

Vulnerability and Uncertainty

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Significance of Vulnerability

- The consequences of climate changes will be unevenly distributed
- Understand potential losses
 - Economic
 - Mortality and morbidity
 - Many other valued things
- Inform adaptation strategies, policies, and funding
 - Local, regional, and global

Feeling at risk matters

- “A recurring criticism of risk characterizations is that the underlying analysis failed to pay adequate attention to questions of central concern to some of the interested and affected parties”
 - NRC 1996 *Understanding Risk: Informing Decisions in a Democratic Society*
- “Another problem that often arises with environmental analysis is a failure to address key decision-relevant questions. ... In short, when science is gathered to inform environmental decisions, it is often not the right science.”
 - NRC 2005 *Decision Making for the Environment: Social and Behavioral Science Research Priorities*

Vulnerability Analysis

- Risk – 3 common elements to various definitions
 - Threat to something people value
 - probability of occurrence of an event
 - A way to combine the two (Renn 2008)
- Vulnerability - the degree to which a system, subsystem, sector, or social group is likely to experience harm due to exposure to a hazard, either a perturbation or stressor
 - Policy strategies' can also be vulnerable – decision analytic approach
- Vulnerability analysis aims to understand the factors and processes shaping the distribution of impacts from a chronic stress or a perturbation
- Impacts may be result of climate variability, change, or climate-related policies

Dimensions of Vulnerability

Vulnerability is composed of three dimensions:

- Exposure, types of events and stresses
- Sensitivity, the degree of harm likely from exposure
- Resilience or some prefer Adaptive capacity, the ability to recover from impacts and adapt

Or, expressed as an equation

$${}^t V f(E, S, R)_{s, g}^c$$

V – vulnerability is a function of Exposure, Sensitivity, and Resilience/Adaptive Capacity

t - time frame; it is a dynamic trait

s - sector or **g** – group; it varies across groups and scales (local, state, regional, etc.)

c – consequence; climate change involves many types of consequences

Exposure

- What are the causes of exposures?
 - Choice of risky location
 - Marginalized people in marginal areas
 - Indirect: Social or economic “teleconnections”
- What is the exposure to what event?
 - Climate change is not going to be experienced as a single event
 - How well do we know what might be exposed?
- What is the timing of the event?
 - Tourist season
 - Growing season
 - Reservoir recharge time

