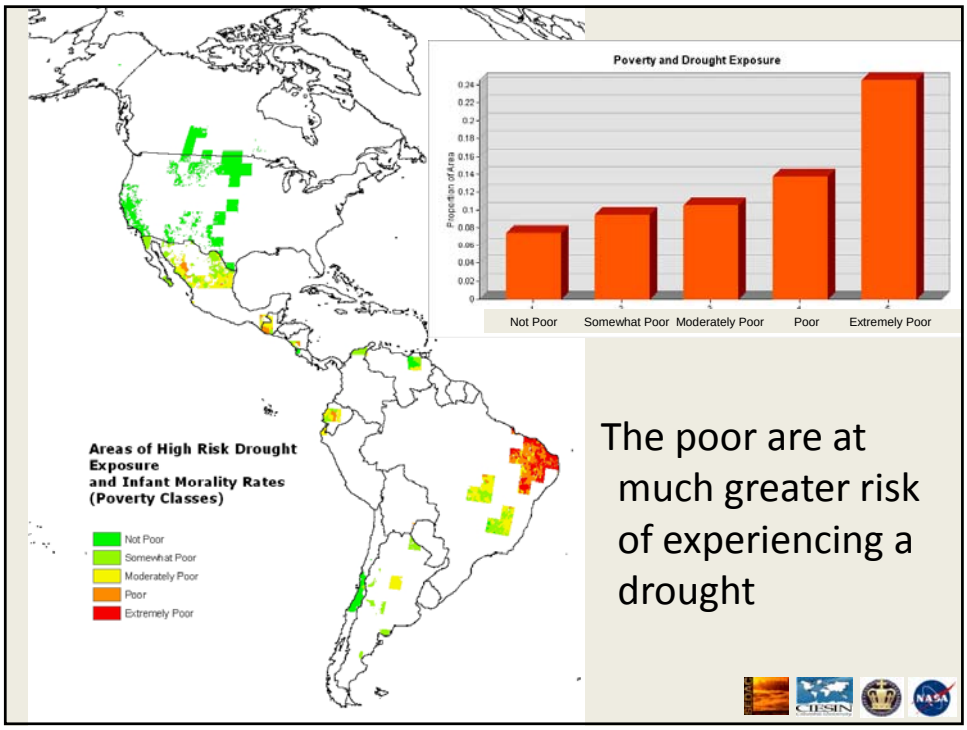
Table 5.2. Population Growth within MA Systems, 1990–2000

System	Change in Population (million)	Net Change in Population (percent)	Change in Population per Square Kilometer
Cultivated	505.7	14.1	14.3
Dryland	329.6	18.5	5.5
Inland Water	203.5	17.0	7.0
Mountain	171.0	16.3	5.4
Forest	142.1	13.5	3.4
Coastal	140.3	15.9	23.3
Island	67.0	12.3	9.5
Polar	–117.9	–6.5	0.0

