Global change and adaptive water management: Review of concepts

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Global Change

- Climate change and variability
  - one, but not the only, dimension of global change
- Land use and land cover change
  - Expanding agriculture
  - Deforestation
  - Invasive species
- Urbanization
- Globalizing markets
- Knowledge and cultural integration, Internet

Global Change Symptoms

- Worldwide impacts, e.g., global warming
- Long-term, often irreversible effects, e.g., species extinction
- No “magic bullet” easy solutions
- Instead, difficult and gradual change
  - … the kind that decision-makers and politicians often hate

Climate Change & Variability

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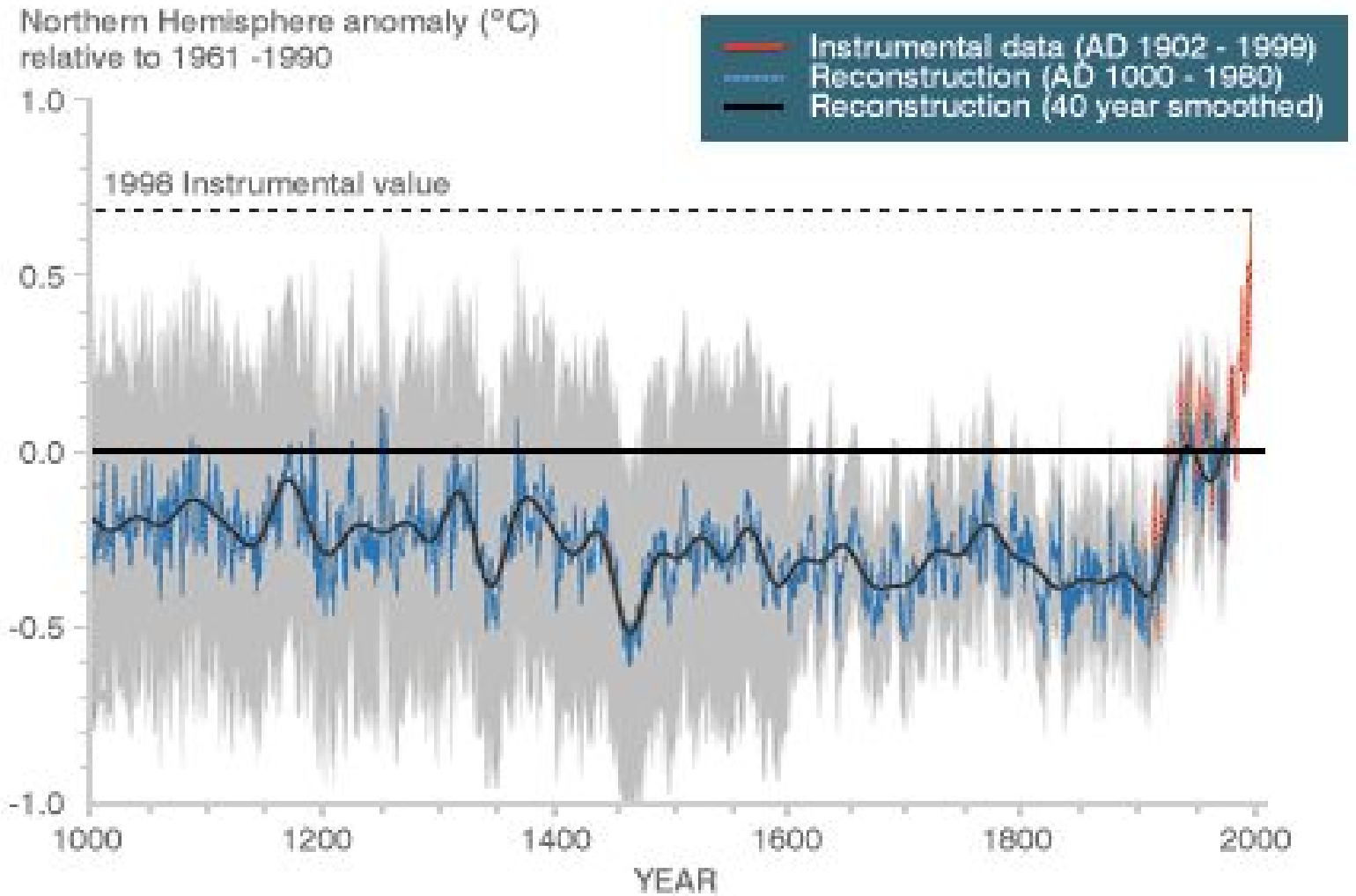
Climate Change



Millennial Northern Hemisphere (NH) temperature reconstruction (blue – tree rings, corals, ice cores, historical records) and instrumental data (red) from AD 1000 to 1999. A smoother version (black), and two standard error limits (grey) are shown. Source: IPCC Third Assessment Report

Economic Impacts of Climate Change

(Nicholas Stern Report, Nov. 2006)

- Extreme weather could reduce the global economy by up to 1% (=US$430 billion per year)
- A 2-3 degree C rise in temperatures could reduce global economic output by over US$1 trillion
- 5 degree C rise: up to US$4 trillion lost, with poorest countries disproportionately hit
- To stabilize at manageable levels, emissions would need to stabilize in the next 20 years and fall between 1% and 3% after that. This would cost 1% of GDP, or what extreme weather is expected to cost us.

Global warming: Causes and effects

Earth's temperature has risen about 1 degree Fahrenheit in the last century. The past 50 years of warming has been attributed to human activity.

Greenhouse gases are emissions that rise into the atmosphere and trap the sun's energy, keeping heat from escaping.

During the past 100 years global sea levels have risen 4 to 8 inches.

Burning fuels such as coal, natural gas and oil produces greenhouse gases in excessive amounts.

The United States was responsible for 20 percent of the global greenhouse gases emitted in 1997.

Most of the world's emissions are attributed to the United States' large-scale use of fuels in vehicles and factories.

Some predictions for local changes include increasingly hot summers and intense thunderstorms.

Damaging storms, droughts and related weather phenomena cause an increase in economic and health problems. Warmer weather provides breeding grounds for insects such as malaria-carrying mosquitoes.

Source: Environmental Protection Agency

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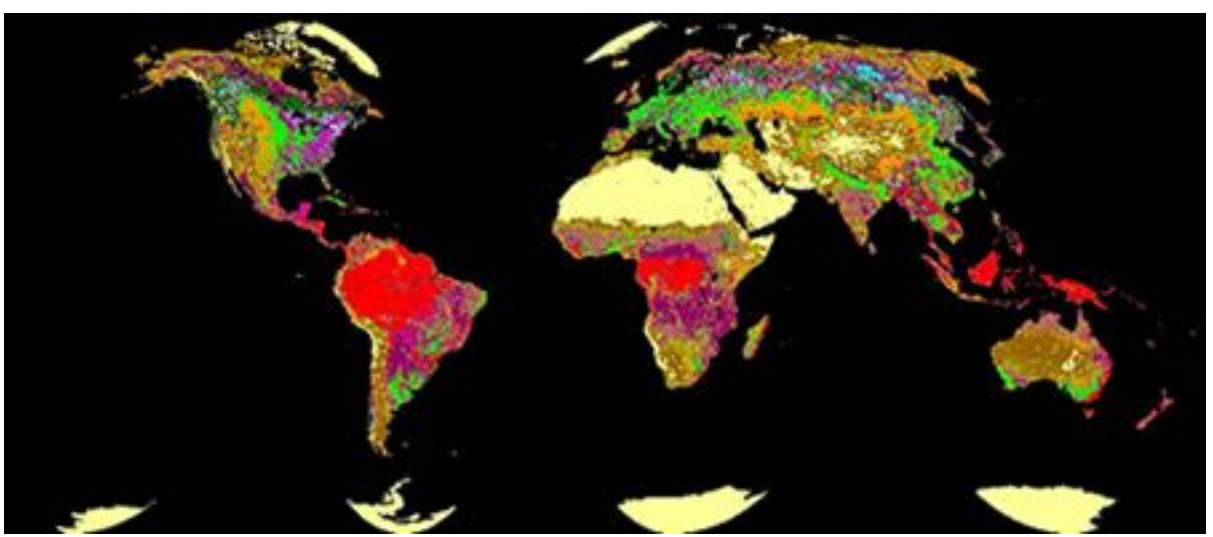
Ozone Depletion

- Chloro fluoro carbons (CFCs) in solvents and refrigerants banned after 50+ years of use
- **Montreal Protocol** in 1987 – signed by 49 countries
- Relatively easy adoption (relatively cheap alternatives existed)