Risk Hazards Approach

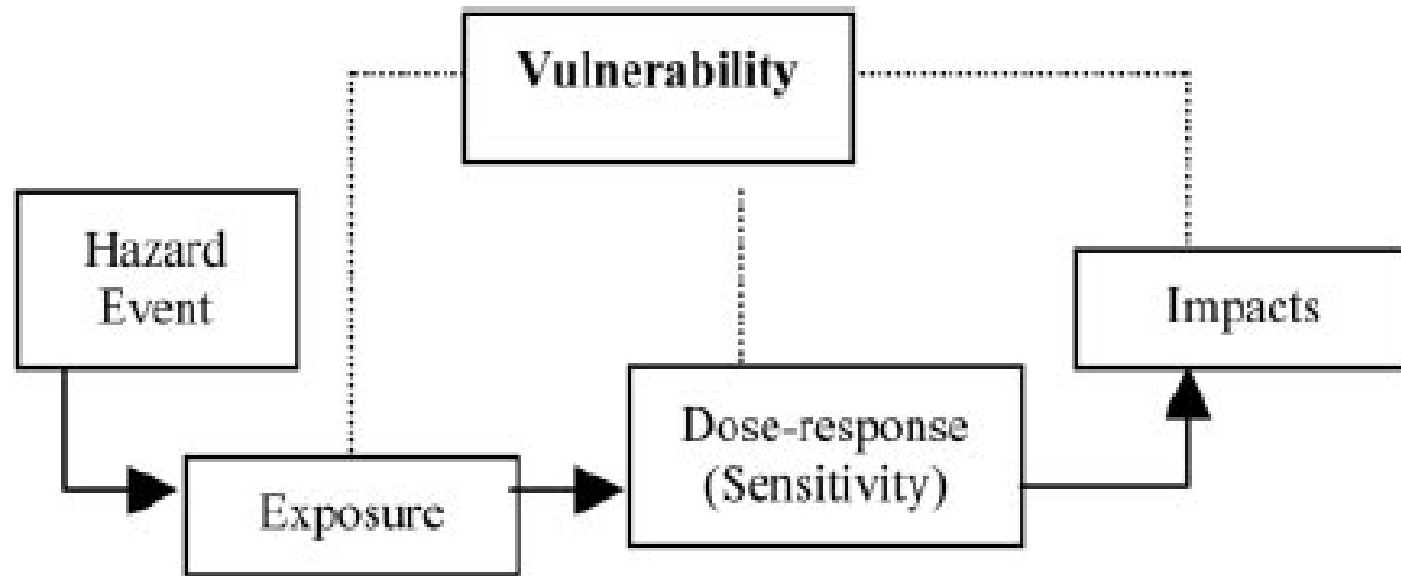
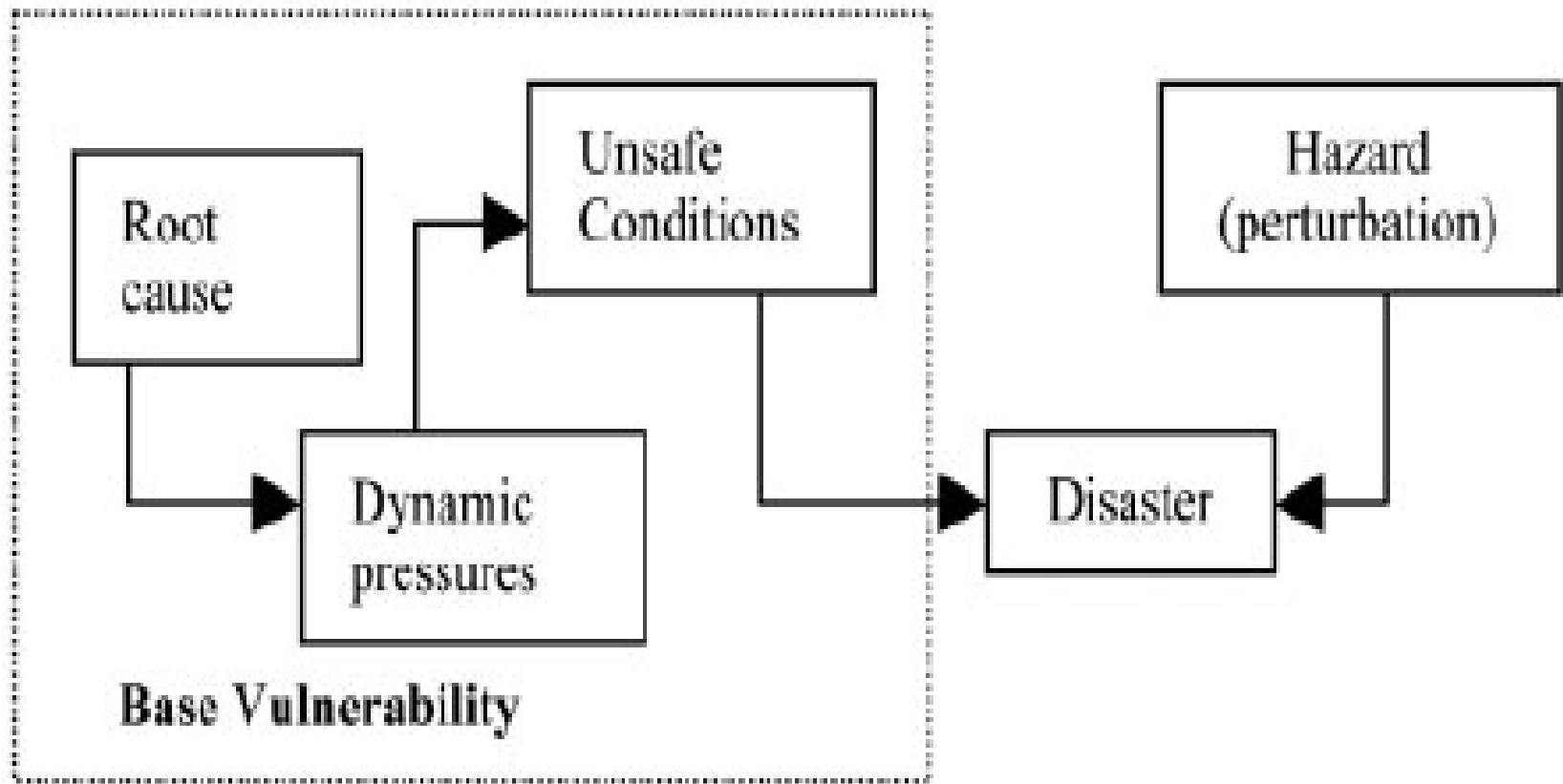


Fig. 1. RH framework (common to risk application). Chain sequence begins with hazard; concept of vulnerability commonly implicit as noted by dotted lines.