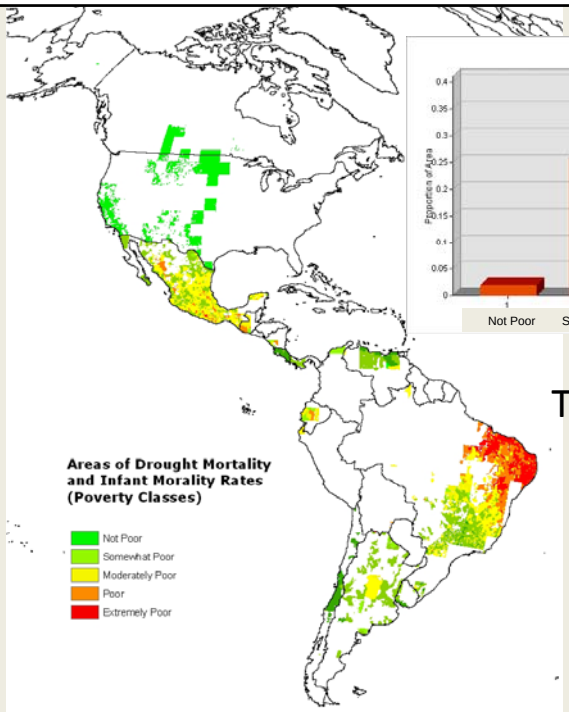
Millennium Ecosystem Assessment, 2005

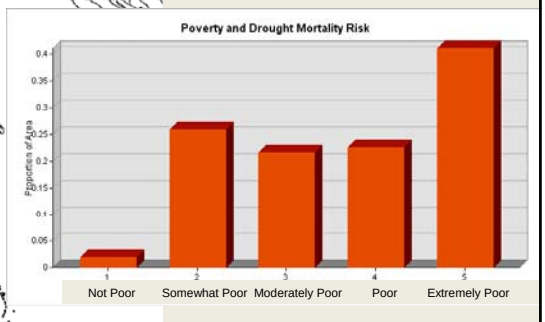
Exposure to Drought & Sensitivity





The poor are at much greater risk of experiencing a drought

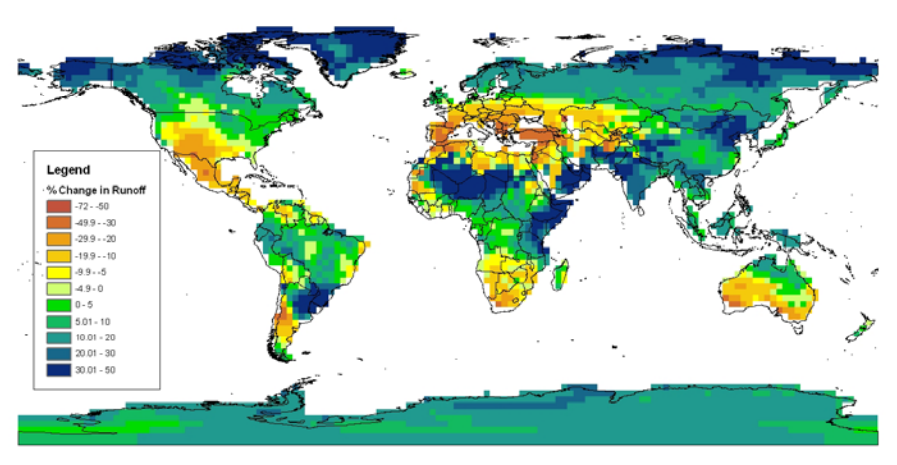




The poor are also much more vulnerable to drought

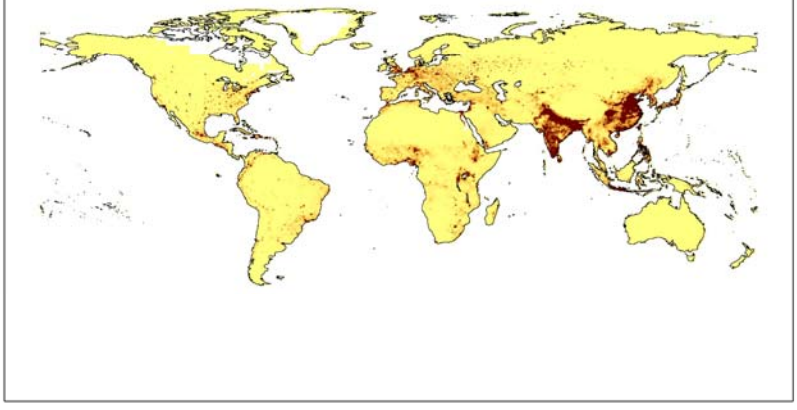
Potential Future Vulnerabilities to Climate Change and Data Needs

