Humans Altering the Water Cycle

GTN-Hydrology Meeting

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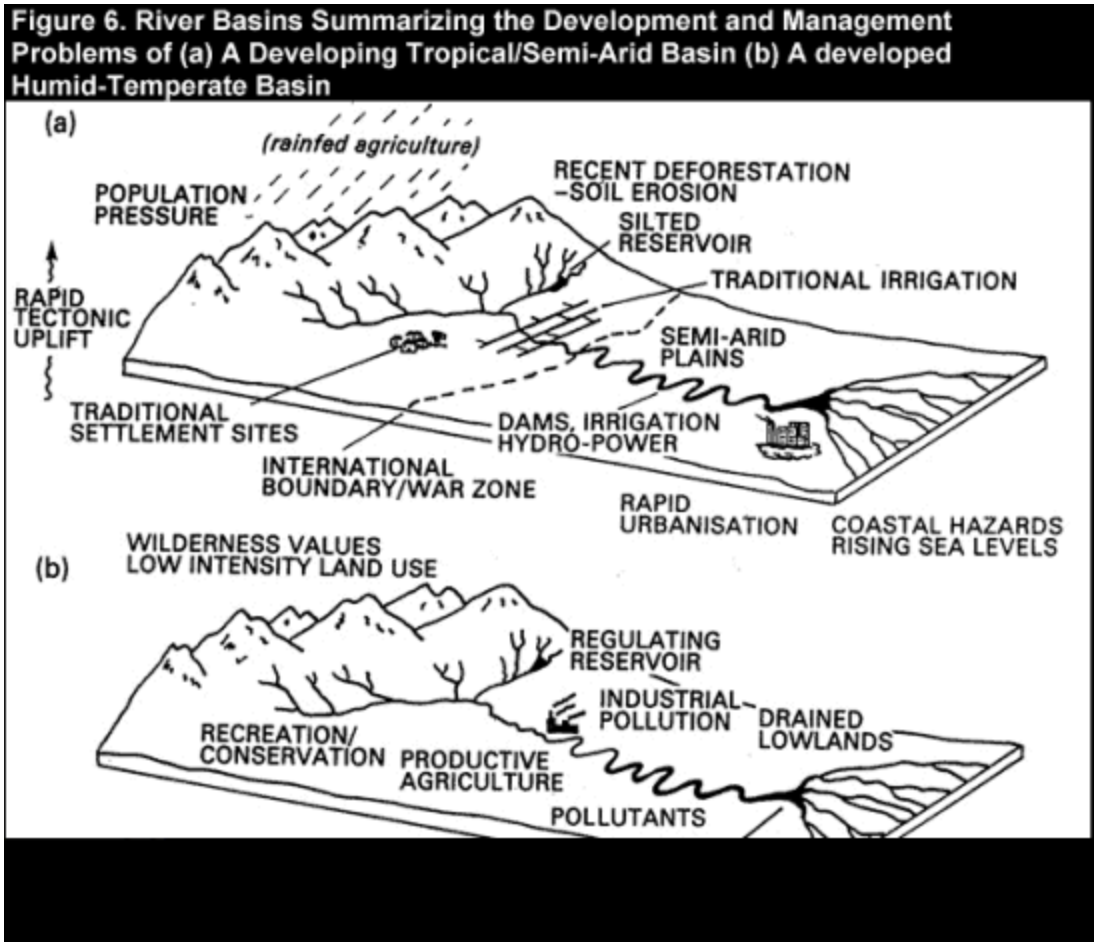
Outline

- Abstraction for DIA
- Water management infrastructure
- Land cover change
- Institutions & pricing
- Climate change
- Reciprocal linkages:
  - Humans settle in moist but not too moist zones
  - Water quality

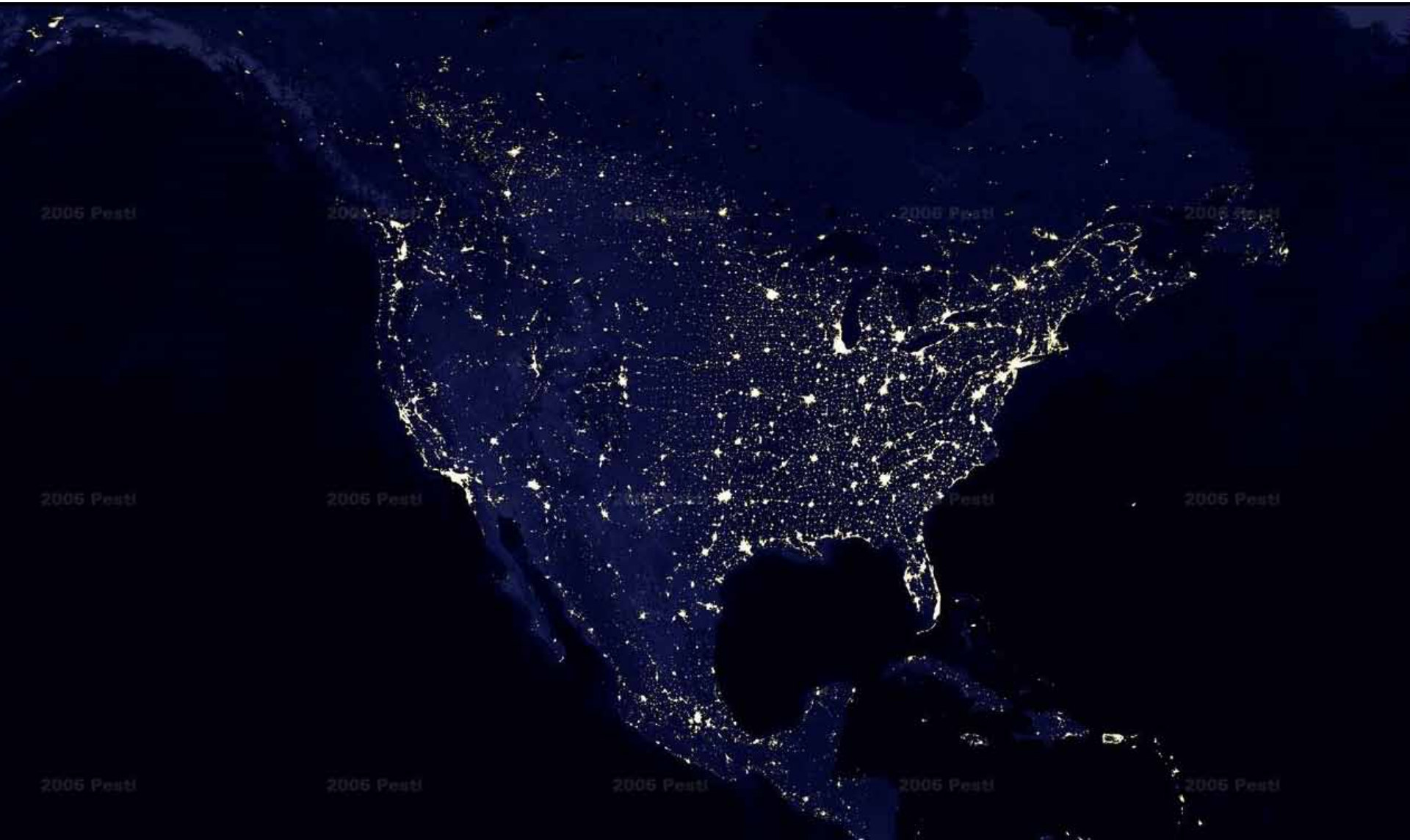
Schematic of Human Activities in Hypothetical River Basins