Pressure and Release Model

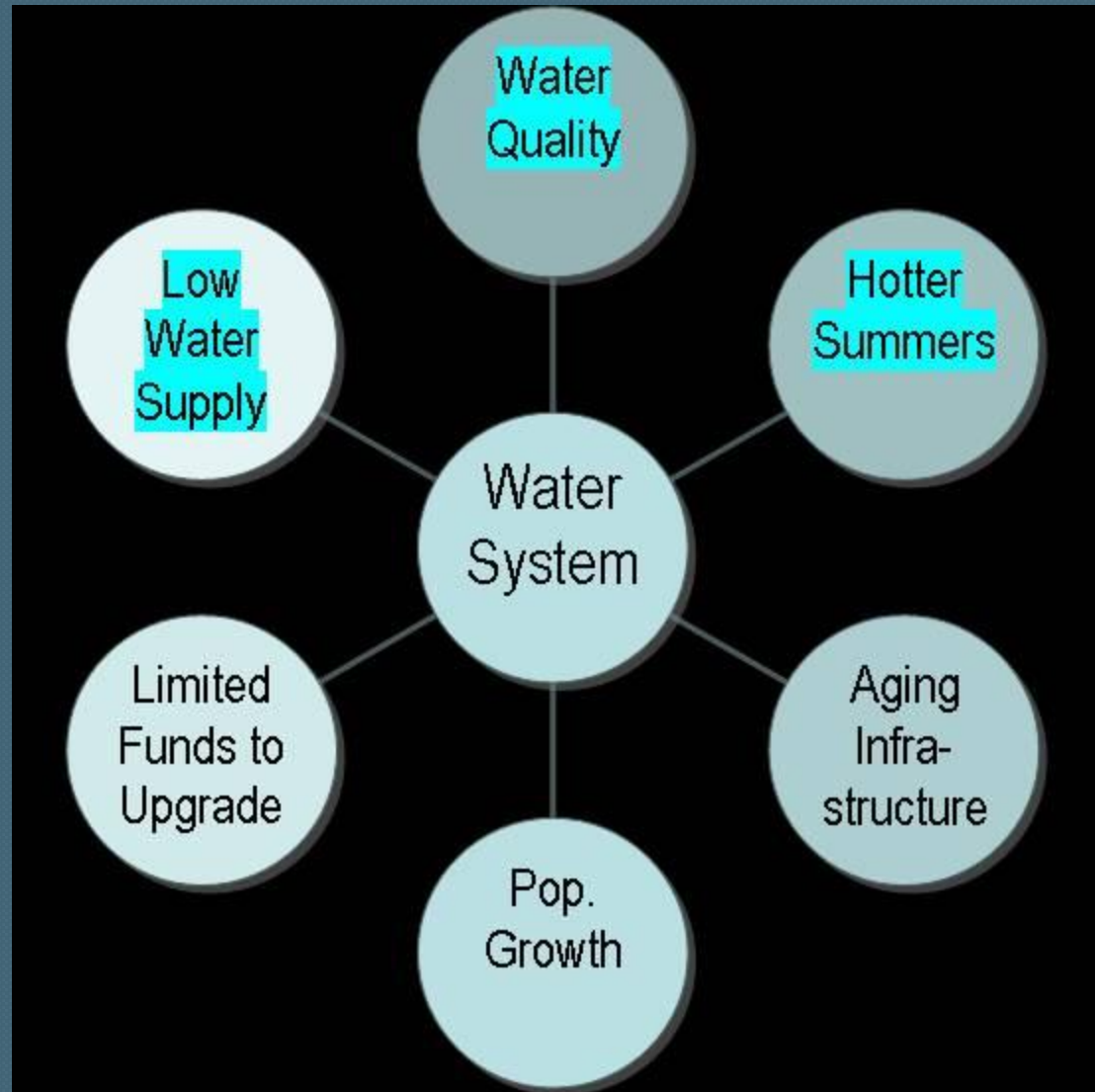


Multiple stresses: Water system example

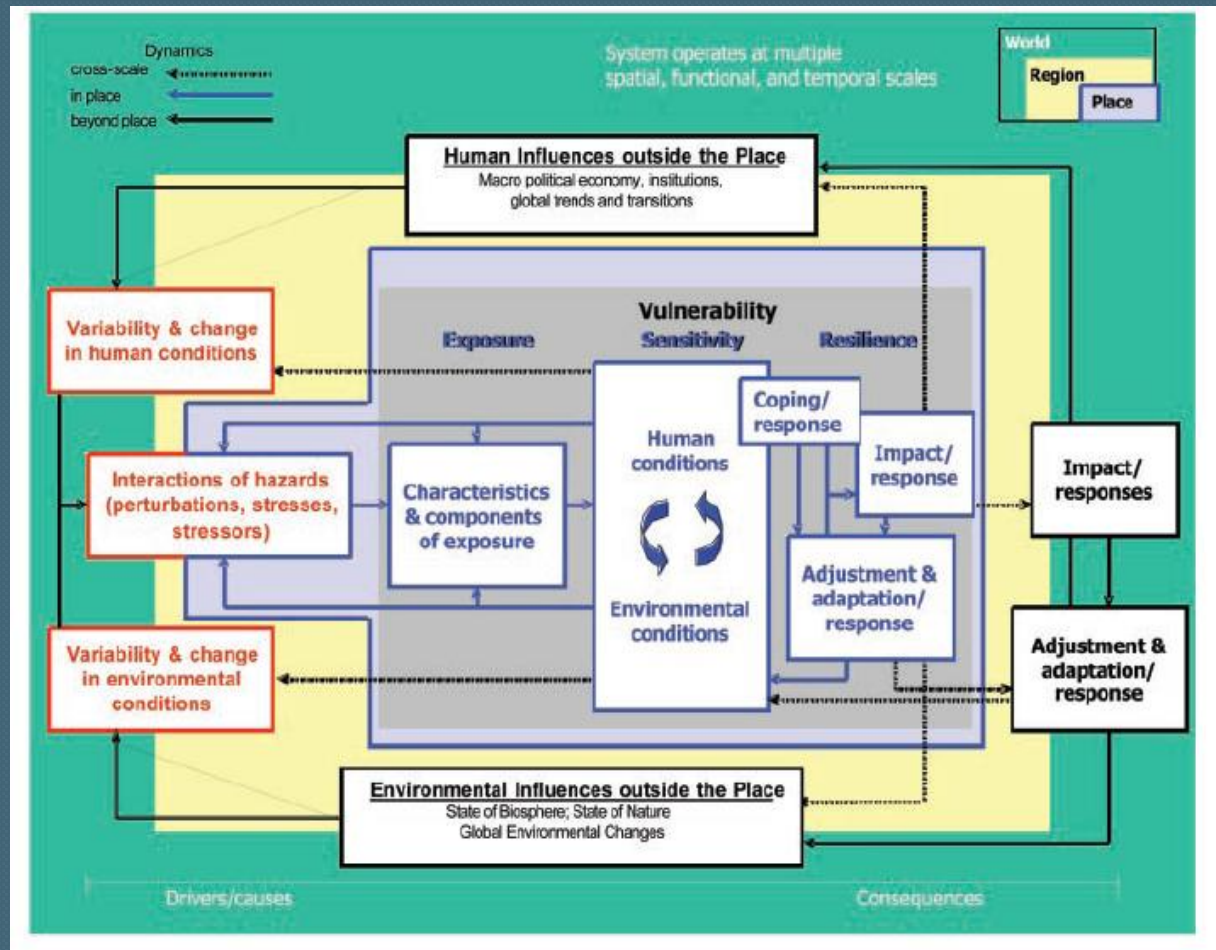
- Interactions
 - Additive
 - Synergistic
- Internal
- External