Change in Runoff by 2080

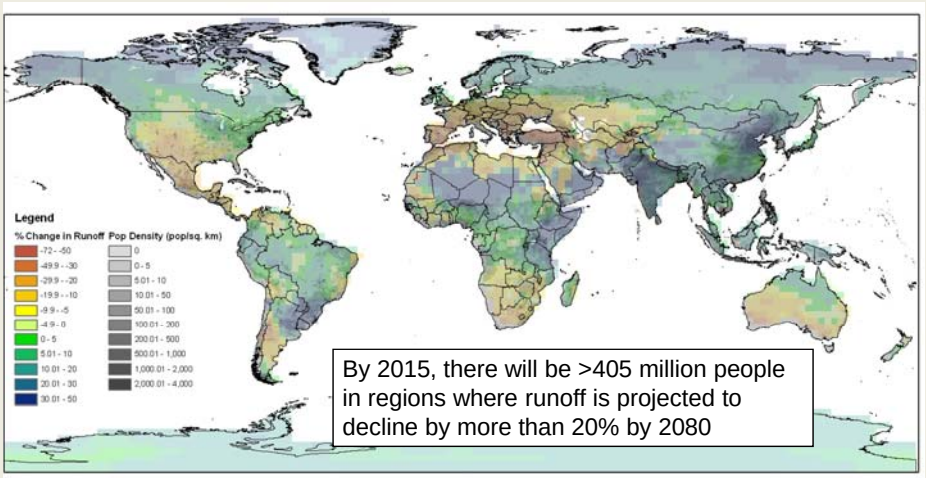


Source: Nohara et al.(2006). Impact of climate change on river runoff. *Journal of Hydrometeorology*. 7: 1076-1089, cited in the IPCC AR4 WG-2 report.

Knowing where people are…

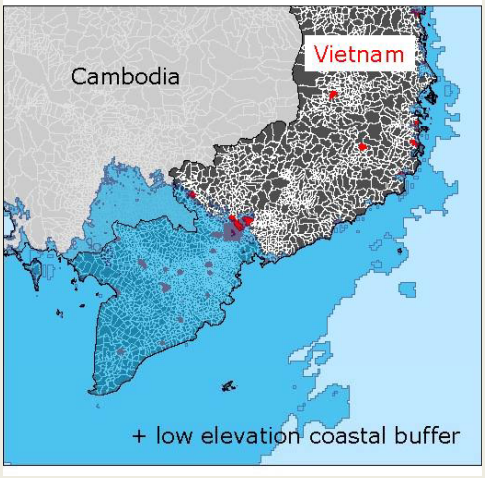


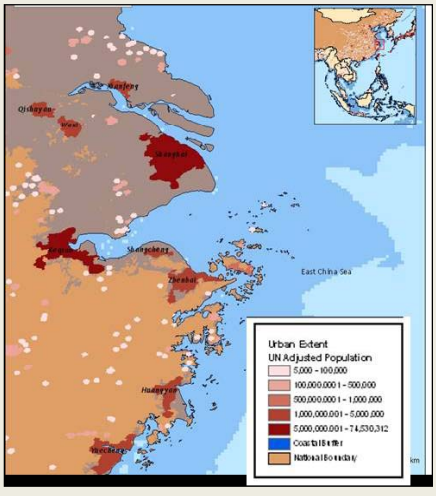
…in relation to prolonged drying, drought, and floods



Source: Adamo and de Sherbinin (forthcoming). The impact of climate change on the spatial distribution of populations and migration. Proceedings of the Expert Group Meeting on Migration, UN Population Division, January 2008.

Knowing where people and cities are in relation to sea level rise of 10 meters





Source: Balk, D., G. McGranahan, and B. Anderson. 2006. *Population and Land Area in Distribution in Urban Coastal Zones A Systematic Assessment.* Earth System Science Partnership Open Science Meeting, Nov 2006, Beijing.

Differences in population in the low elevation coastal zone (LECZ) by Region

Region	Total Population		Urban population	
	(10^6)	(%)	(10^6)	(%)
Africa	56	7%	31	12%
Asia	466	13%	238	18%
Europe	50	7%	40	8%
Latin America	29	6%	23	7%
Australia & N. Z.	3	13%	3	13%
North America	24	8%	21	8%
SIS	6	13%	4	13%
World	**634**	**10%**	**360**	**13%**