Vanishing Wilderness

- Deforestation
  - Loss of forest area
  - Reduced biodiversity of “old growth”
  - Effects on hydrologic cycle
- Economic & societal benefits & costs

http://glcf.umiacs.umd.edu/
data/landcover/



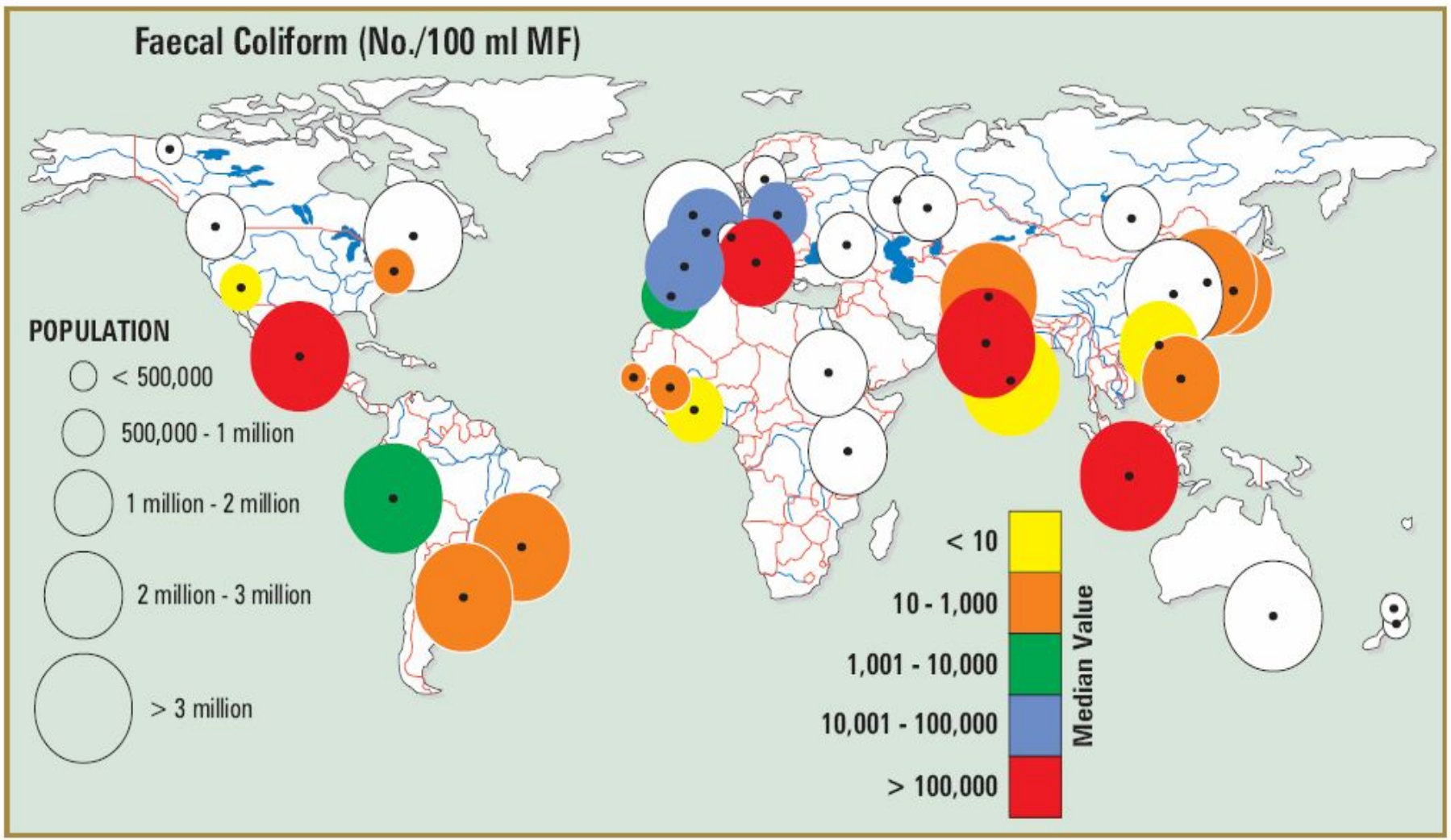
Agriculture & Fisheries under Stress

- Total food production is up; per capita production is down
- Sustainability issues with soil and water
- “Global fish stocks could be almost eliminated within 50 years if current trends continue, says a major scientific study… published i journal Science”

Pollution and Other Garbage

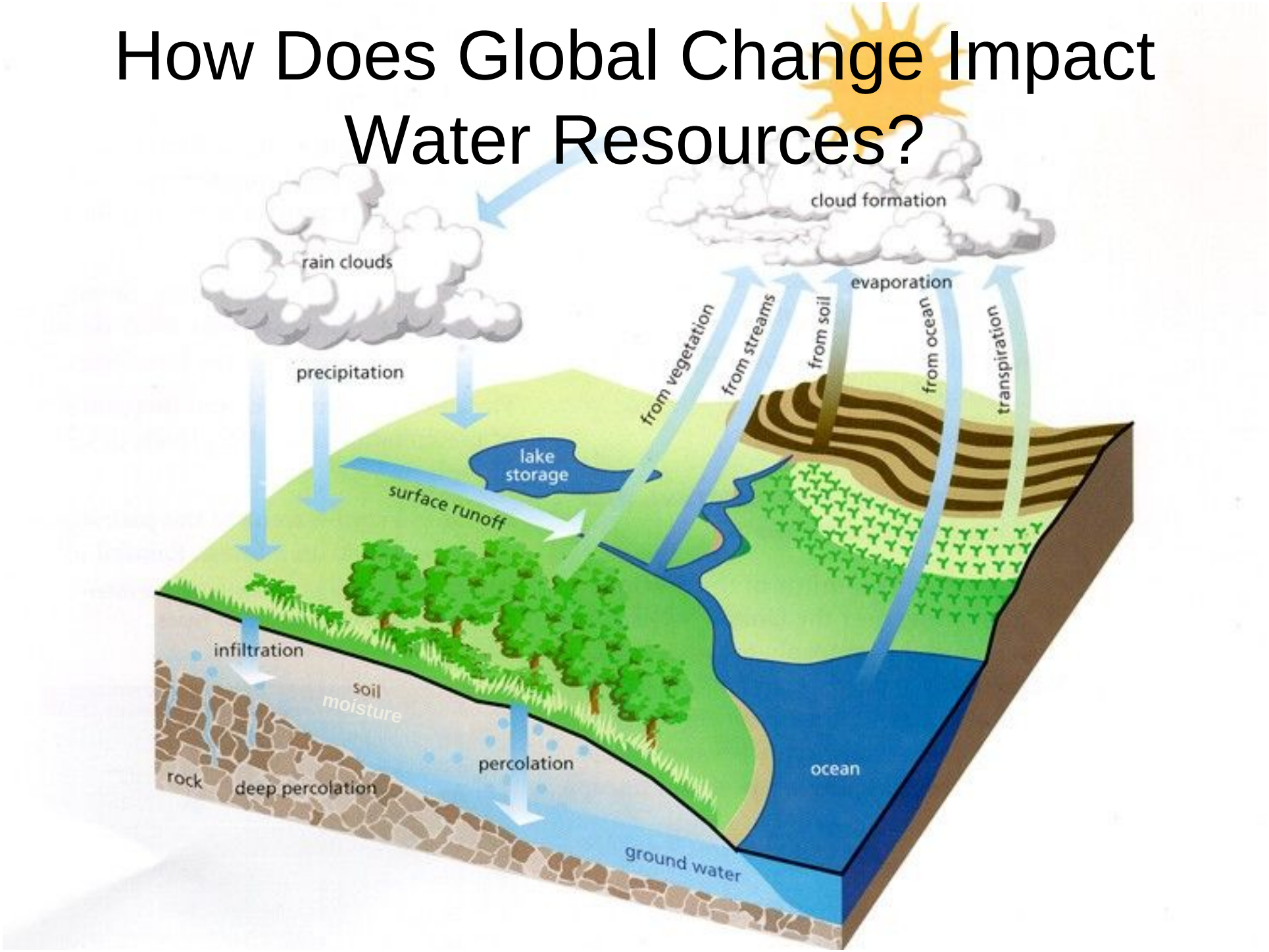
- Solid waste
- Air pollution
- Ecosystems assimilate wastes and pollution, but limits to capacity
- Polluters or consumers to blame?