May require collecting new types of information about existing inventories or integrating databases

- Better temporal resolution



Coupled Human-Environmental Systems



Sensitivity

Degree of harm to system, subsystem, group, if the event or stressor occurs

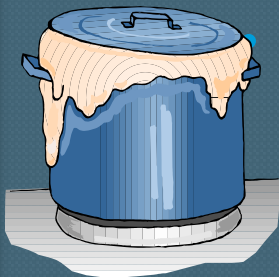
Improving here is a major challenge

What is likely to be harmed most severely?

- Who or what is marginal under current stressors or future stressors?
 - Thresholds, tipping points, non linearities
 - Engineering analyses, infrastructure
 - Health children, elderly . .
 - Systems versus marginal groups

Highly dependent on a relatively narrow range of conditions?

- Skiing industry – will coping alter water demand?



Resilience and Adaptive Capacity

- The ability to recover from impacts and adapt to new circumstances (more in Adger et al. 2006)

Adaptive capacity

- Ongoing learning
- Flexibility
- Ability to experiment and adopt novel solutions
- Potential to develop generalized responses to a broad classes of challenges

Walker *et al.*, 2002

Generalized determinants of adaptive capacity

1. Range of available technological options
2. Availability of resources and their distribution across the population
3. Institutional arrangements, decision-making authority and decision criteria
4. The stock of human capital, i.e. education, personal security
5. Stock of social capital including the definition of property rights
6. Systems access to risk spreading processes
7. Credibility of information, decision making capabilities and credibility of decision-makers
8. The match between the public's perception of the source of stress and local manifestations/exposure

Interactions among determinants of adaptive capacity

- Often are interacting elements
- Positive and negative feedbacks among them
- Possibility that the determinants of adaptive capacity operate differently in different contexts
 - Ability to generalize may be limited
 - Which factors are more likely to operate differently?
 - And, why

Additional issues

- Adaptive capacity is a latent quality – hard to measure until it is tested
- People are not adapting to climate directly, but climate-related pressures
- People are reacting not anticipating
- Tendency to think short term might be maladaptive in the longer term

Uncertainty in Vulnerability

- Who and where are the vulnerable?
 - E.g., poverty and urban and rural populations
- Millennium Ecosystem Assessment 2005
- Why Is Human Well-being Increasing as Ecosystem Services Degrade? Untangling the Environmentalist's Paradox
 - Raudsepp-Hearne et al. 2010
 1. *Well-being is dependent on food services, which are increasing, and not on other services that are declining;*
 2. *technology has decoupled well-being from nature;*
 3. *Time lags may lead to future declines in well-being.*
- Going beyond case studies and general proxies

Lack of data on vulnerabilities of interest

- Scale of data: lack of data at subnational level – although microlevel is critical
 - Mapping homelessness or small natural resource dependent communities
 - The census is not designed to reflect vulnerability – imperfect source
- 3 vulnerability indices on past hazards
 - Mortality
 - Morbidity
 - Economic loss
- Under reporting of losses
- Losses to non-market things
- Measuring wealth in different contexts
- A key issue in linking vulnerability to integrated assessment models