Source: Acreman, M. 1998 “Principles of Water Management for People and the Environment,” *In: Water and Population Dynamics: Local Approaches to a Global Challenge*. de Sherbinin & Dompka (eds.). Washington, DC: AAAS.

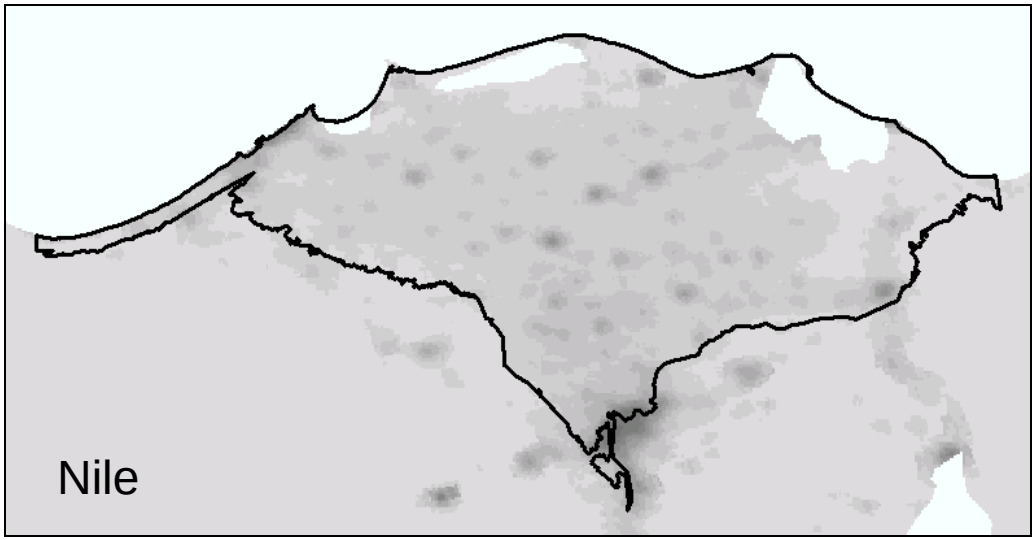
ABSTRACTION FOR DIA

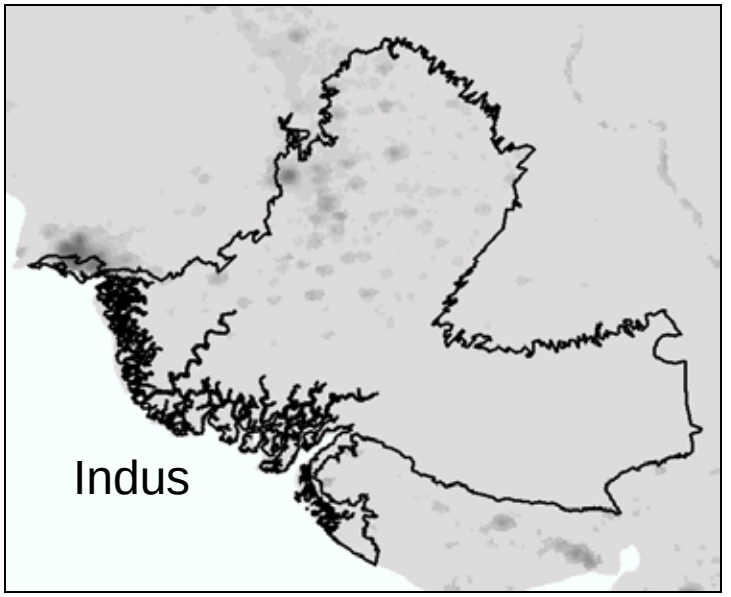
Night-time Lights as a Proxy for Domestic/Industrial Use