Pollution a Global Threat to Health and the Environment

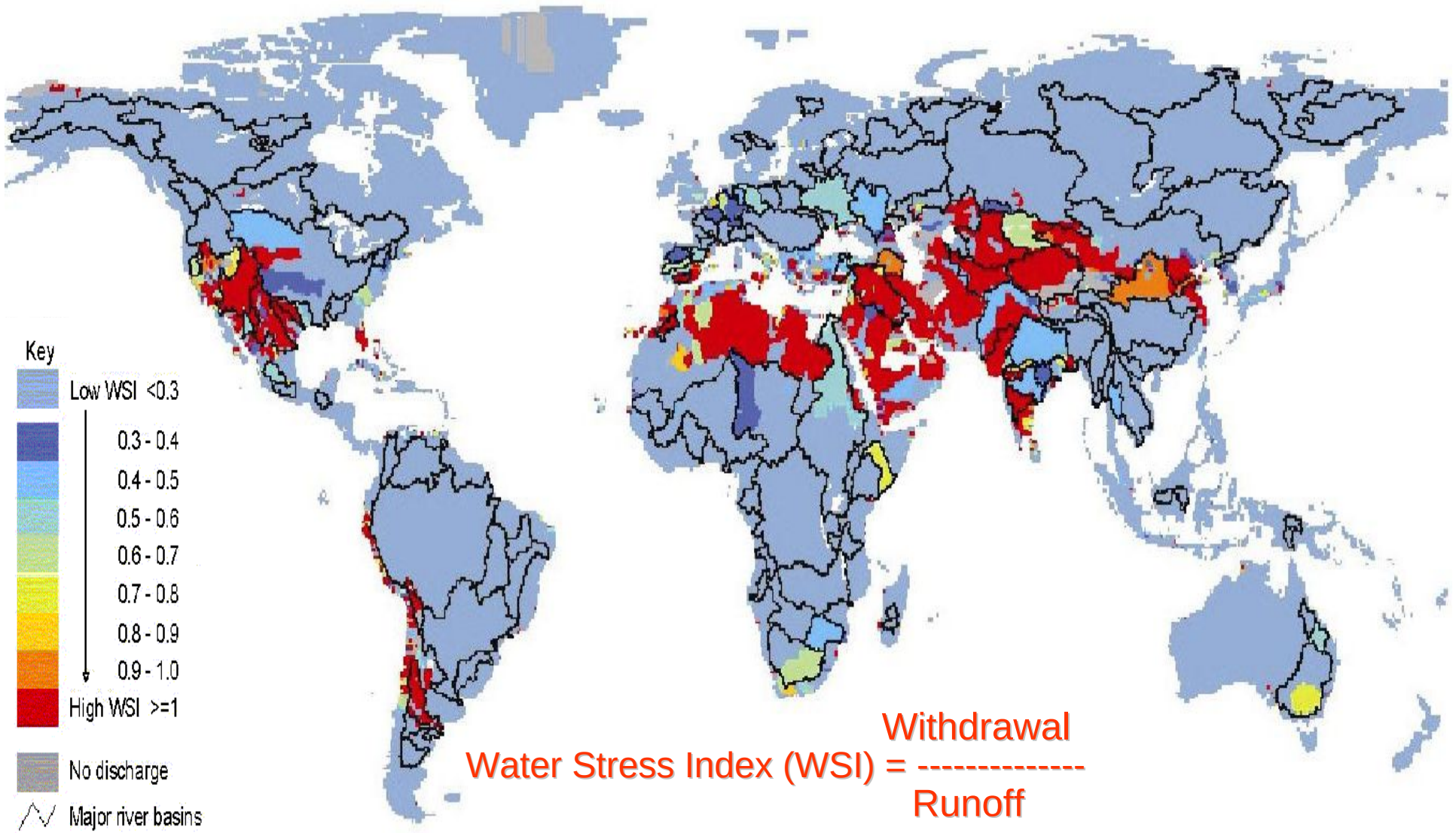


Source: UNEP Global Environment Monitoring System (GEMS) Water Programme

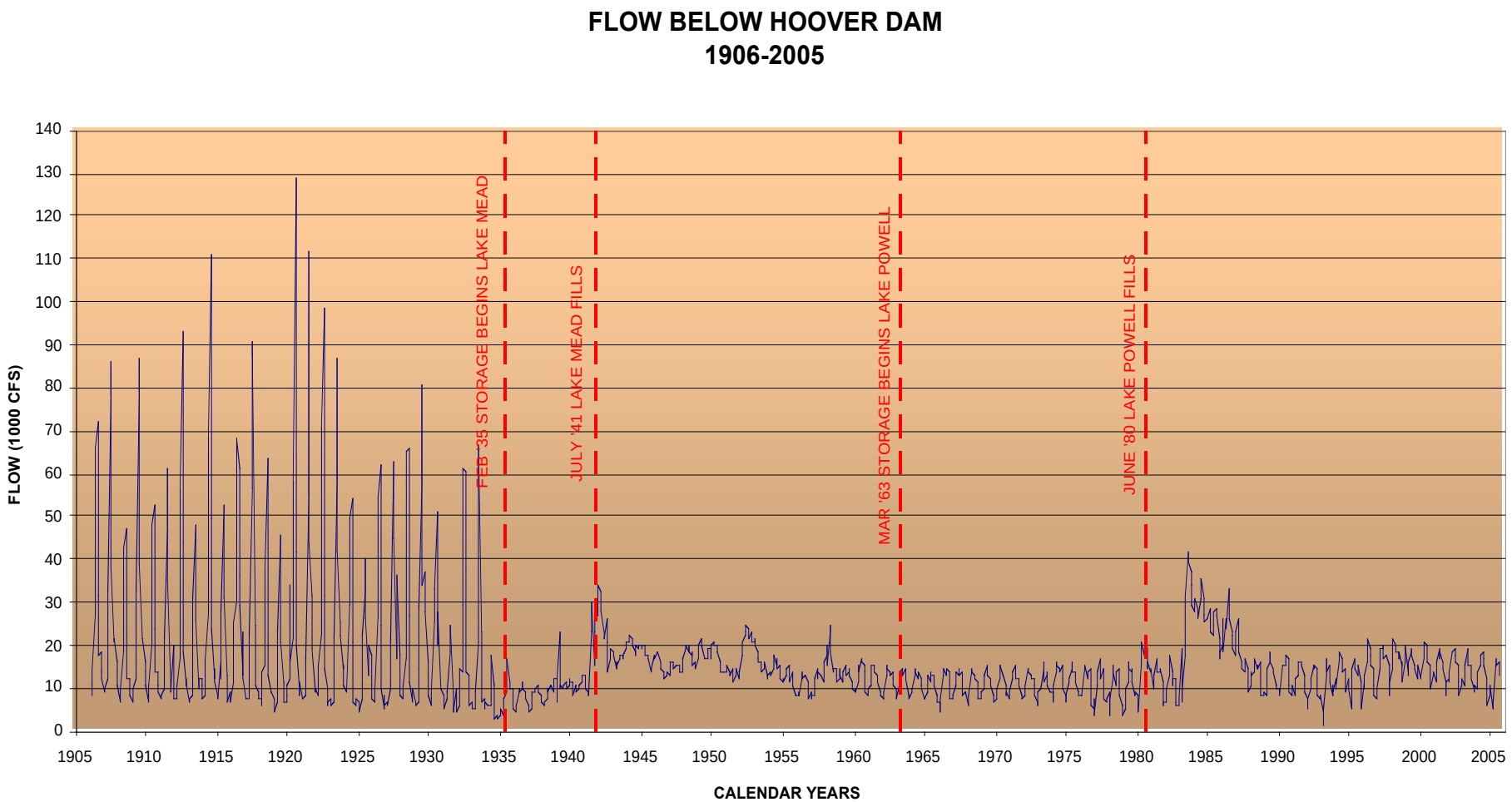
How Does Global Change Impact Water Resources?