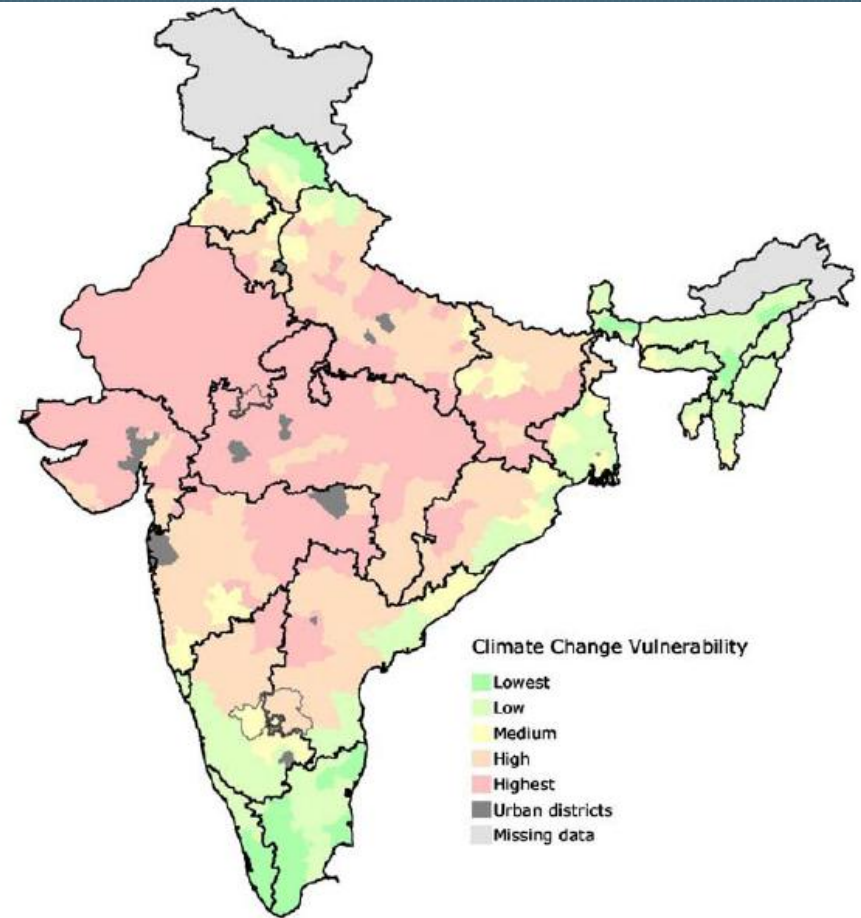
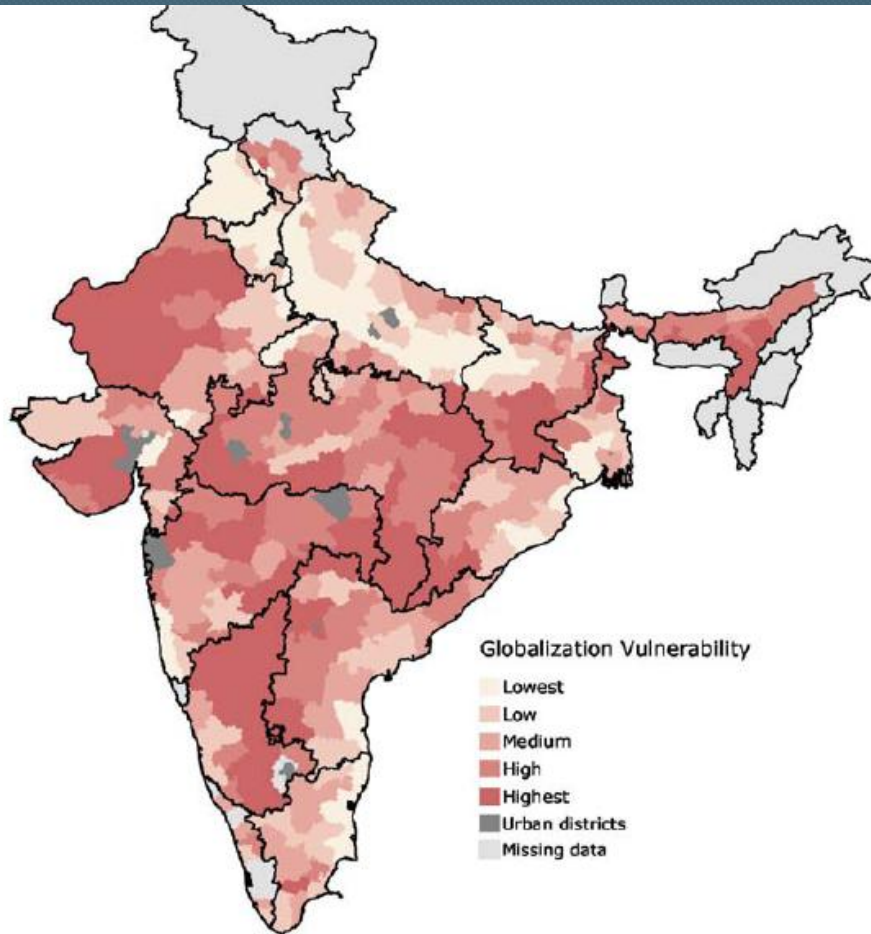
Issues for the next generation of vulnerability assessments

- Multiple stresses
- Sensitivity
- System restructuring after an event
 - e.g., Repetitive losses
- Differential vulnerability within a system
- Role of institutions
- Cause and effect relationships