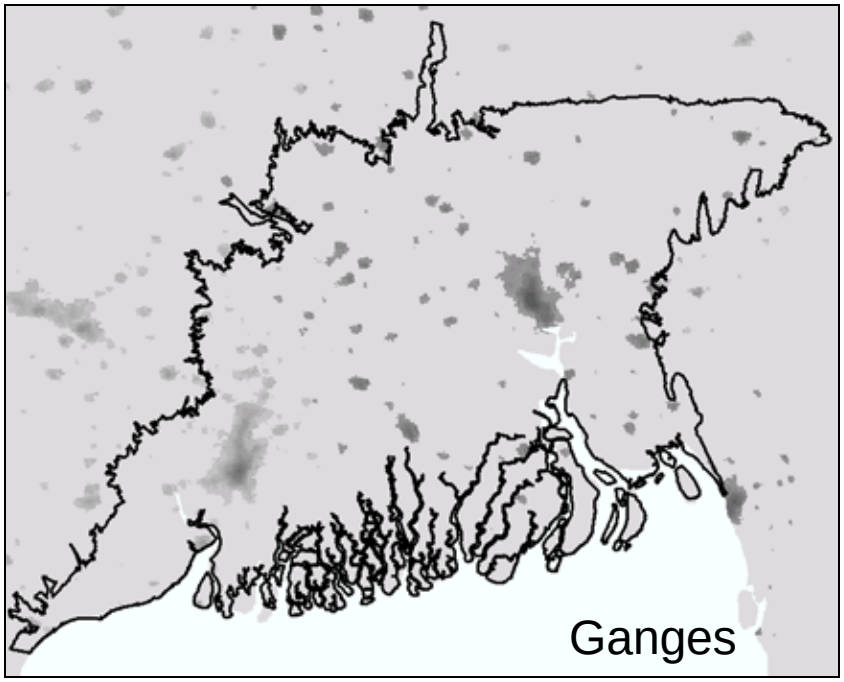


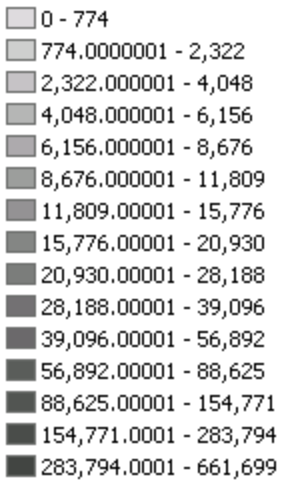
GDP: Proxy for Domestic & Industrial Use

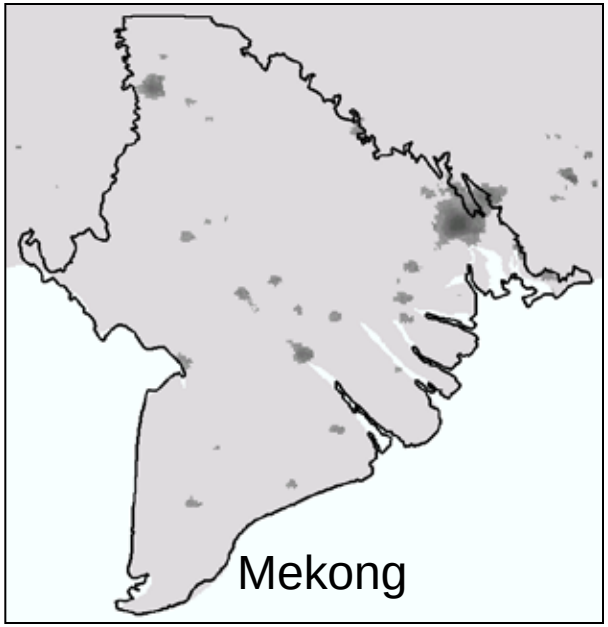
Source: Sutton & Costanza, 2001

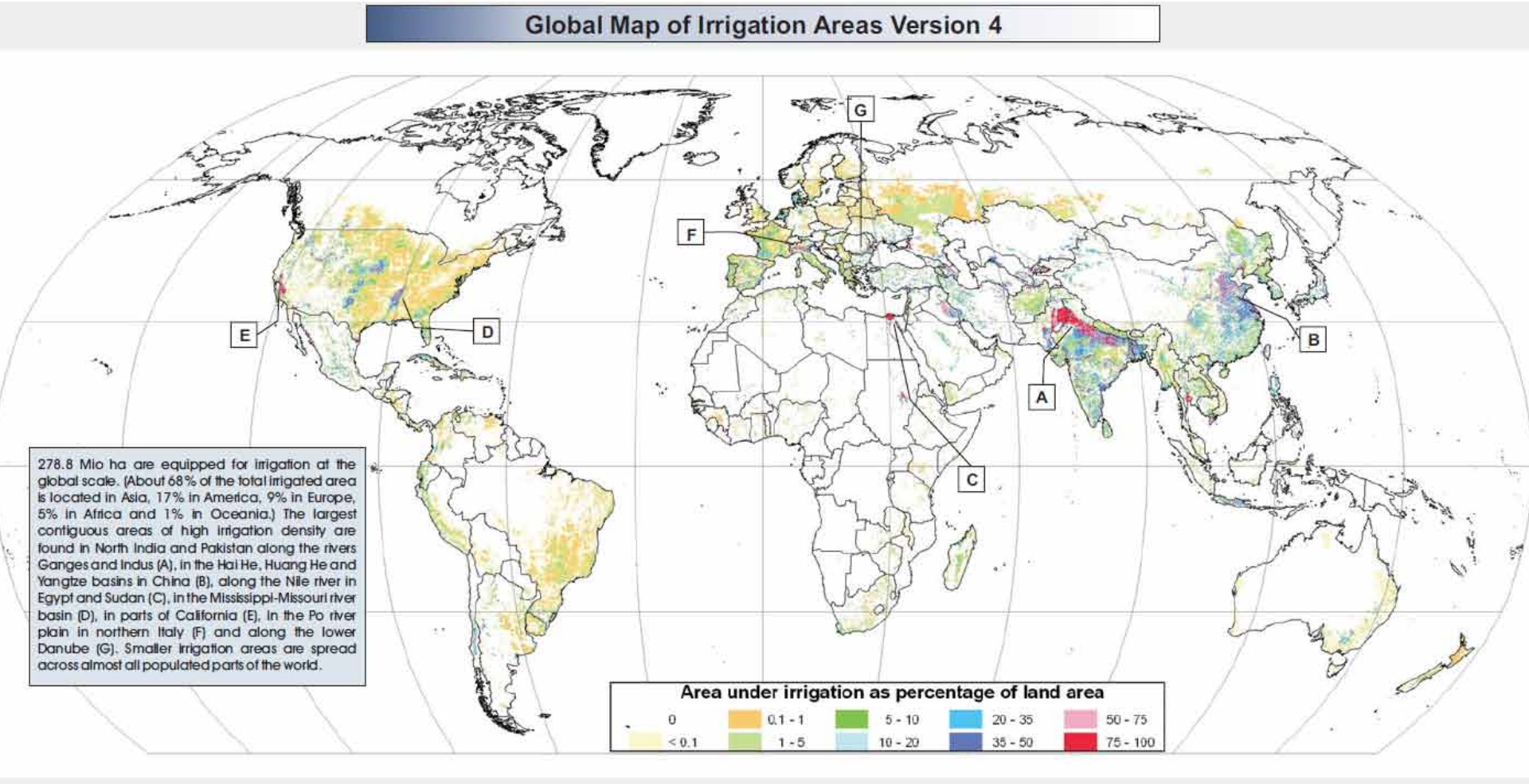








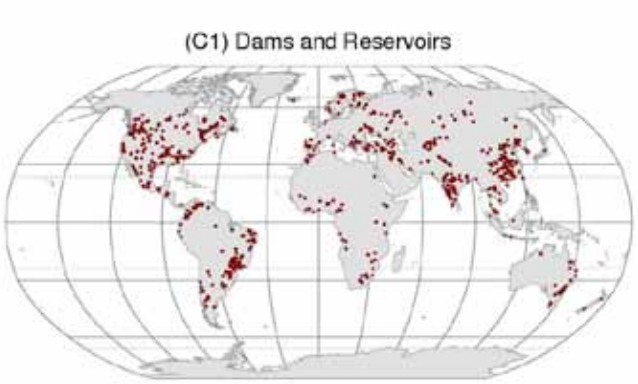




Source: Siebert, Doll, et al. Global Map of Irrigation Areas. University of Frankfurt and FAO.

