Carrying out Vulnerability Analyses

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Vulnerability Analysis

- Risk – probability of occurrence of an event
- 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
- 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, sometimes also called adaptive capacity, the ability to recover from impacts and adapt

For the Engineers, an Equation

$$ {}^{t}V_{s,g}^{c} = f(E,S,R) $$

V – vulnerability is a function of **E**xposure, **S**ensitivity, and **R**esilience

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

After: Downing et al. 2004

Exposure

What are these perturbations and stresses associated with climate changes?

Intense storms, flooding, drought, sea-level rise and saltwater intrusion, changes in water quality characteristics, growing seasons and water demand patterns

They are familiar, but different

- Stationarity is dead
- At best, “Probability” Density Functions surrounded by uncertainties and some ignorance
- Always interacting with other social, economic, and political stressors

Vulnerability Analyses

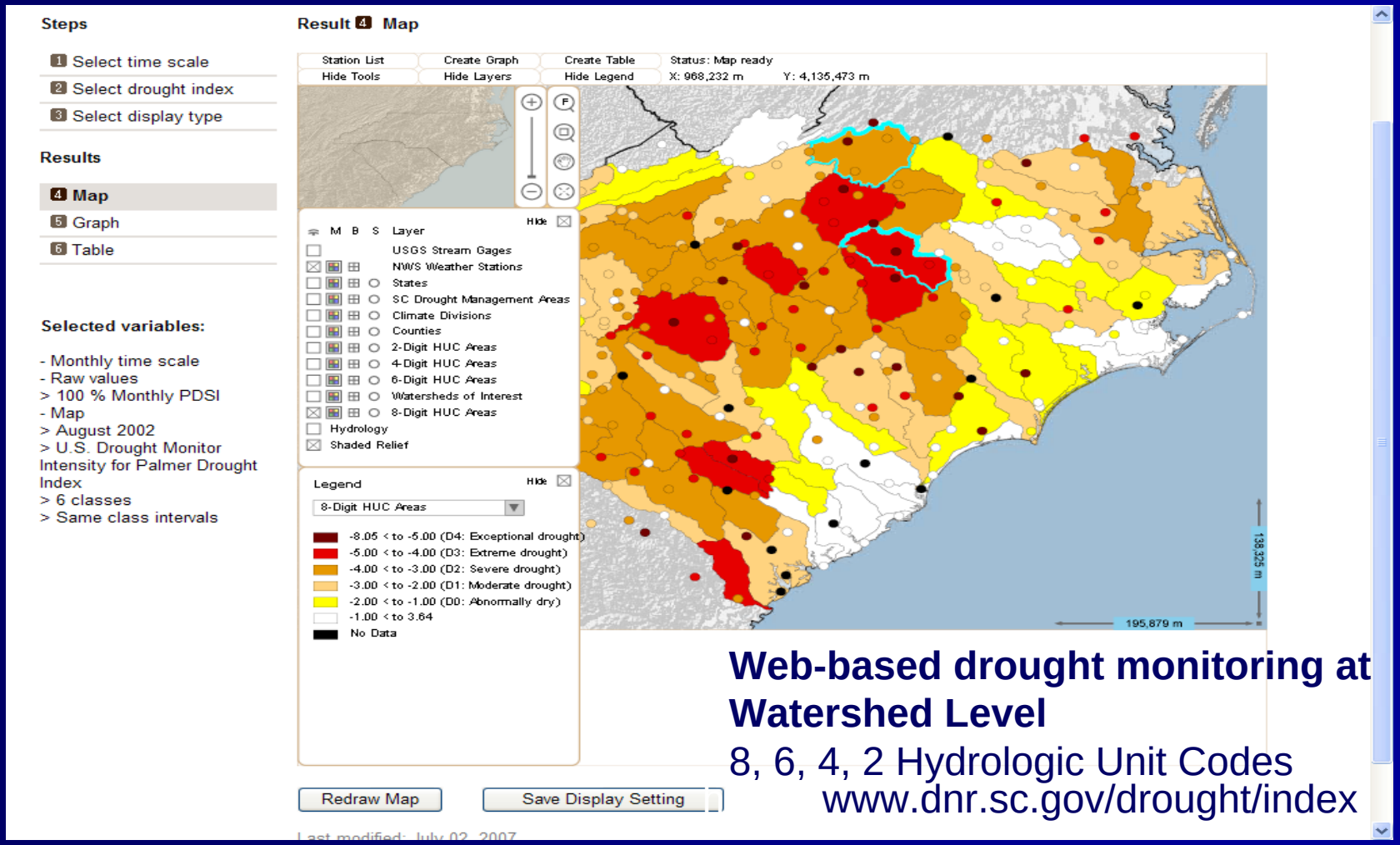
- Exposure
  - Step 1 – What are the priority consequences?
    - Water Quality
    - Flooding
    - Water Supply
    - Ecological Needs
    - Safety, Availability, Affordability, Equity – potential winners and losers