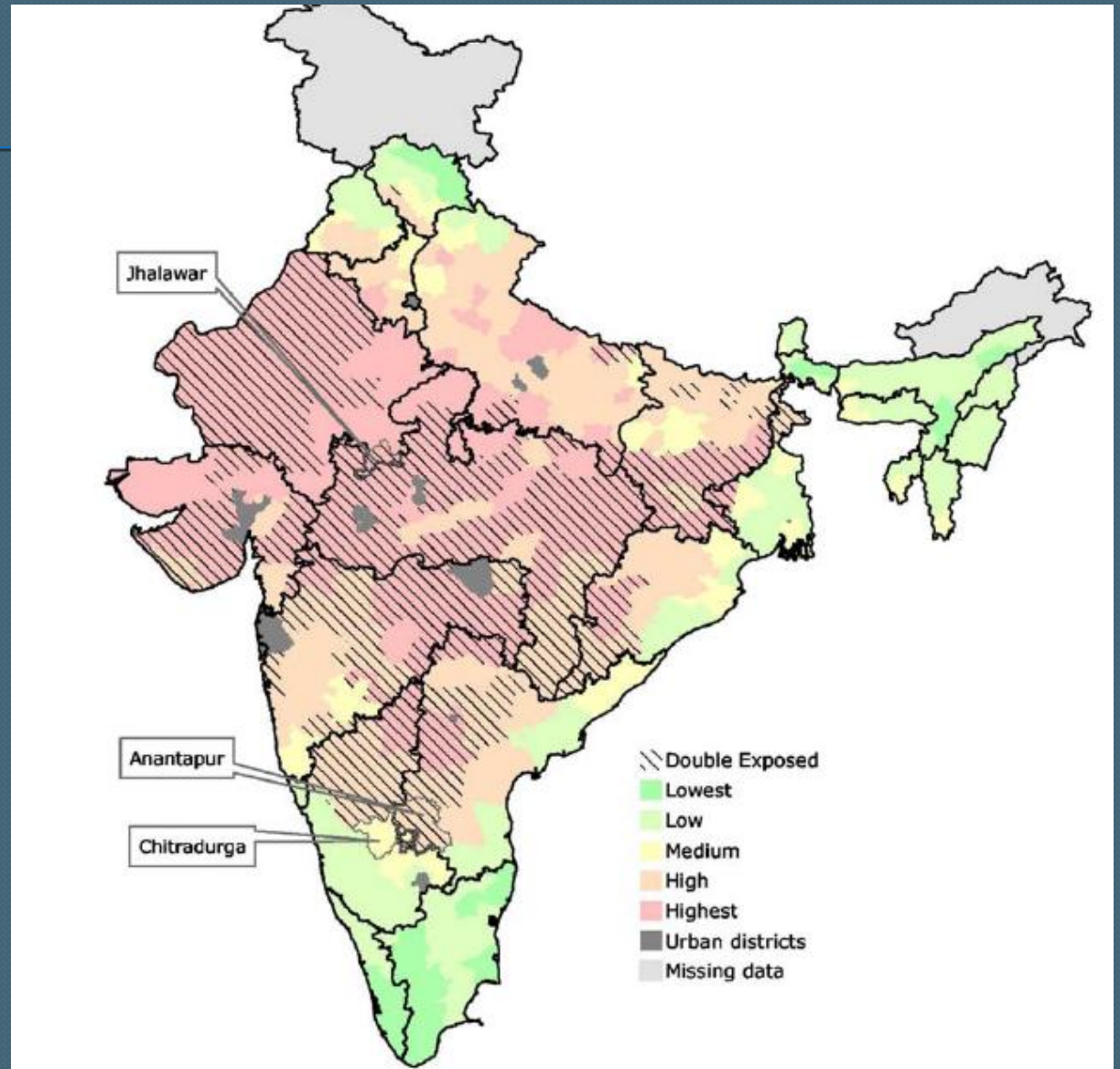
Multiple stresses

- Joint probabilities of exposure plus interactions of sensitivities and adaptive capacity
- Which combinations of stresses?

Double Exposure



Combined exposures to globalization and climate changes



Ground truthing vulnerability in India

- Interviews with local government officials
- Local statistics
- Local household interviews
- Jhalawar District
 - Entered global market for soybeans
 - 4th year of drought
 - Majority without irrigation
 - Some migrating for work
 - Taking high interest loans (36%)



System changes after an event

- Recovery
 - New Orleans
 - Western wildfires
- Sequential hazard events
- Restructuring
 - Supply chains after a Tsunami
- Adaptation choices
 - Policy
 - Capacity
 - Preparedness for rebuilding



Differential vulnerability within a system

- Natural resource dependent communities
- Across scales – nested approaches
- Household vulnerability – mix of assets in a home (livelihoods approach)
- Understanding implications for a system