WATER MANAGEMENT INFRASTRUCTURE

Flow Stabilization



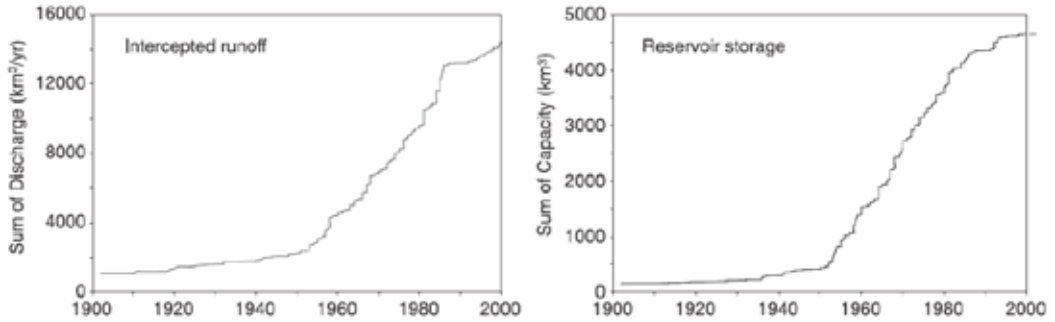


Figure D2. World's Largest Reservoirs

The time series here represent a subset of the world's largest reservoirs (>0.5 km³ maximum storage each), representing about 70% of impounded volume globally (ICOLD and IWPDC archives).

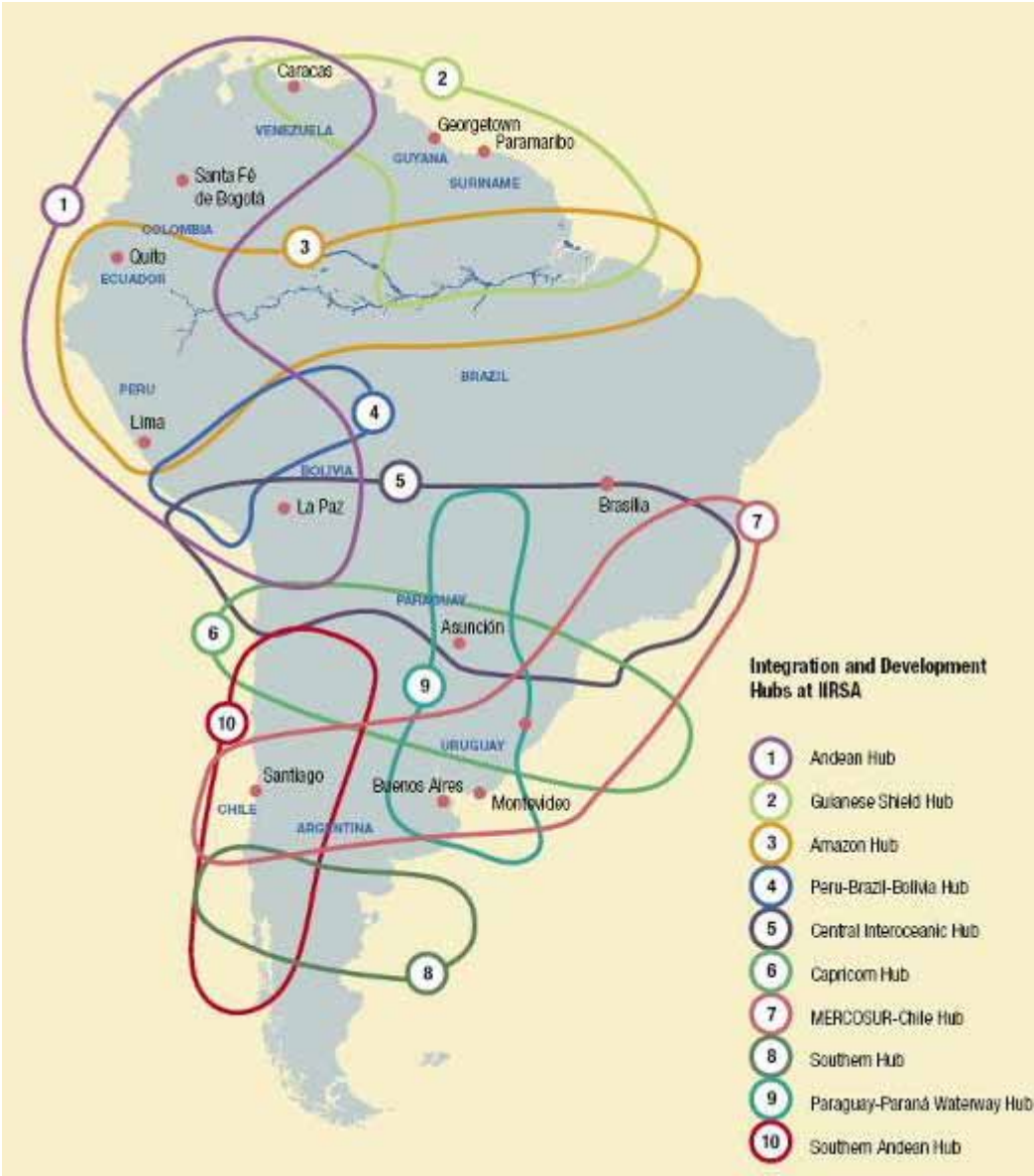
Country	Residence time all dams (in years)	Country	Residence time all dams (in years)
Egypt	31.0	Macedonia	1.4
Lesotho	10.6	Zambia	1.0
South Africa	7.2	Libya	1.0
Kyrgyzstan	4.3	Kazakhstan	0.6
Ghana	4.1	Tunisia	0.6
Morocco	4.1	North Korea	0.6
Tajikistan	3.2	Spain	0.6
Azerbaijan	2.9	Cyprus	0.6
Iraq	1.7	Albania	0.5
Turkey	1.7	Argentina	0.5

- 40,000 large dams, ~800,000 small dams
- **Positive effects:** water for irrigation, industry, and domestic purposes; flood control; hydroelectricity
- **Negative effects:** fragmentation and destruction of habitat; loss of species, health impacts from stagnant water; loss of sediments and nutrients to downstream systems

Source: Vorosmarty. 2006 Pilot Environmental Performance Index.