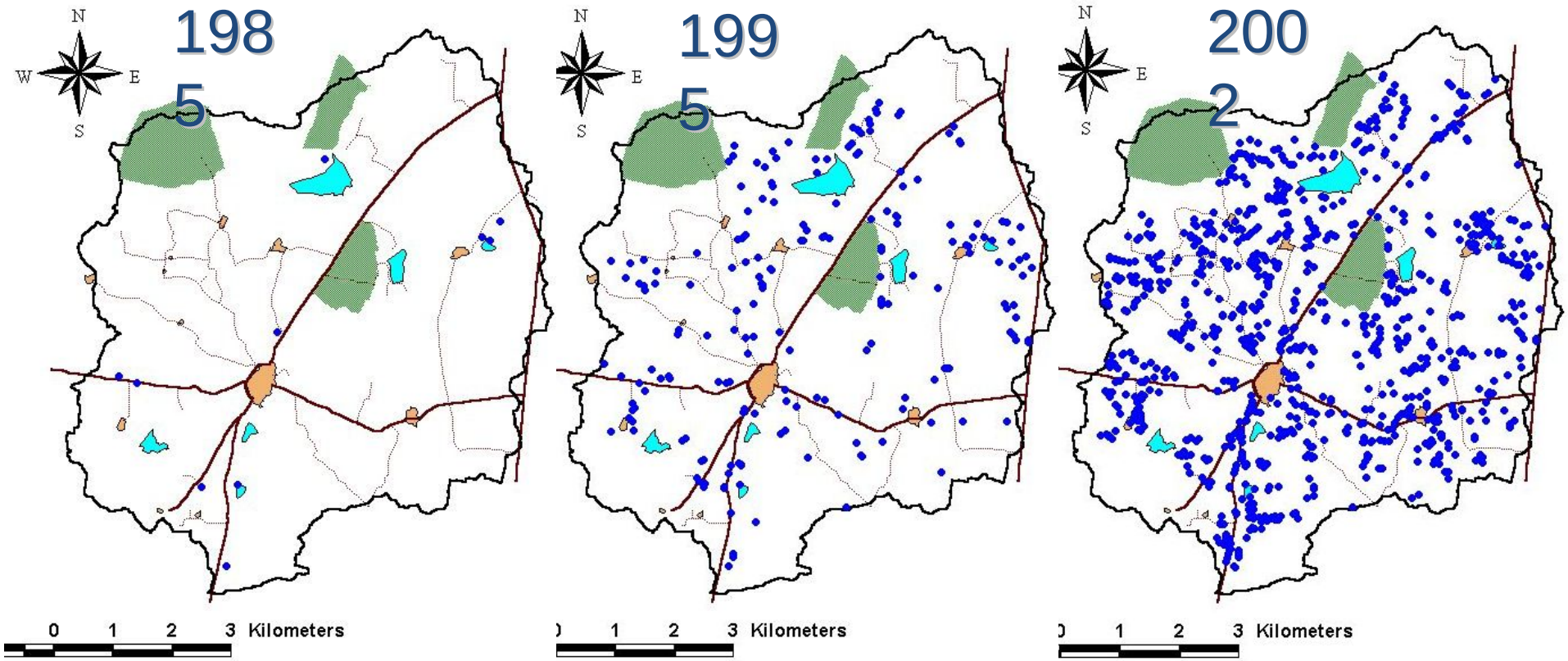
Human Use of Water is Increasingly in Conflict with the Environment



Colorado River (629,000 km^2)