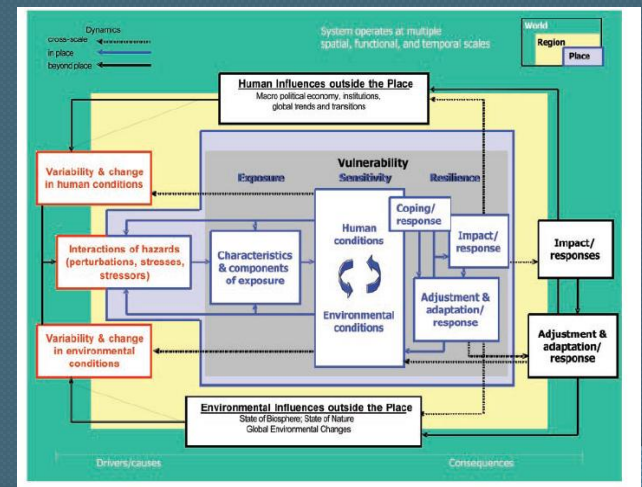
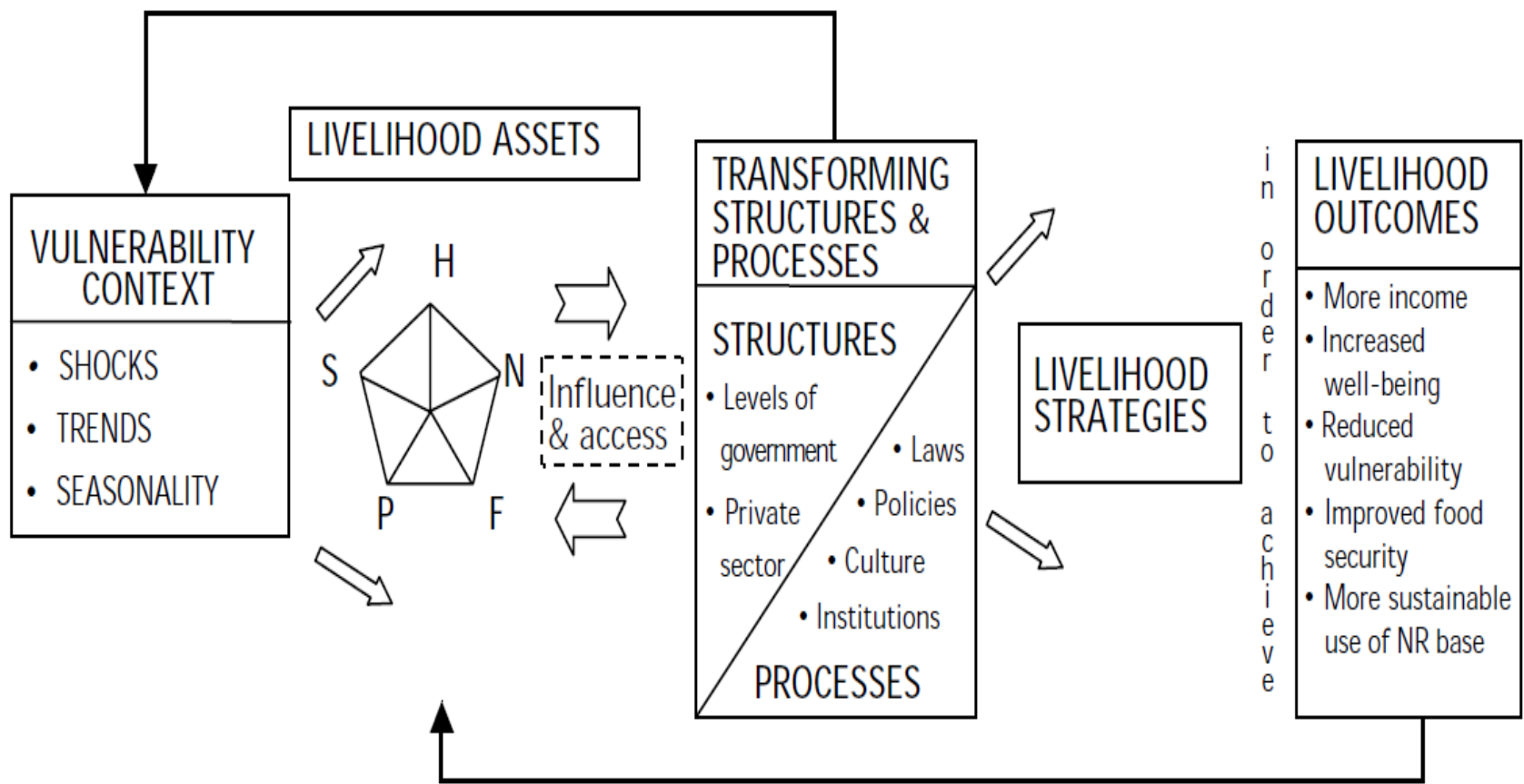


Figure 1. Sustainable livelihoods framework

Key
 H = Human Capital S = Social Capital
 N = Natural Capital P = Physical Capital
 F = Financial Capital



Role of institutions

- Institutions: Rules and norms governing collective action and social life
 - often referring to rules governing common-property environmental resources like rivers oceans or the atmosphere.
- Examples: Property rights, use rights, access to forms of capital, gendered forms of labor
- Challenge to characterize these for local places and understand how they influence vulnerability

Social Capital

One of many definitions

“the value of these aspects of social structure to actors as resources that they can use to achieve their interests” Coleman (1988)

- Obligations and expectations
- trustworthiness of structures
- information channels
- norms and effective sanctions

Cause and effect relationships

- Impacts across scales

- To what extent are the details of local vulnerabilities and adaptation challenges locally driven
- A significant issue in linking to integrated models
- Going from a highly unequal world to local impacts