Differences in land area in the LECZ by Region

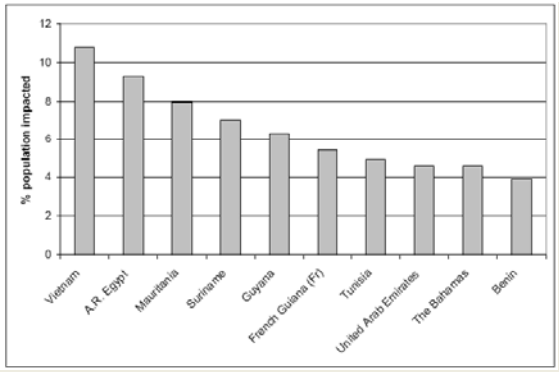
Region	Total Land		Urban Land	
	(10^3 km^2)	(%)	(10^3 km^2)	(%)
Africa	191	1%	15	7%
Asia	881	3%	113	12%
Europe	490	2%	56	7%
Latin America	397	2%	33	7%
Australia & N. Z.	131	2%	6	13%
North America	553	3%	52	6%
SIS	58	16%	5	13%
World	**2,700**	**2%**	**279**	**8%**

Which country has the greatest share of its population living in the LECZ?

	Countries ranked by share of their population in the LECZ			
	Country	Rank[1]	Population in LECZ	% of Pop in LECZ
1	Bahamas	172	266,580	88%
2	Suriname	168	317,683	76%
3	Netherlands	58	11,716,861	74%
4	Vietnam	13	43,050,593	55%
5	Guyana	155	415,456	55%
6	Bangladesh	8	62,524,048	46%
7	Belize	177	91,268	40%
8	Djibouti	158	248,394	39%
9	Gambia	148	510,159	39%
10	Egypt	16	25,655,481	38%

Indicators	World	LA	MENA	SSA	EA	SA
	1m SLR					
Area	0.31	0.34	0.25	0.12	0.52	0.29
Population	1.28	0.57	3.20	0.45	1.97	0.45
GDP	1.30	0.54	1.49	0.23	2.09	0.55
Urban extent	1.02	0.61	1.94	0.39	1.71	0.33
Ag. extent	0.39	0.33	1.15	0.04	0.83	0.11
Wetlands	1.86	1.35	3.32	1.11	2.67	1.59
	5m SLR					
Area	1.21	1.24	0.63	0.48	2.30	1.65
Population	5.57	2.69	7.49	2.38	8.63	3.02
GDP	6.05	2.38	3.91	1.42	10.2	2.85
Urban extent	4.68	3.03	4.94	2.24	8.99	2.72
Ag. extent	2.10	1.76	3.23	0.38	4.19	1.16
Wetlands	7.30	6.57	7.09	4.70	9.57	7.94

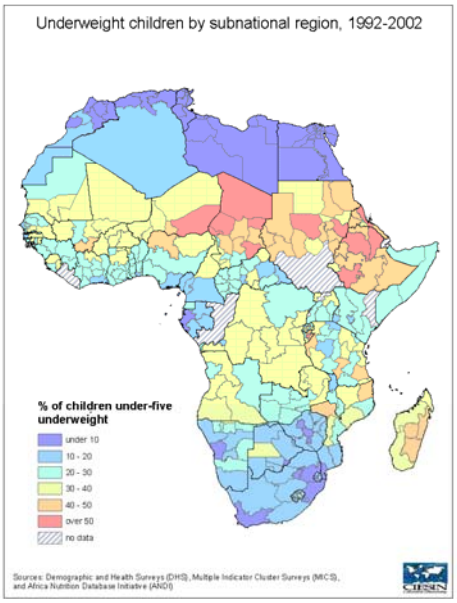
LA: Latin America and Caribbean; MENA: Middle East and North Africa; SSA: Sub-Saharan Africa; EA: East Asia; SA: South Asia.

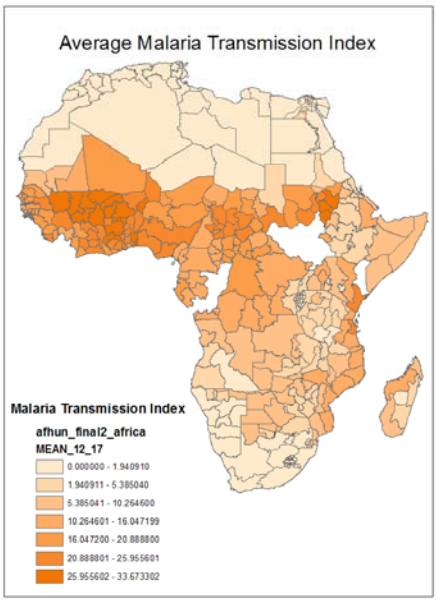


Varying levels of sea level rise can be assessed

Source: Dasgupta *et al.* (2007). "The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis" *World Bank Working Paper No. 4136*