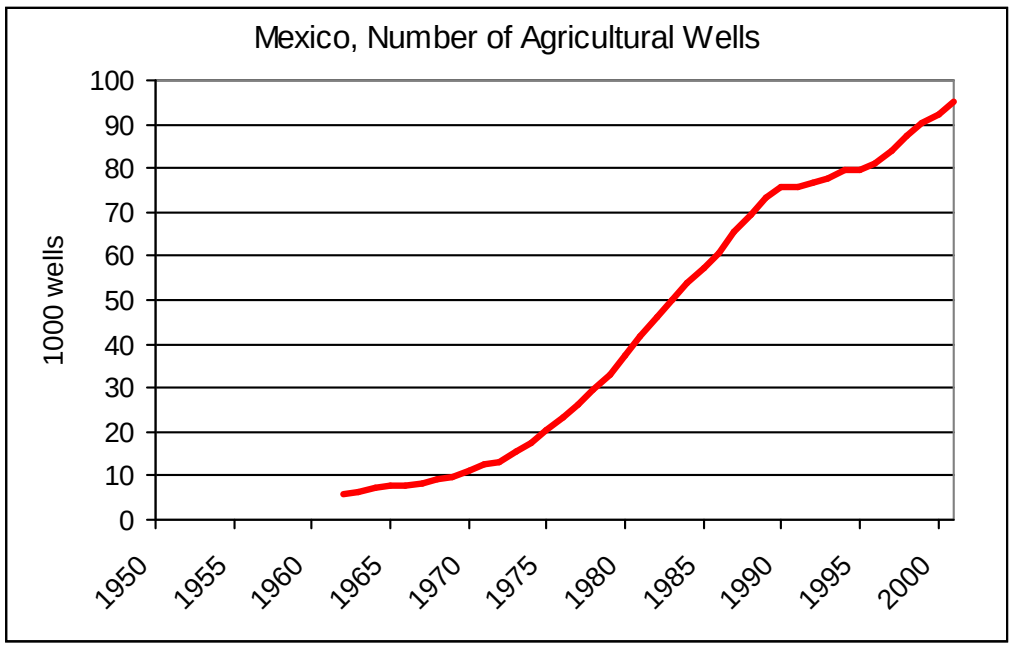


Well Density Increasing

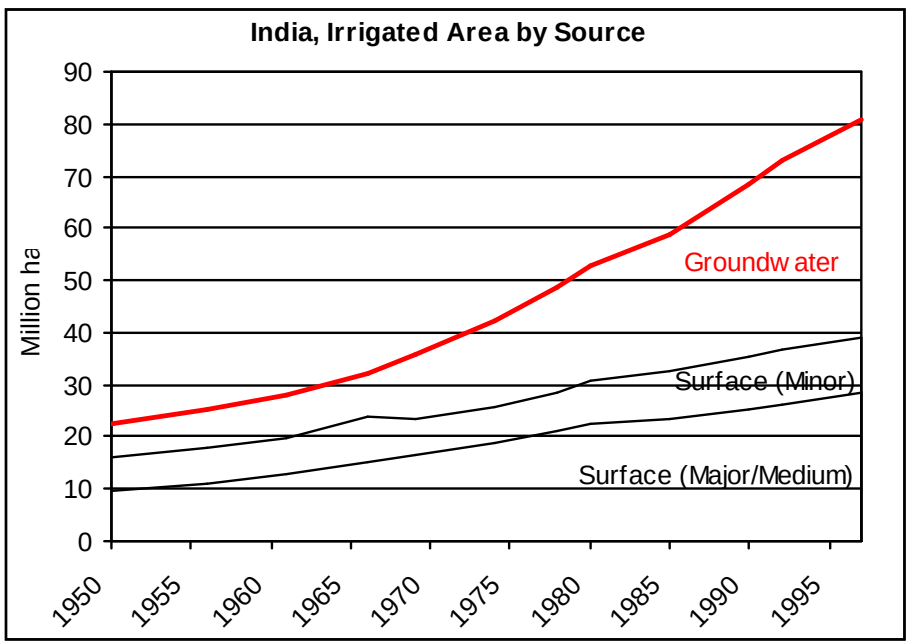


Groundwater Boom

Number of Wells in Mexico

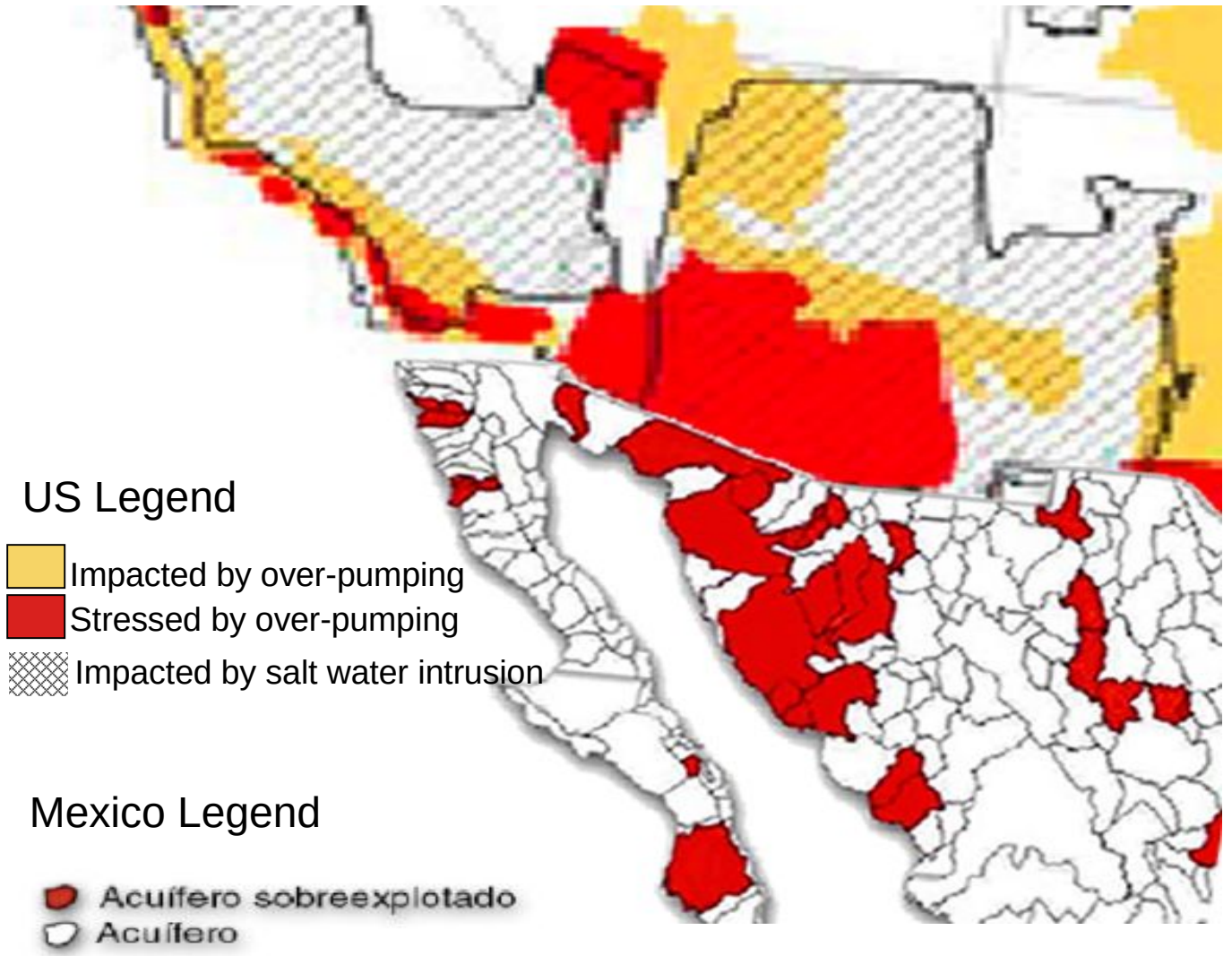


GW Irrigation in India



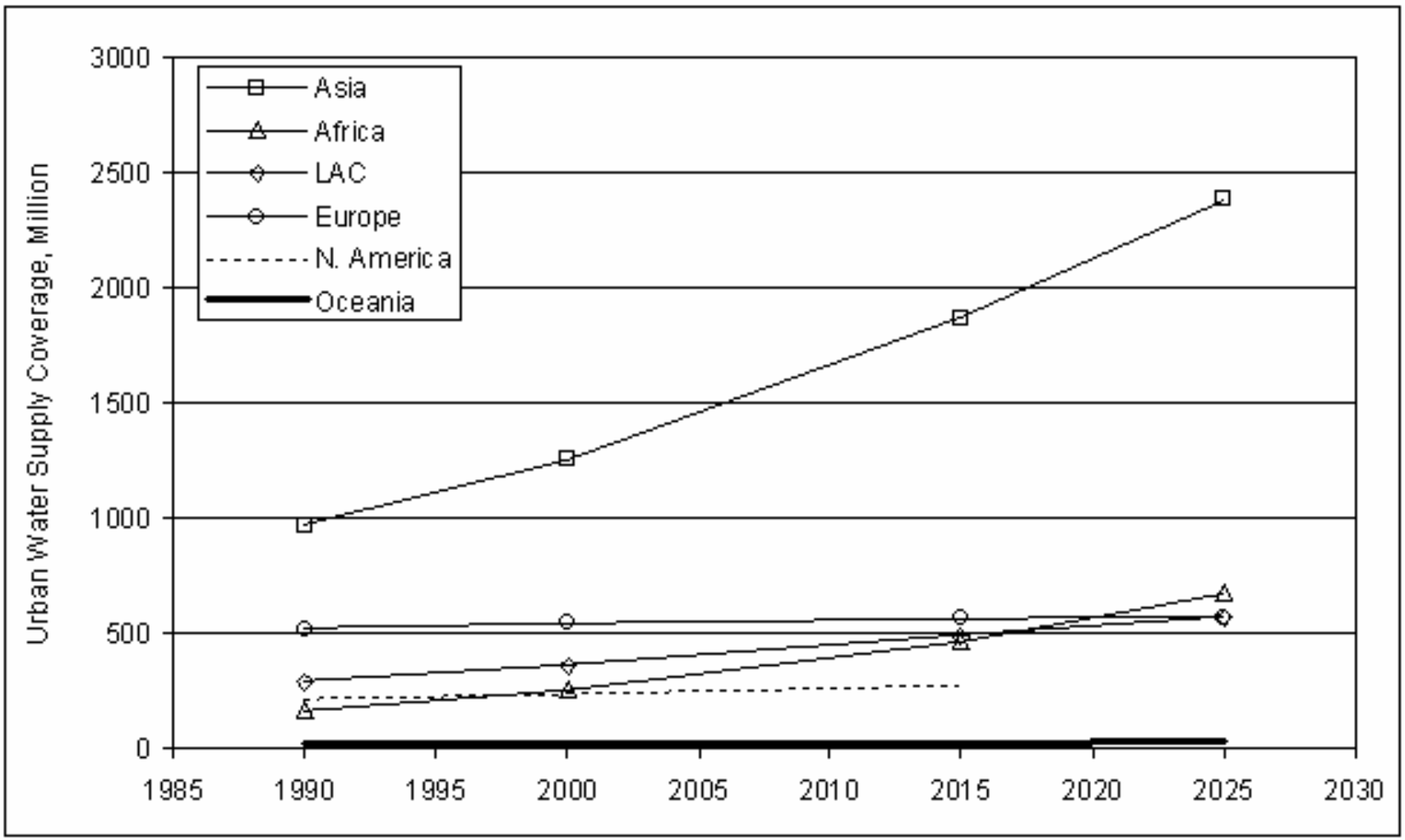
1950 – 2000: 290% increase in area irrigated more than once, i.e., during dry season