- Local consequences of national or global policy

- Representing higher order consequences from economic damage to social harm

- Household stress
- Mental health impacts
- Small business impacts

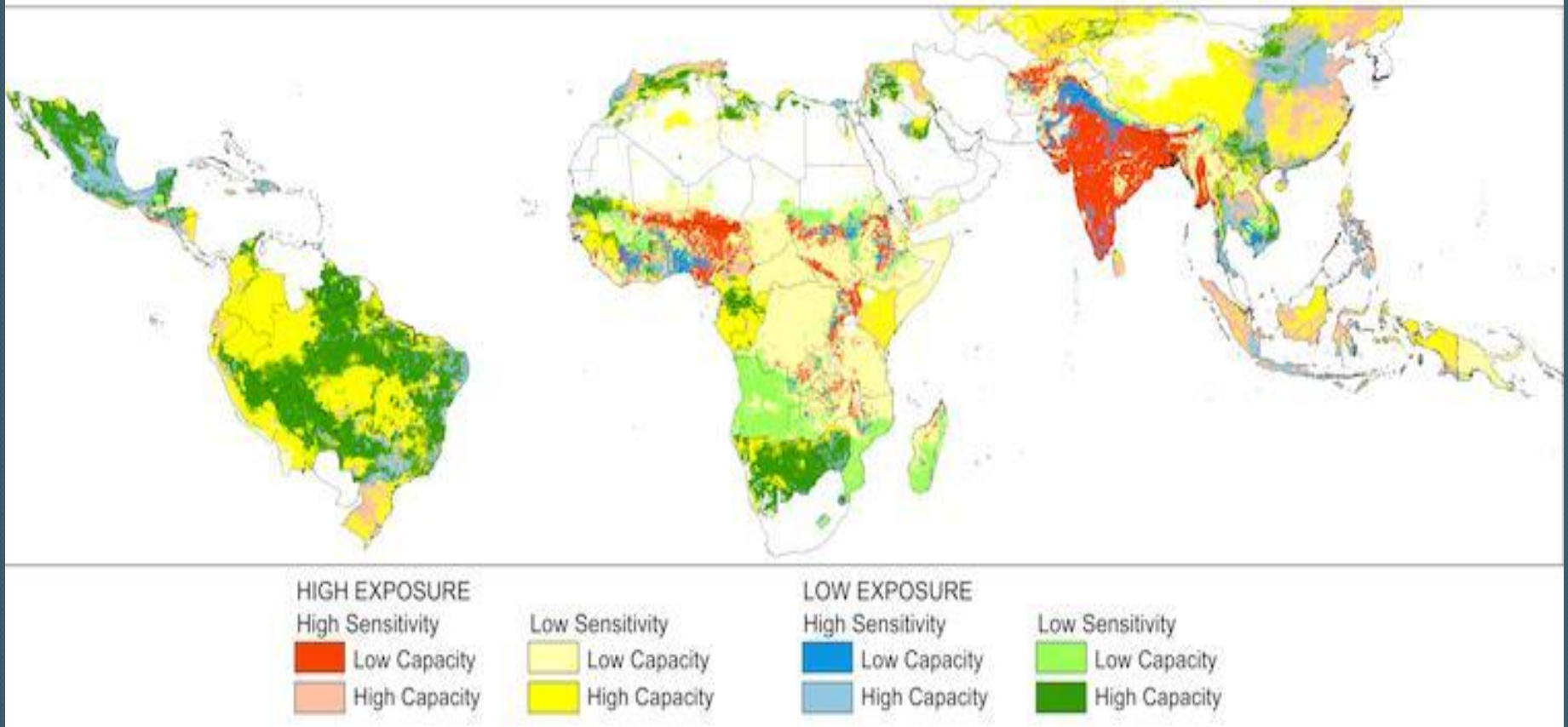
Looking into the future

- Imagine using scenarios or story lines or projections to provide some information
 - Difficult to project or forecast many relevant variables
 - Growing population - children
 - Aging populations
 - Development pathways
 - Success of the millennium development goals
 - Surprise
 - Reflexivity in social processes

Linking to integrated assessment

- Metrics
- Relationships across scales
- When you need to link vulnerability research to integrated models
- Indicators of governance
- What combinations of things could produce these outcomes
 - Make it harder to adapt or easier to adapt

“Hotspots”



"Mapping Hotspots of Climate Change and Food Insecurity in the Global Tropics", CGIAR 2011

Some of the underlying metrics

- ⊕ Mapping current food insecurity outcome indicators
 - Access
 - GDP per capita
 - Current poverty levels: % population living below USD 2 a day
 - **Transport time to markets**
 - **Monthly staple food prices**
 - **Utilization**
 - **Prevalence of malnutrition – stunting, wasting**
 - **Unimproved water source**
- ⊕ climate change hotspots in 2050
 - Reduced growing days
 - Reduced length of growing period
 - others
- ⊕ the overlap between these.

Approaches to Hotspots

- Single Dimensions
 - Outcome studies - single and multiple outcomes
 - Threats or stresses - multiple and single threats
 - Receptor sensitivity or vulnerability
- Integrated Efforts
 - Coupled Threat & Outcome
 - Coupled Threat & Vulnerability
 - Integrated Analysis – threat, vulnerability, & outcome

Challenges in Hotspot Approaches

- Choosing threats and receptors of interest – what is “hot”?
 - Developing priority setting strategies
 - Data management, availability, and accuracy
 - Accounting for the role of expert judgment
 - Representing of spatial linkages
 - Between threat origin and impacts
 - Migration; Market or other distribution networks
 - Capturing differences across scales and cross scale interactions
 - Delineating “Hotspots”
 - Justification of boundaries
 - Size of area
 - Incorporating participatory processes
- THEN, what next
- Linking to management implications

Summary

Multiple sources of uncertainty in measuring vulnerability

losses, exposures, sensitivity, adaptive capacity

Understanding interactions – causes, development of stresses, geospatial patterns

Adaptive capacity as latent trait

Therefore report the limits to analysis, support better monitoring

Look for links from cases to broader generalizations

Vulnerability Assessment

What are the goals and objectives? Is there a particular utility associated with spatial analysis of vulnerability that justifies its use and, if so, what are the anticipated goals and benefits to stakeholders? Are there potential risks associated with presenting information spatially that may undermined expressed goals?

2. How is the assessment of vulnerability framed? What aspects of systems are vulnerable and what are the determinants of that vulnerability? How are spatial, temporal and multi-scale dynamics of vulnerability represented?

3. By what methods will vulnerability be assessed? What methods are used in the assessment and mapping of vulnerability and how does one cope with complexity and uncertainty?

4. Who participates and how are results translated into action? Who is responsible for designing and undertaking a spatial analysis, and which stakeholders will participate in the process? Who are the intended audience and what efforts will be made to ensure information is presented in a relevant manner and, subsequently, interpreted appropriately? What are the processes by which an assessment of vulnerability can facilitate adaptive responses?