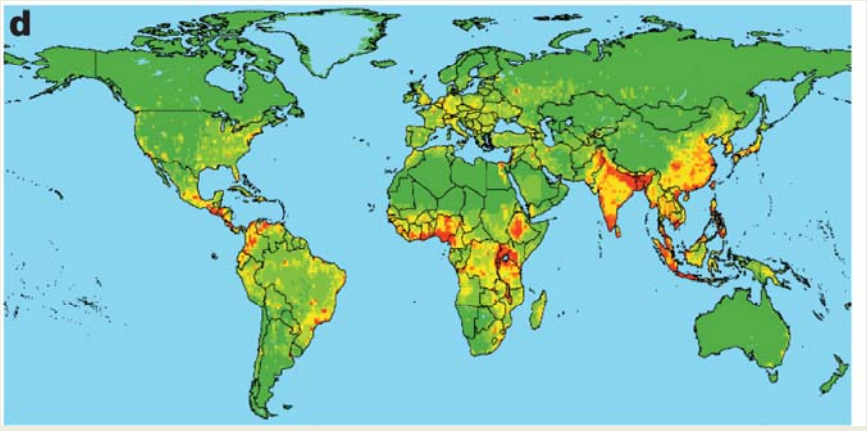
Climate Change Health Impacts





Source: de Sherbinin. (2005) "Covariates of Malnutrition in Africa," 2005 Open Meeting

Relative risk of a vector-borne emerging infectious disease outbreak

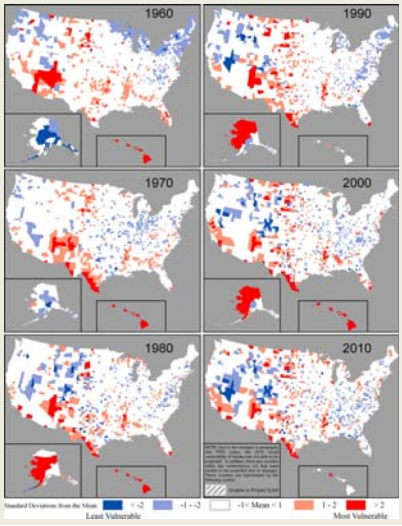


Source: Jones *et al.* 2008. Global Trends in EIDs. *Nature,* 451(21 Feb)

Other Data Needs for Vulnerability Analysis

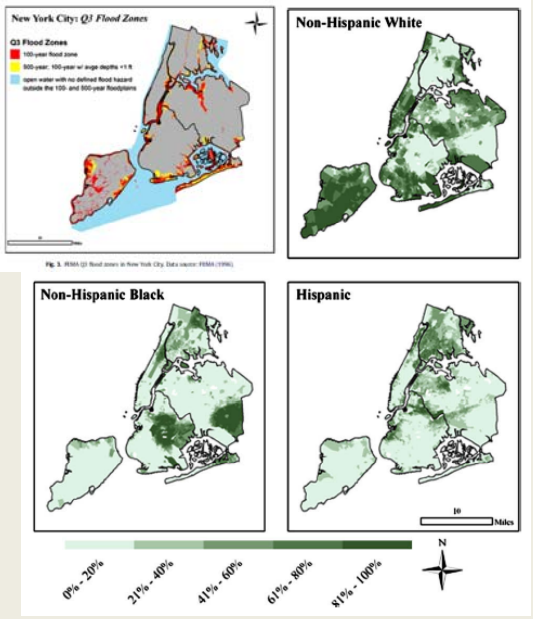
- Age/sex breakdown of population
- High spatial resolution poverty data
- Sector-specific employment data
- Better health statistics/epidemiological data
- Data on race/ethnicity

Social vulnerability 1960–2010.