Aquifer Overdraft

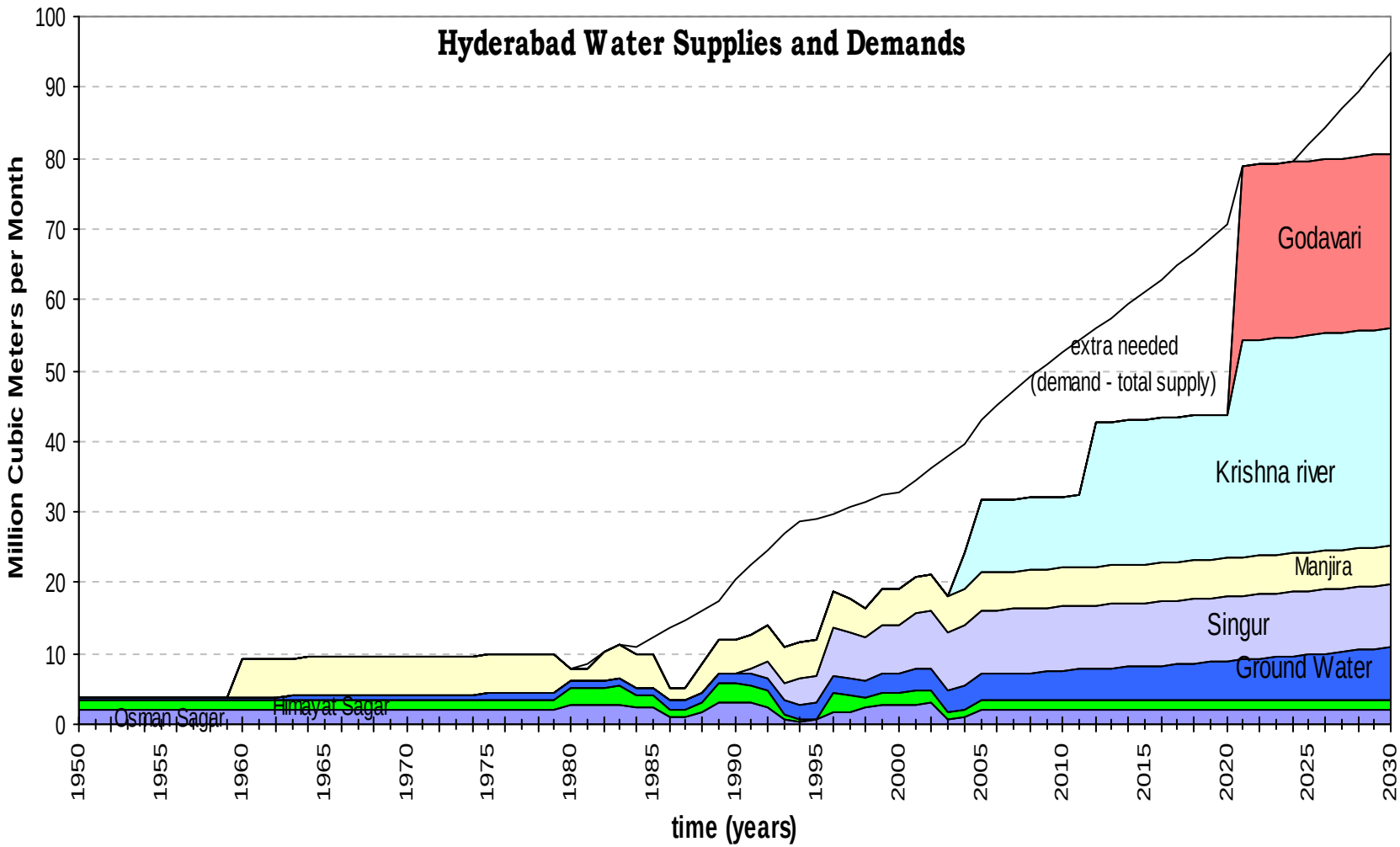


*Student question: hydraulic “fracking”?