South America: IIRSA

- Initiative for the Integration of Regional Infrastructure in South America (IIRSA)
- **Purpose**: Regional integration; launched in 2000
- **EIA:** More than 360 infrastructure projects, mainly transportation (roads, ports, airports, waterways, bridges, and railroads) and energy (hydropowers, gas pipelines, and transmission lines). Each project will require a separate assessment.
- **Estimated Impacts:** Will directly impact ~ 2.5 million km^2 in South America, including, just in Brazil, 137 conservation units, 107 indigenous areas, and 484 areas considered of high priority for conservation due to biodiversity.

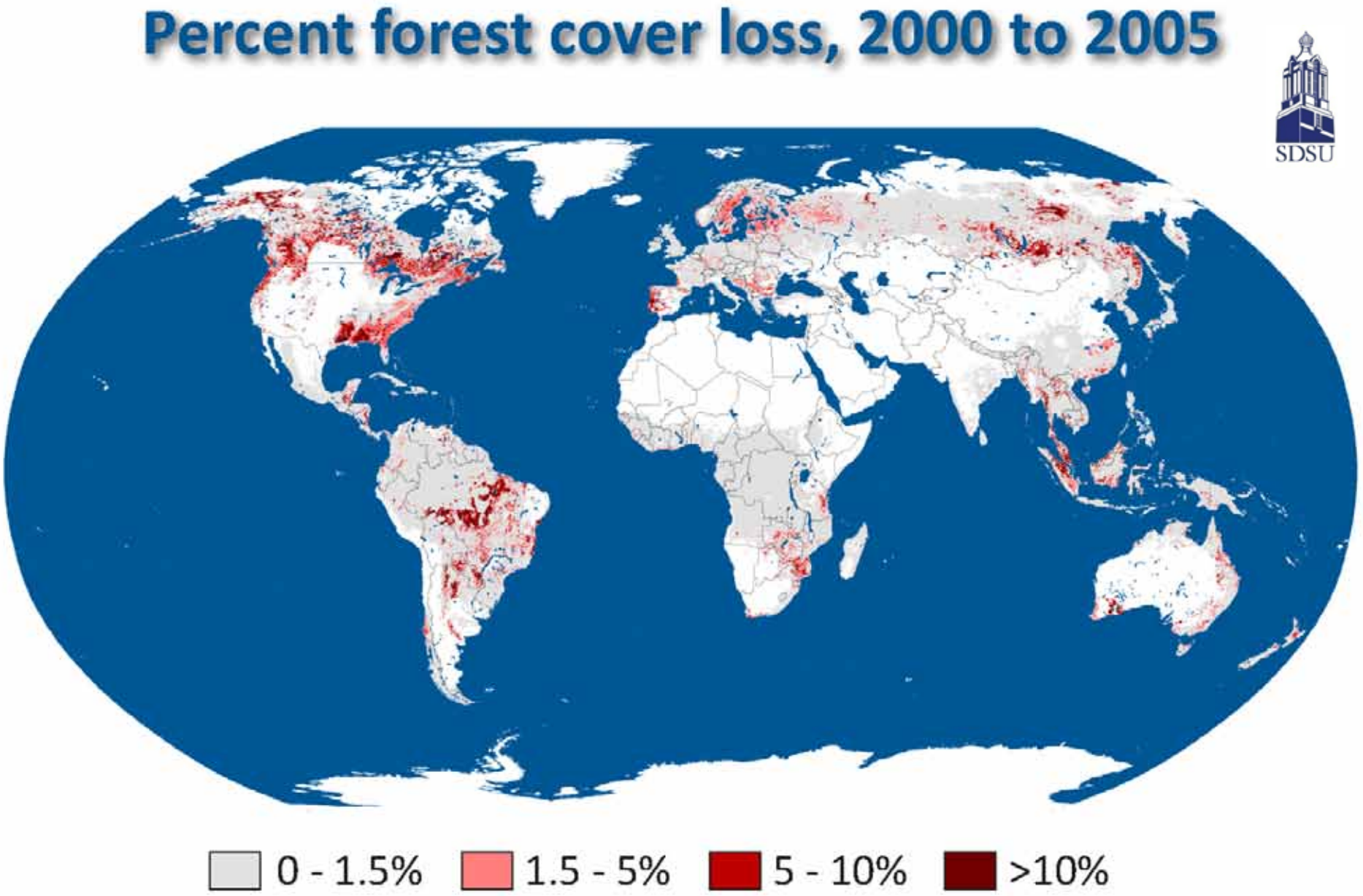


LAND COVER CHANGE

Land Cover Change

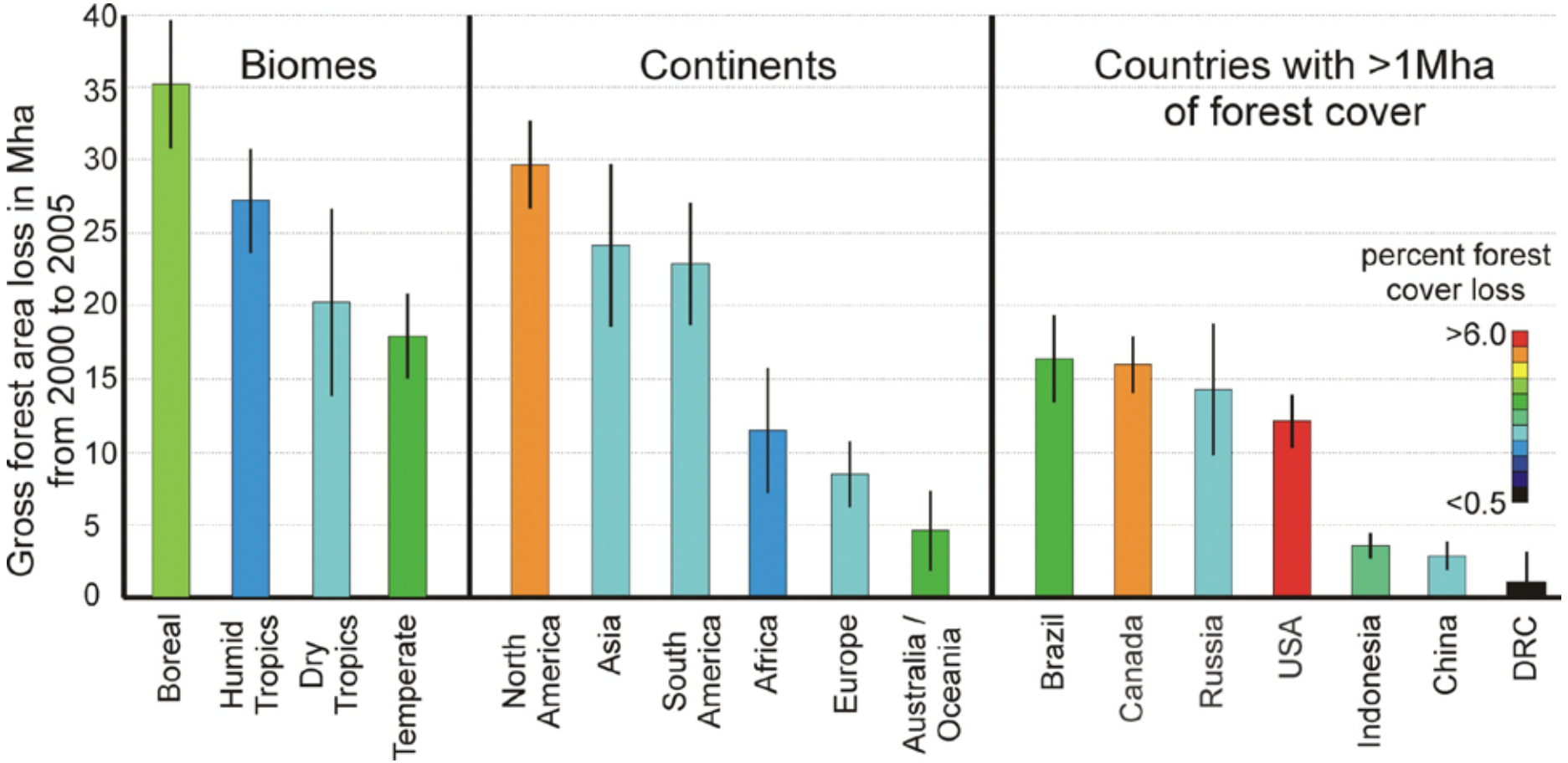
- Affects:
  - Evapotranspiration
  - Infiltration rates
  - Runoff quantity
  - Runoff timing

Land Cover Change



Source: Matthew Hansen, South Dakota State University

Global gross forest cover loss, 2000 to 2005



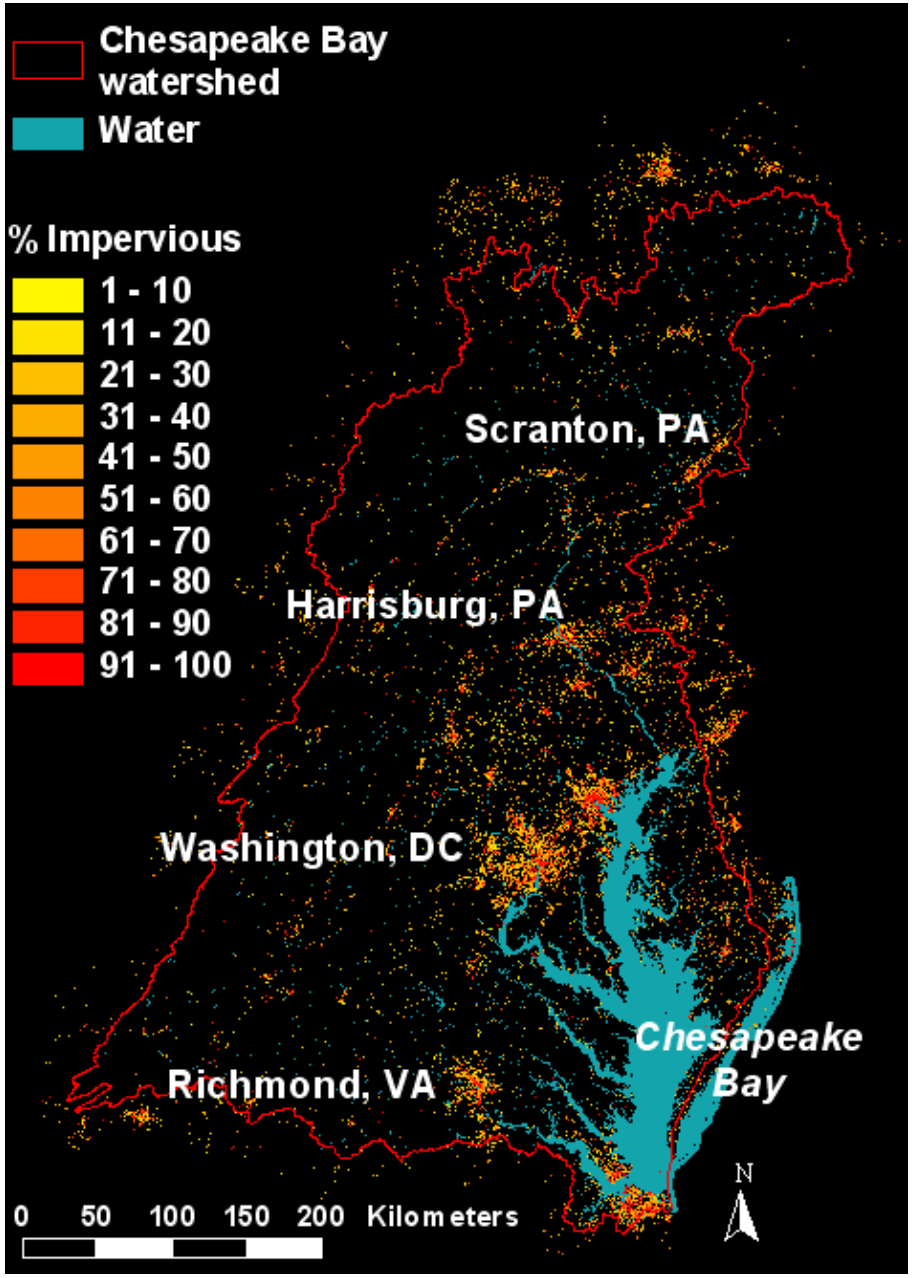
Source: Matthew Hansen, South Dakota State University