Cutter S. L., Finch C. PNAS 2008;105:2301-2306

PNAS



Source: Maantay, J., Maroko, A.. 2008. Mapping urban risk: Flood hazards, race, & environmental justice in New York, *Applied Geography*, doi:10.1016/j.apgeog.2008.08.002

This paper demonstrates the importance of disaggregating population data aggregated by census tracts or other units, for more realistic population distribution/location. A newly developed mapping method, the Cadastral-based Expert Dasymetric System (CEDS), calculates population in hyper-heterogeneous urban areas better than traditional mapping techniques. A case study estimating population potentially impacted by flood hazard in New York City compares the impacted population determined by CEDS with that derived by centroid-containment method and filtered areal-weighting interpolation.

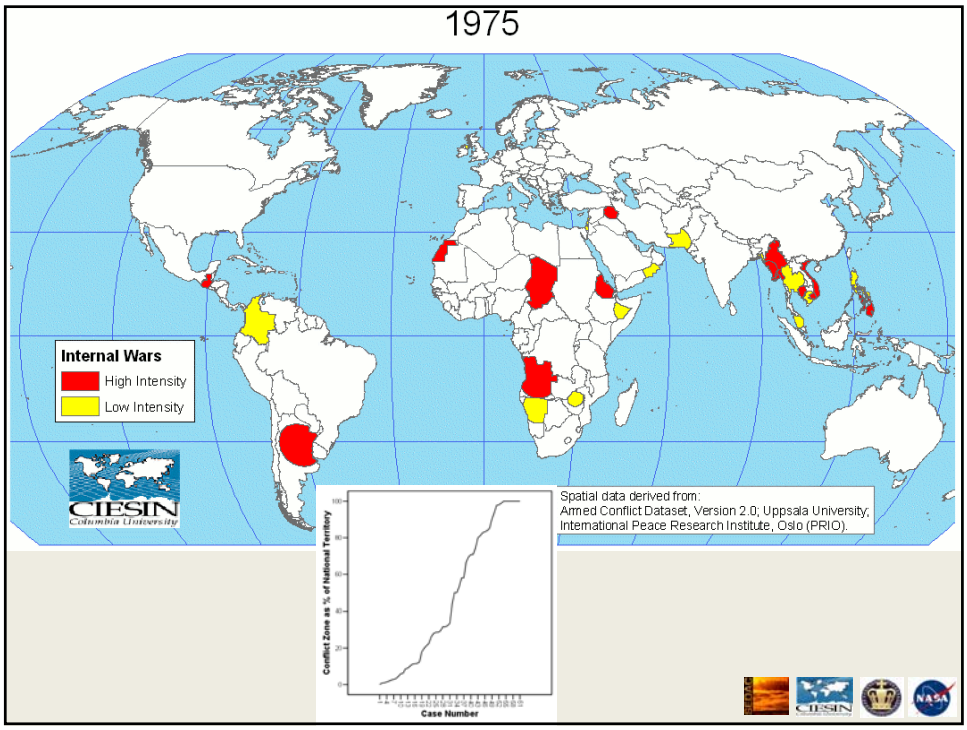
Demographic Data Challenges

- National census units are often not well delineated in geographic space, making it difficult to locate human populations with respect to climate risks, particularly in relation to coastlines and sea level rise risks.
- Intra-annual variation in population distribution is not systematically tracked, making it difficult to characterize exposure to highly variable climate risks.
- Inter-annual change in the spatial distribution of population is difficult to characterize with precision because of incommensurate administrative boundaries across censuses.
- Changes in census spatial units are more common at higher resolution (census tract level and higher), which are the ones needed for vulnerability assessment.