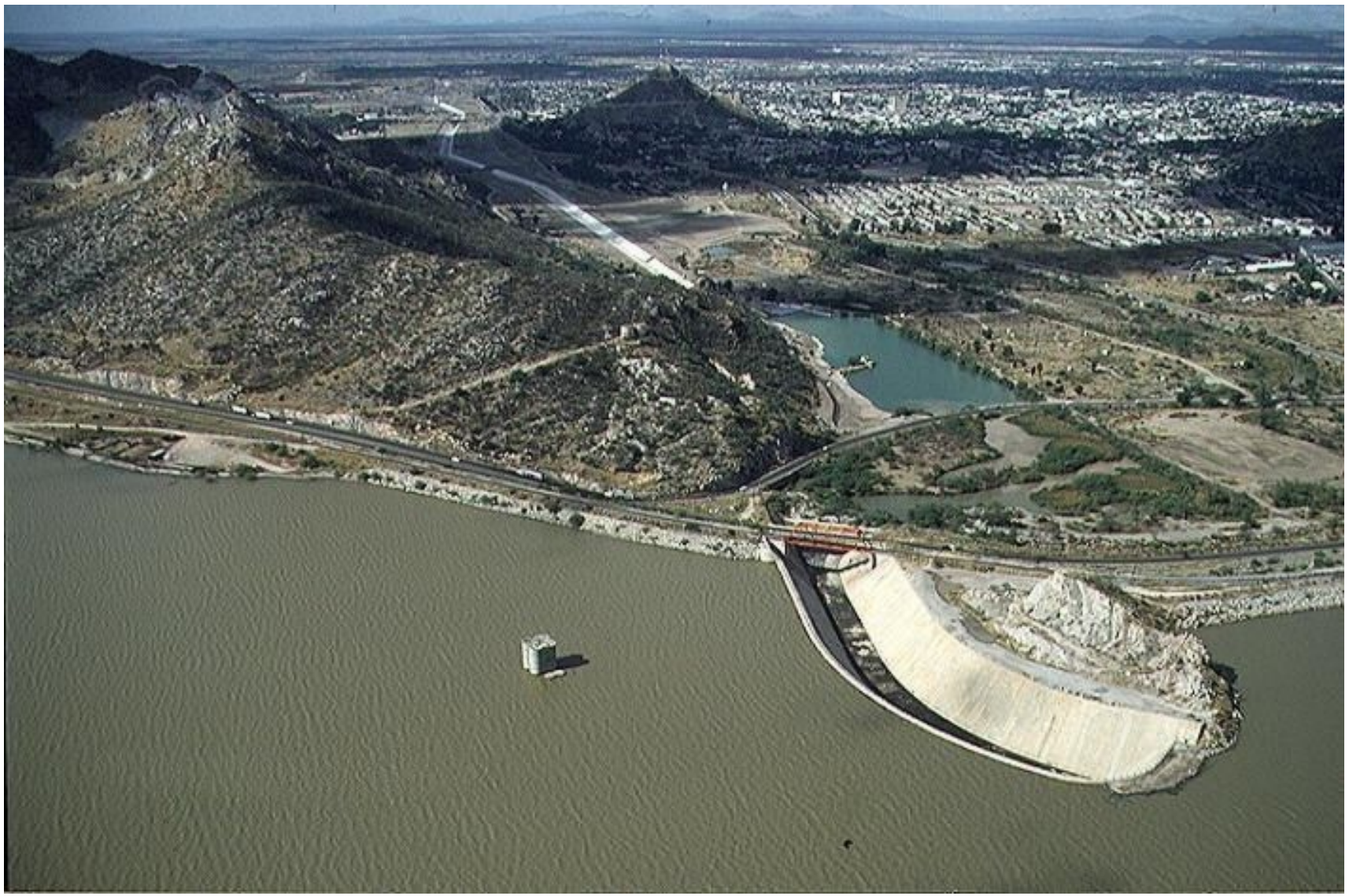
Growth in Urban Water Supply Coverage



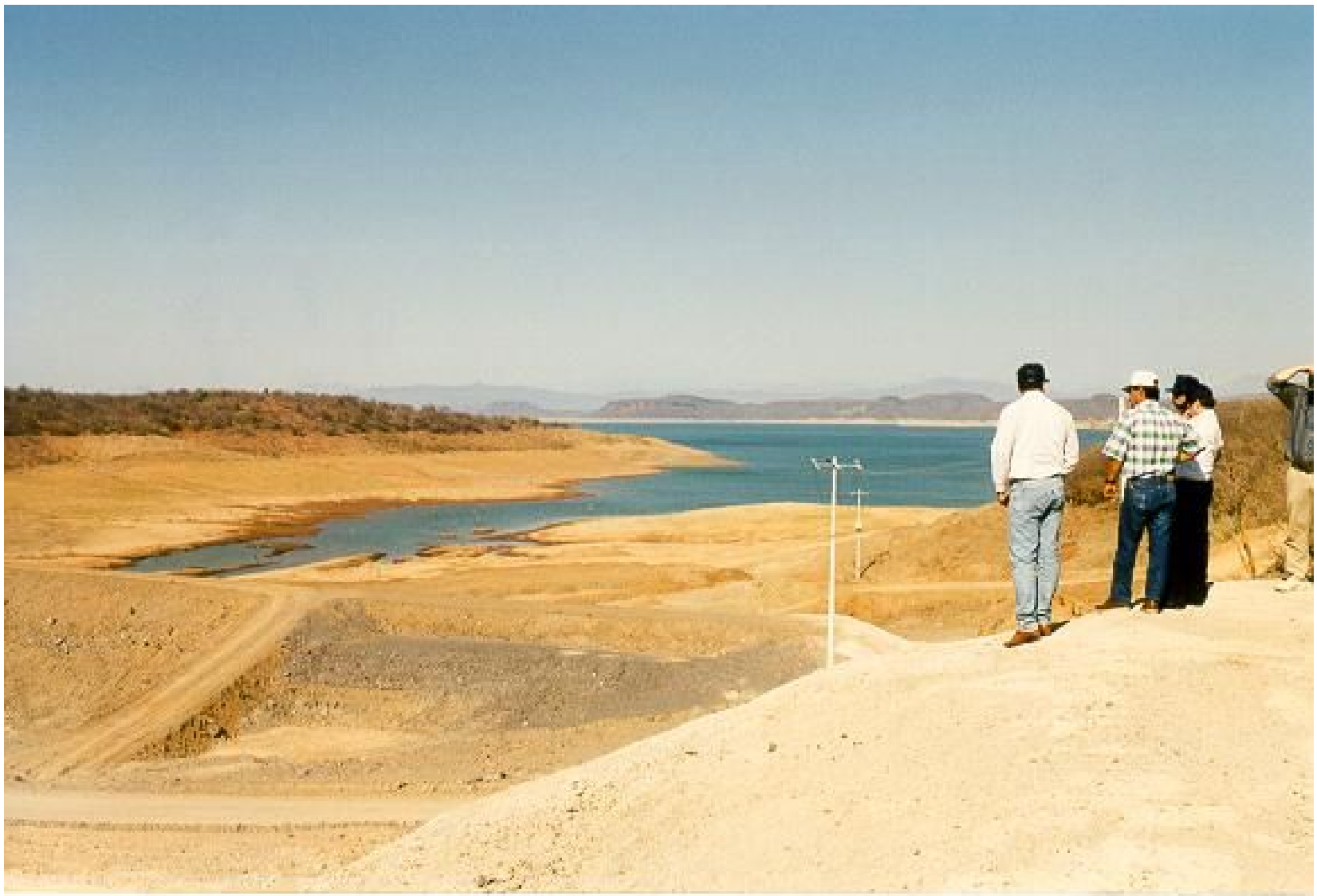
Urban Water Demand Growth



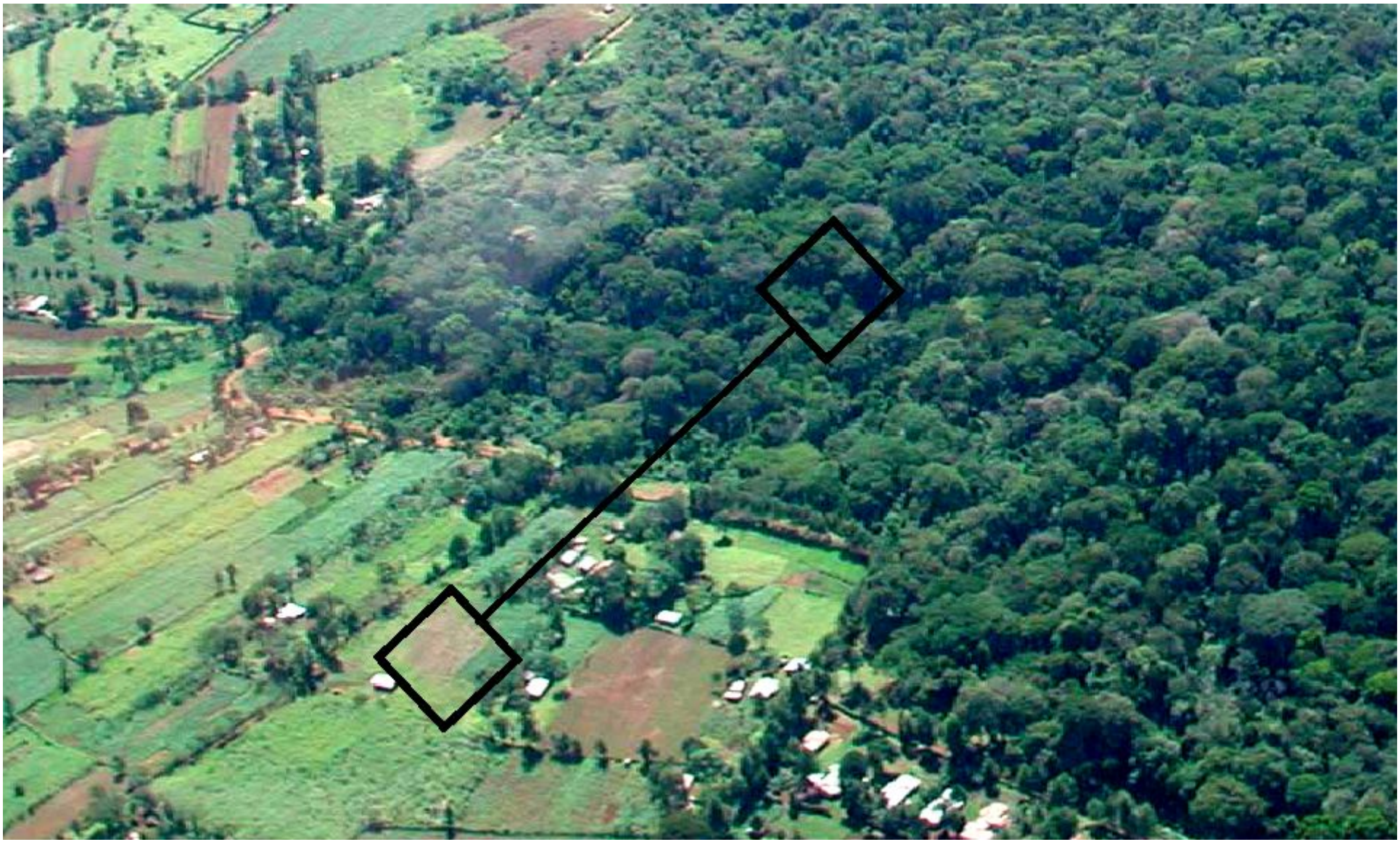
Urban residential (drinking) water often has priority over other uses



Water scarcity resulting from competition



Land Use Change



Ecosystem Change

- Natural selection
- Coevolution
- Compartment model
  - Maturity
  - Stability
  - Think resilience – the ability of an ecosystem (or social system) to encounter shocks or stresses and re-establish functions and services
- Monoculture
- Biodiversity

Sociocultural Systems

- Culture
  - Paradigms
  - Knowledge, beliefs
  - Language
- Social structure
  - Institutions (not same as organizations)
  - Socio-economic class
  - Politics
- Material infrastructure
  - Wealth
  - Technology
- How do these influence human-environment interactions?

Desafíos en las Américas

- Escasez de agua
  - hidroclimatológica
  - uso humano
- Inseguridad energética
- Adaptación
  - ciencia y política
  - redes
- Gobernanza
  - intersectorial
  - transfronteriza
  - inter-regional

Challenges in the Americas

- Water scarcity
  - hydroclimatological
  - human use
- Energy insecurity
- Adaptation
  - science & policy
  - networks
- Governance
  - intersectoral
  - transboundary
  - cross-regional

Desafios nas Américas

- Escassez de água
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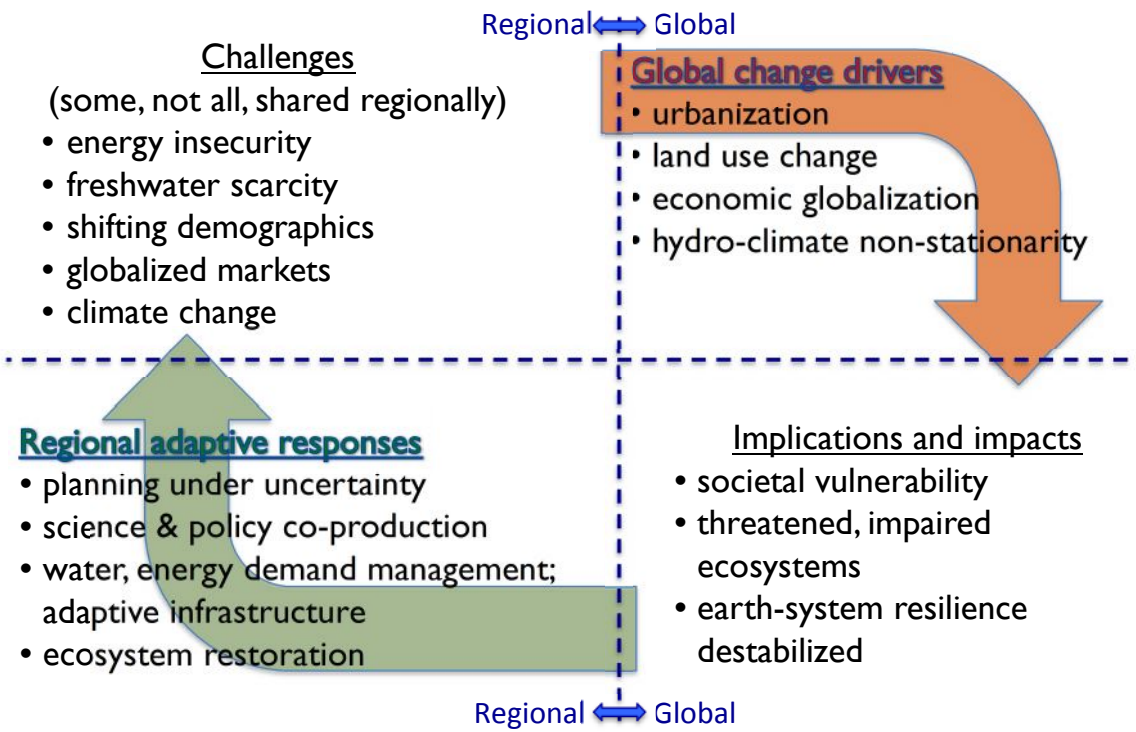
Adaptation and Social-Ecological Resilience