Tools for Vulnerability Analyses

Regional climate projections
- linked to hydrologic and other models
- clear information on uncertainties

- Scenario analyses
  - Multiple scales, more emphasis on watersheds
  - Socioeconomic dimensions, changing demand
- Appropriate inventories
  - Infrastructure, Water use, Number and location of limited wells
- Likely need new or revised monitoring programs for impacts as well as physical changes

Examples of New Tools for Assessing Exposure



Web-based drought monitoring at Watershed Level

8, 6, 4, 2 Hydrologic Unit Codes

www.dnr.sc.gov/drought/index

Sensitivity

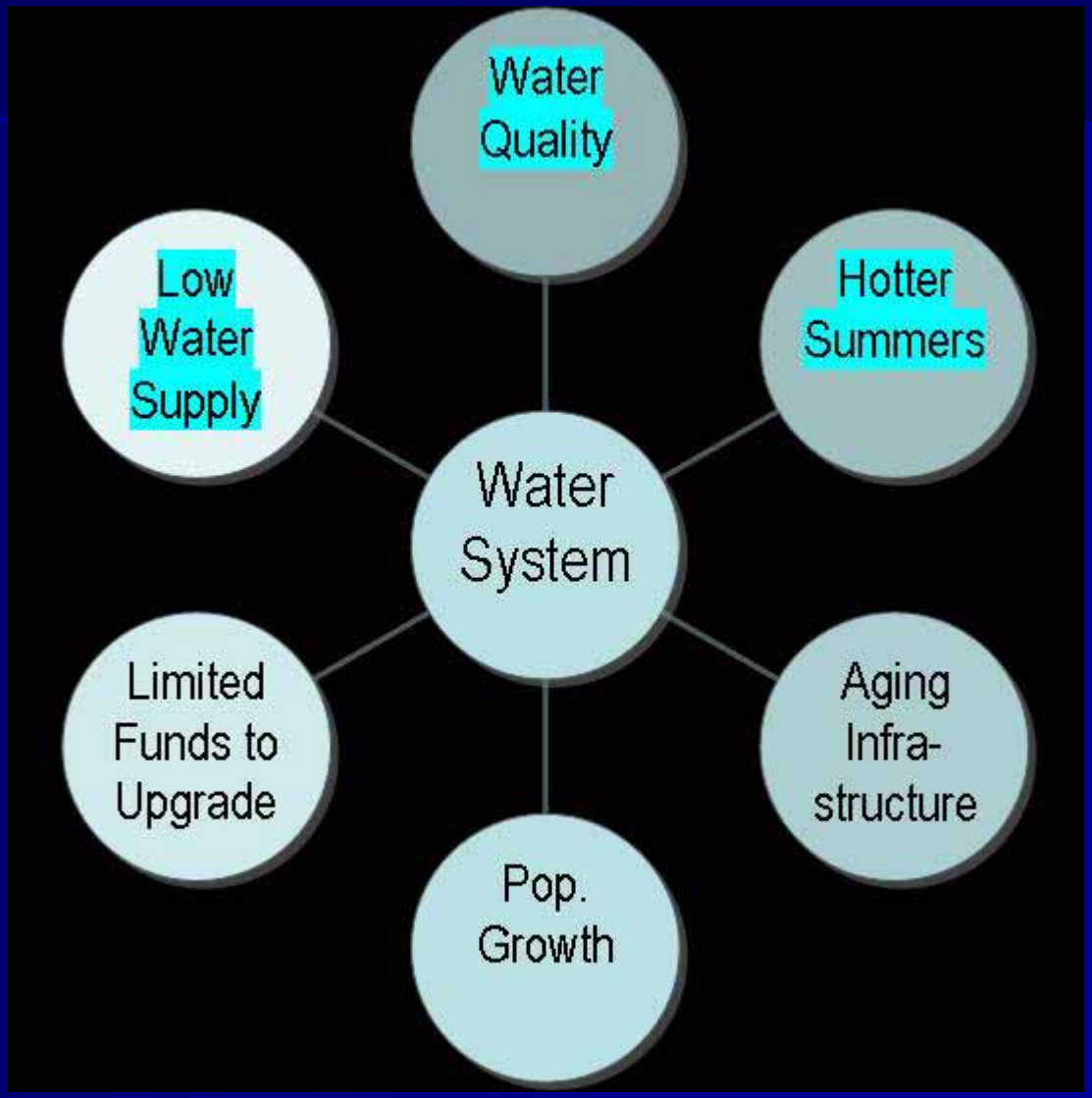
- Opportunities to reduce harm if the event cannot be avoided
- What is likely to be harmed most severely?
  - Who or what is marginal under current stressors or future stressors?
    - Engineering analyses, infrastructure
    - Drought and Water Quality
      - Particular systems – for example, small water systems
      - Groups - Rural, low income households with shallow wells
  - Highly dependent on a relatively narrow range of conditions?
    - Skiing industry – will coping alter water demand?