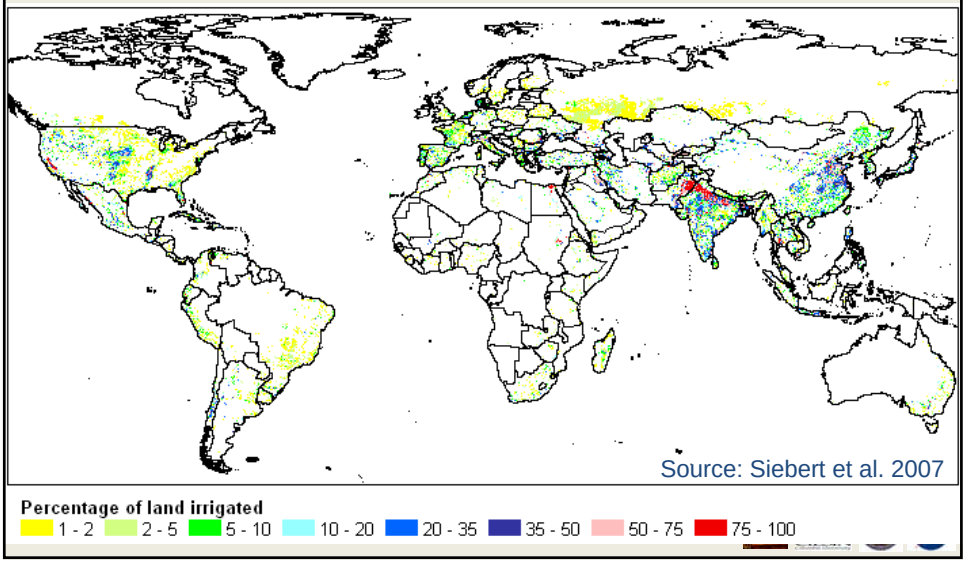
Adaptive Capacity

"Determinants of coping capacity are awareness, ability, and action" – Lucas and Hilderink 2004

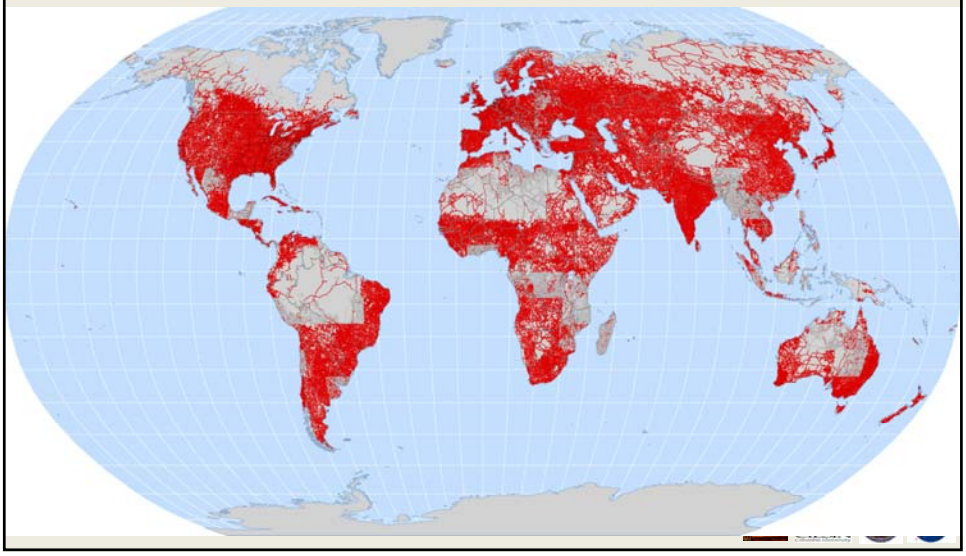
- A function of national income
- A function of human and social capital
- A function of past infrastructure development
- A function of good governance
- A function of political stability
- And many other issues…



Water storage capacity an important indicator of drought resilience:
Global Map of Irrigated Areas