Science – policy approach to global-change drivers

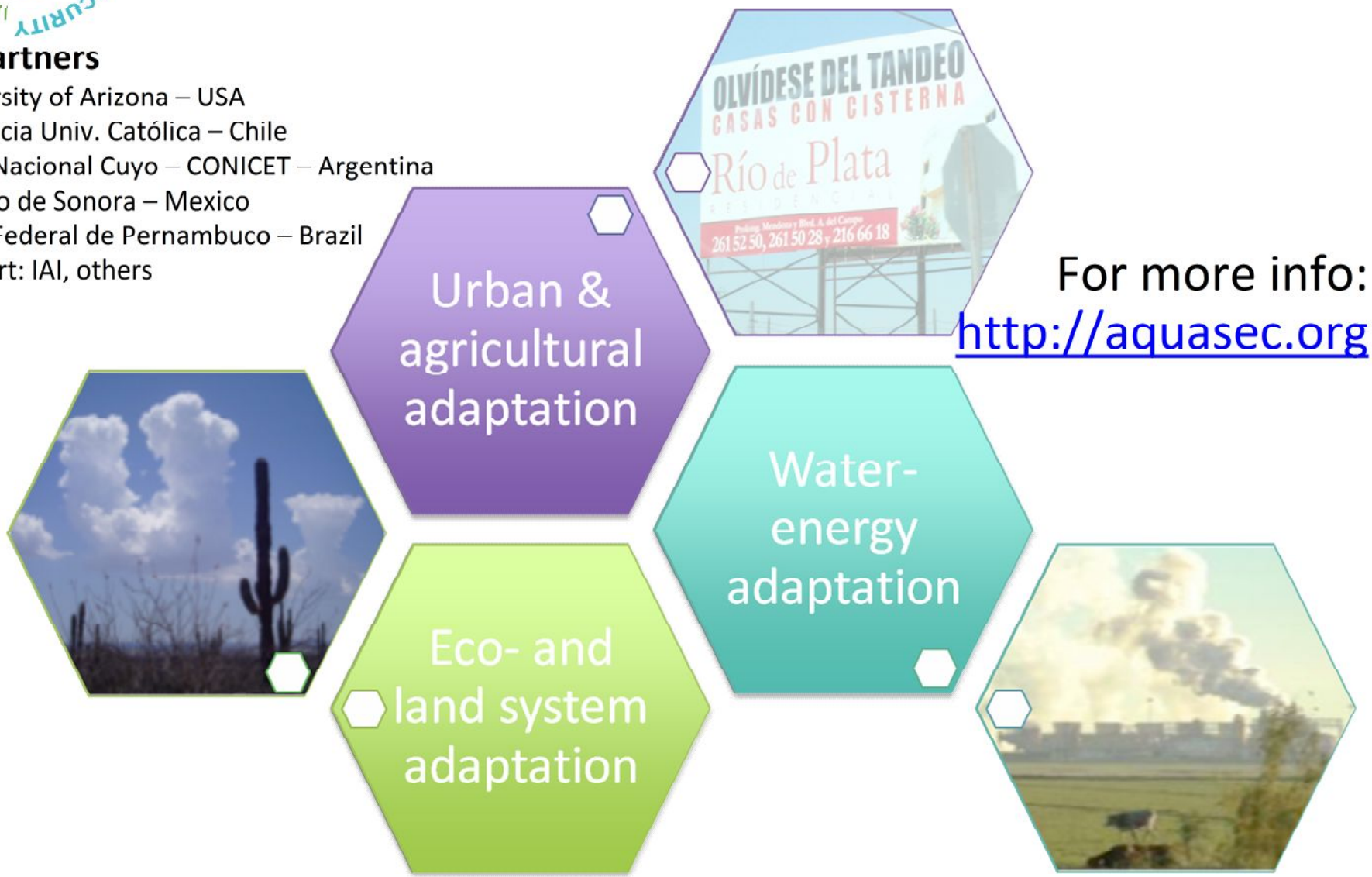


AQUASEC Center of Excellence for Water Security

Linked adaptation strategies in the arid Americas

Key Partners

- University of Arizona – USA
- Pontificia Univ. Católica – Chile
- Univ. Nacional Cuyo – CONICET – Argentina
- Colegio de Sonora – Mexico
- Univ. Federal de Pernambuco – Brazil
- Support: IAI, others



For more info:
http://aquasec.org

What is Adaptation?

- Conventionally understood as complementary to mitigation (e.g., of emissions causing climate change)
- A means to address and incorporate uncertainty, not attempt to overcome it
- Considers systems as dynamic
  - Interlinking human-biophysical interactions
- Non-linear
  - Multiple potential outcomes, not 1-to-1 deterministic, hysteresis (system memory)
- Non-stationary
  - Statistical relations between climate, hydrology, and water resources are evolving, sometimes in poorly understood ways

Adaptation & Resilience

- Adaptive cycle (C.S. Hollings, Lance Gunderson)
- Change is eposidic, caused by inter-action of fast and slow variables.
- Spatial attributes are patchy and discontinuous; can not scale up from small to large simply by aggregation.
- Ecosystems have multiple equilibria. Destabilizing forces maintain diversity and resilience, stabilizing forces create productivity.
- Policies that apply fixed rules will lead to loss of resilience in ecosystems.

Adaptation & Resilience

- Adaptive cycle (C.S. Hollings, Lance Gunderson)

- r = exploitation, rapid colonization of recently disturbed areas (r often exponential growth)
- K = conservation, sustained plateau or maximum population
- These two make up traditional theory of ecological succession
- Authors add two new dimensions that close the loop (making the infinity symbol)
- Omega = release = creative destruction, accumulation of biomass and nutrients becomes overconnected, fragile, until a release, such as drought, fire, or pests.
- Alpha = reorganization = soil processes minimize nutrient loss so available for next phase of exploitation, condition of greatest uncertainty
- Front-loop stage = from r to K, slow, incremental phase of accumulation and growth

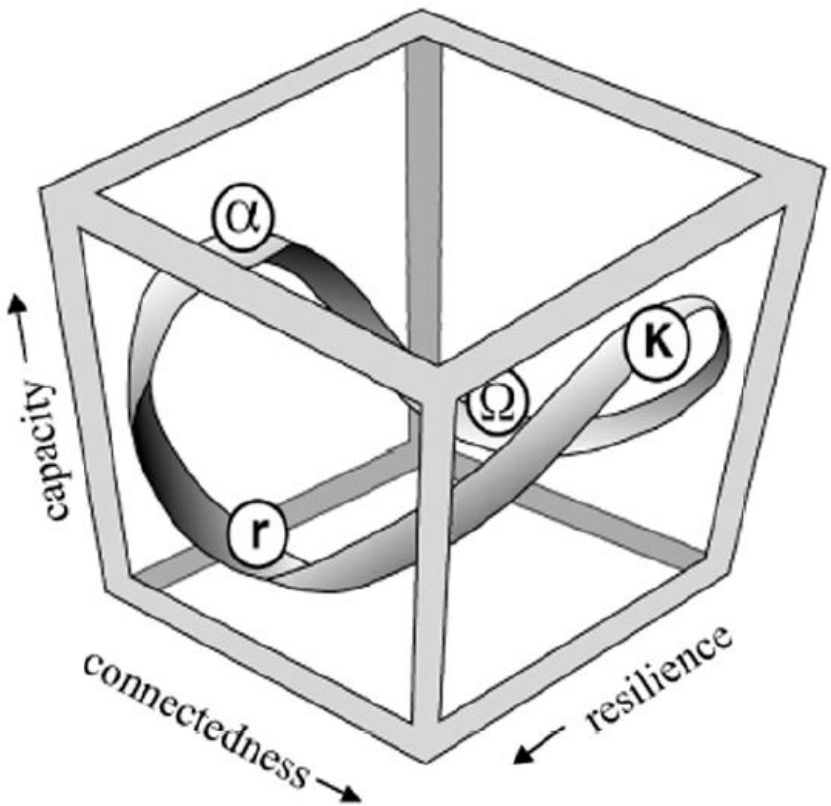


Figure 1 Adaptive Management Cycle in three dimensions showing capacity, connectedness and resilience. Source: Holling and Gunderson, 2002

Adaptive Water Management

- Social & institutional learning
  - "Learning to manage while managing to learn" (Claudia Pahl-Wostl)
- Multiple techniques to address uncertainty, including Scenario Planning, will be presented during this Training Institute