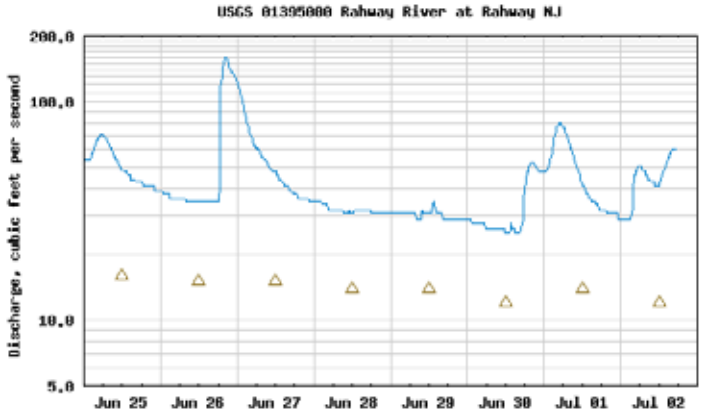
SDSU

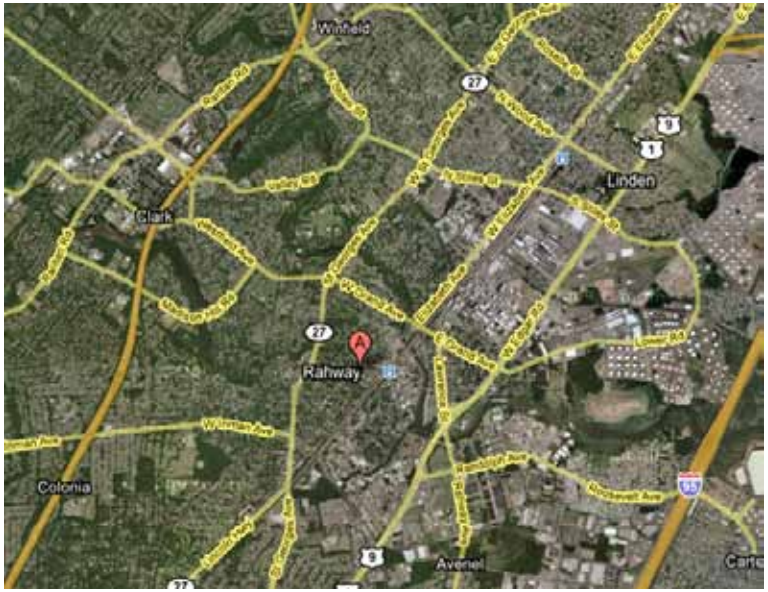
Impervious Surfaces

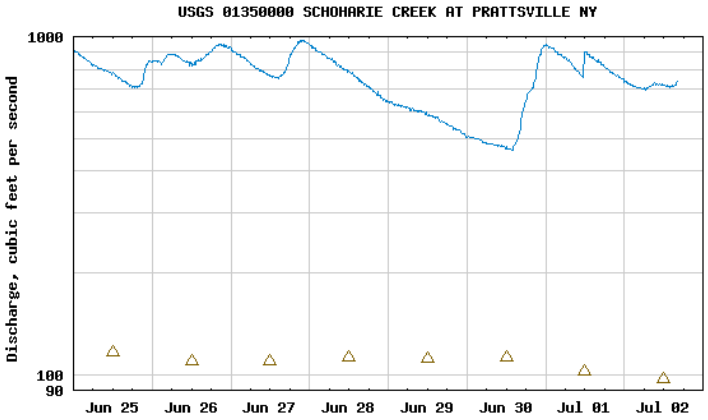
• Affects flow regulation: Increases peaks and valleys in runoff

•Affects water quality through oil and gas residues




USGS 01395000 Rahway River at Rahway NJ
200.0
100.0
10.0
5.0
Discharge, cubic feet per second
Jun 25
Jun 26
Jun 27
Jun 28
Jun 29
Jun 30
Jul 01
Jul 02