Multiple Stresses

- Interactions
  - Additive
  - Synergistic
- Internal
- External

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

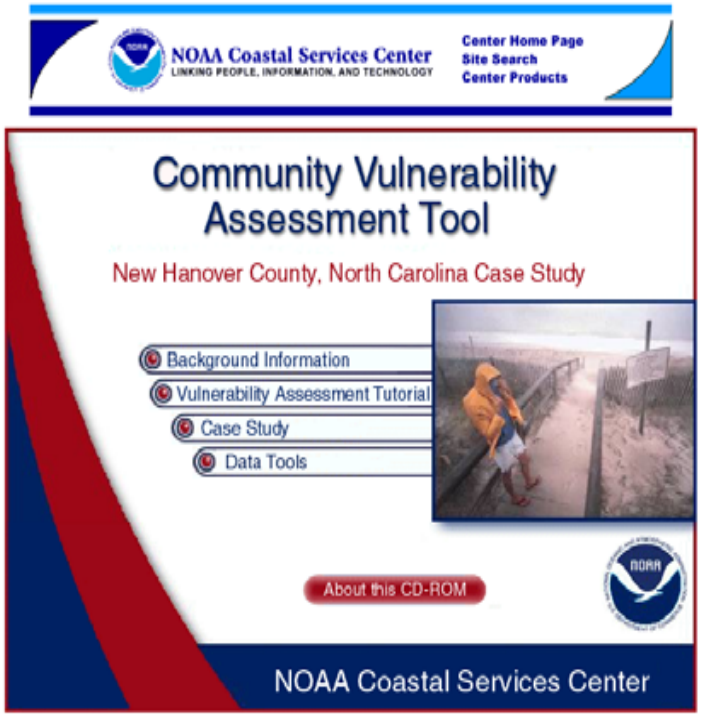
- Better temporal resolution



Resources on Sensitivity

- To identify factors contributing to sensitivity
  - Professional judgment, expert consultation
  - Environmentally sensitive or critical area mapping
  - Economic dependency on resources or climate sensitive sectors
    - Industries, e.g. energy, agriculture
  - Water rights
  - Case studies
  - Multiscale
    - Changes within your system
    - Changes among populations you serve – altered demand
    - Changes beyond your system that will affect you
      - New water quality regulations