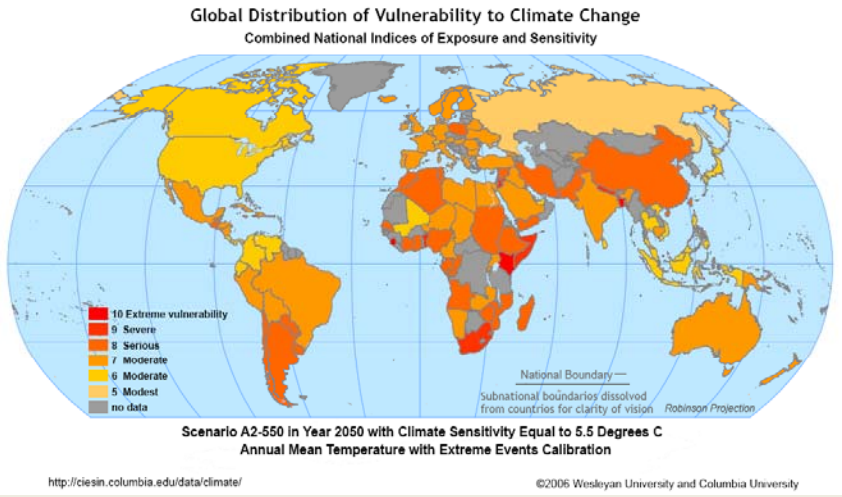
Road networks



Spatial data on adaptive/coping capacities exist for the following

- Gridded income data (Nordhaus, Sutton)
- Radio/TV ownership, Internet access (UNESCO)
- Water holding capacity of dams (UNH WSAG)
- Governance indicators at the national level (World Bank, Transparency Int'l, POLITY proj.)
- Conflict areas (PRIO, CRED CE-DAT, CIESIN)
- Refugee camps (UNHCR)
- Health infrastructure (WHO)
- Age structure (CIESIN forthcoming)

This study sought to measure vulnerability as a function of adaptive capacity



Source: Yohe, G., E. Malone, A. Brenkert, M. Schlesinger, H. Meij, X. Xing, and D. Lee. 2006. "A Synthetic Assessment of the Global Distribution of Vulnerability to Climate Change from the IPCC Perspective that Reflects Exposure and Adaptive Capacity." Palisades, New York: CIESIN, Columbia University. http://ciesin.columbia.edu/data/climate/

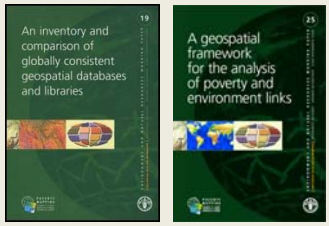
A Climate Change IVA Data Kit

- The proposed data collection would include pre-packaged data layers for a number of biophysical and socioeconomic parameters at a 1-kilometer grid cell resolution (30 arc-seconds). This is equivalent of a map at a scale of 1:1,000,000 that would serve as an adequate base for national-level planning, even for relatively small countries
- Critical data integration "headaches" would be solved, by ensuring each layer has standard coastlines and admin boundaries (where possible)
- Would be a resource for developing countries with limited GIS data creation capacities, and could be distributed under the UNFCCC's Nairobi Work Programme

Potential Layers

- Thirty year "climate normal" (1960-1990) annual and monthly
  - Mean temperature
  - Mean precipitation
  - Mean runoff
- Population distribution (2000, 2015, and 2050)
- Poverty
- GDP
- Roads
- Hazards
- Land cover types
- Cropping areas
  - Percentage land cropped per grid cell
  - By type
  - By value
- Pasture lands
- Soil types
- Elevation
- Coastlines
- First and second level administrative boundaries
- Climate scenarios
  - Ensemble model outputs for changes in temperature (2050, 2100)
  - Ensemble model outputs for changes in precipitation (2050, 2100)
  - Ensemble model outputs for changes in runoff (2050, 2100)
  - Sea level rise (3m, 5m, 7m, 10m)
  - Modeled storm surges based on SLR of different levels
  - Modeled drought frequency
- Remote sensing image mosaics
- Real time data integration:
  - MODIS fire data
  - Climate anomalies in the past three months
  - Flood data
  - Aerosols

Some Starting Points



FAO's *Food Insecurity, Poverty and Environment Global GIS Database* at http://tecproda01.fao.org/~lorenzo/

Overall Conclusions

- Climate change of greater than 2° C is likely to happen: forewarned is fore armed
- Since impacts, vulnerability, and adaptive capacity are spatially differentiated, spatial data are vital
- There is an increasing amount of spatially disaggregated data on hazard exposure, aspects of vulnerability, and adaptive capacity
- *Dynamism* of social systems and multiple stressors on those systems is inadequately captured by most spatial data sets, and some global/regional GIS assessments can risk being perceived as *mechanistic* by lacking adequate grounding in local realities
- Yet, such analyses can identify "hotspots" of vulnerability where adaptation interventions may be required

Thank you!

http://ciesin.columbia.edu