NOAA CSC Flood / Hurricane Vulnerability Tutorial



Tutorial and case study guide to Community Vulnerability Assessment using GIS

- Hazard Identification
- Hazard Analysis
- Critical Facilities Analysis
- Social Analysis
- Economic Analysis
- Environmental Analysis
- Mitigation Analysis

Map exposure of facilities, sensitive social groups, major employers, sensitive environments

Expanding and Exceeding Coping Capacity

- Shifts requiring widening coping capacity
- Shifts requiring shifting band of coping capacity
- Thresholds
  - Cost
  - Potential

Resilience and Adaptive Capacity

- The ability to recover from impacts and adapt to new circumstances
- Highlight some ideas put forward by the Maryland Commission on Climate Change, Adaptation & Response Working Group

Strategies to Increase Resilience

- Social
  - Long term, demand management
- Technological
  - Modify building codes
    - Water efficiency, reuse, grey water systems
    - New design standards for infrastructure
- Economic
  - Increased reserves, diversification
  - Increased rates
- Institutional
  - Planning for increasing pressure and event recovery
  - Ability to respond quickly – reserves and resource sharing arrangements, equipment, personnel

Requirements for Adaptation

- New information must be available
- Systems must be able to process the information
- Systems must have the ability to change based on new information

Source: Pahl-Wostl 2007

Making New Information Available

- Improved observation systems for key changes
  - Integrated and complementing current systems
    - Including GIS data sets
  - Research needed on key indicators
  - Involvement in vector-borne disease monitoring
  - Revise criteria for natural resource priority areas
    - Modeling migration of key species and habitats
- Public Awareness and Outreach
  - Engagement with trades and professions
- Improved information on economic impacts of climate change on resource-based industries

Processing New Information

- Staffing
- Training
- New networks
  - Among water managers, but also with the groups they serve
  - Other cases and experiments
- Scientific resources
  - If downscaled results arrived today, what would it take to see them used effectively?
- Public involvement in risk management decisions

Flexibility - Ability to Change Based on New Information

- Where are the barriers to change?
  - Need for approved guidance on climate change and flood management
  - Lack of institutional coordination
- Adaptation options can be win-win
  - Reduce present and potential future costs
  - Yield unexpected results
  - Make opportunities available that would not otherwise have been there
  - Some will require institutional changes in rules or operating procedures or networks

Fostering the Ability to Change Based on New Information

- Creating Flexibility in Management Systems
  - FERC Relicensing Process Low Inflow Protocols – Catawba-Wateree DMAG
  - Revisit legal obligations
- Understanding the Potential Efficacy of Adaptation Strategies
  - Issues with adoption, implementation, acceptability across groups

Examples

- Integrated planning – improving coordination from state to local through mainstreaming
  - Revised storm water management calculations
  - Advanced Environmental Site Design with emphasis on storm water retention
  - Specific sections of state code that could be revised to enhance coordination
- Adaptation and Response Performance Measurement
  - Agency adaptation response planning and reporting

Summary

- Vulnerability Analysis
  - Sensitivity and Resilience to Exposures
- Opportunities to Increase Adaptive Capacity
  - Take advantage of new information and tools for learning about impacts
  - Develop strategies to process that new information and address multiple impacts
  - Build greater flexibility into long term management strategies
  - Improve understanding of stresses and the potential efficacy of adaptation options

Vulnerability Questions

- Changing demand
  - Adaptation strategies of users, such as agriculture, as well as population growth
- Where current dependency on groundwater is likely to fall short of need?
  - What would it take to provide water there?
- Are small water systems prepared to cope with changes?
- How will rate hikes affect groups within service population?
  - What strategies are available to reduce the impact?