Winfield
Clark
Linden
Rahway
Colonia
Avenel

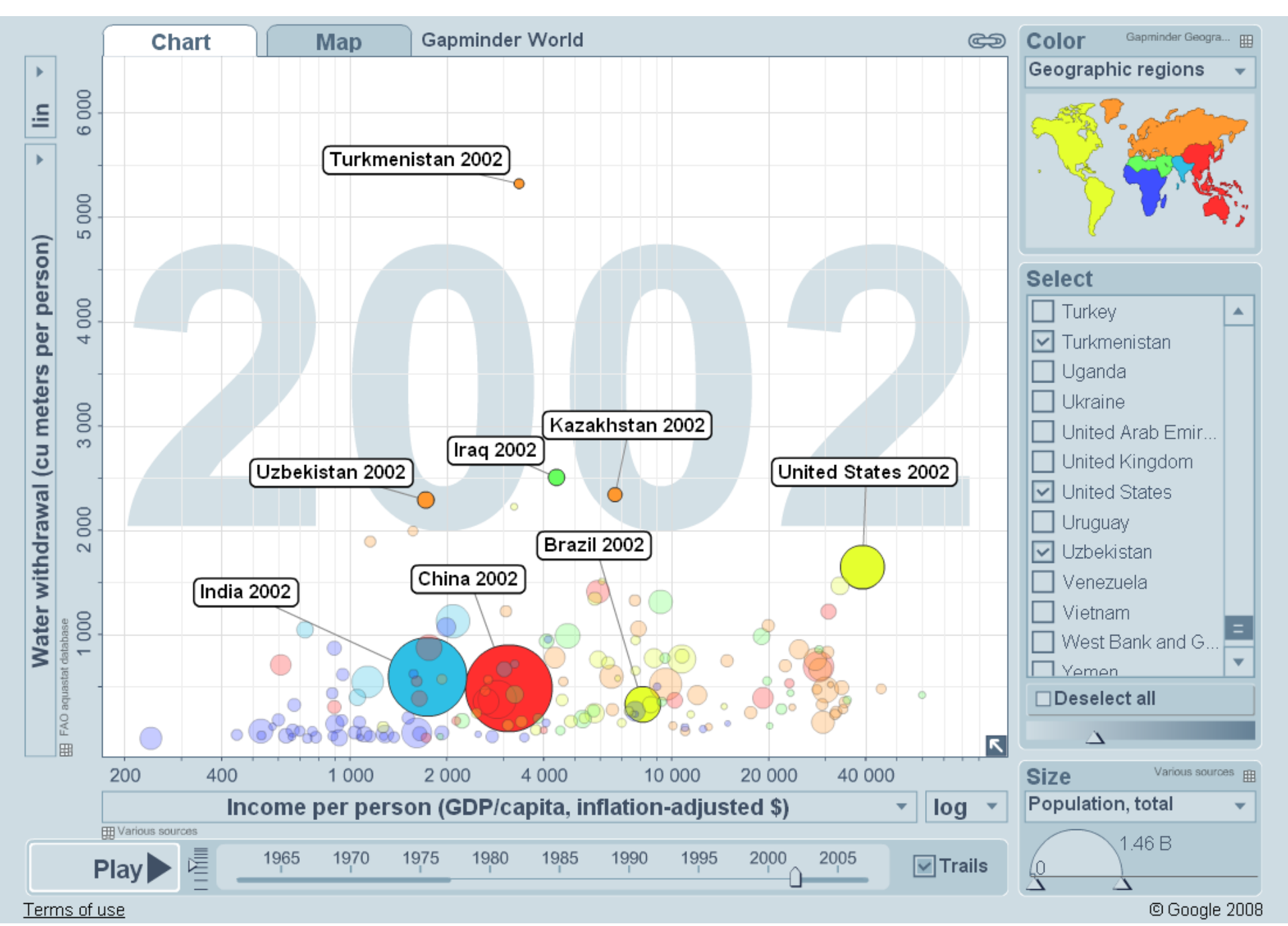

USGS 01350000 SCHOHARIE CREEK AT PRATTSVILLE NY
1000
100
90
Discharge, cubic feet per second
Jun 25
Jun 26
Jun 27
Jun 28
Jun 29
Jun 30
Jul 01
Jul 02

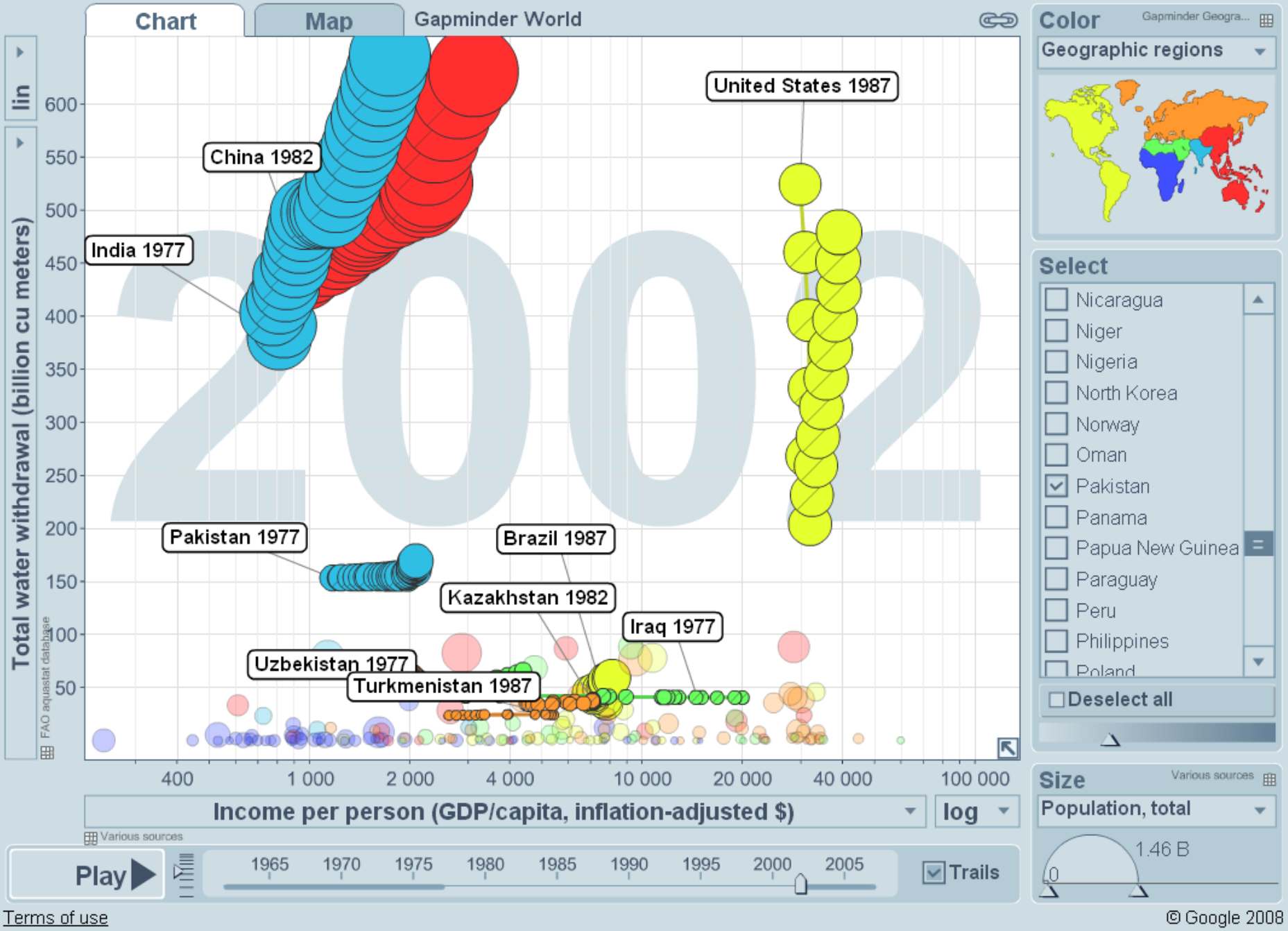

Gilboa
West Conesville
Grand Gorge
West Settlement
Prattsville
Red Falls
Ashland
North Lexington
Mink Hollow

INSTITUTIONS & PRICING

Institutions & Markets

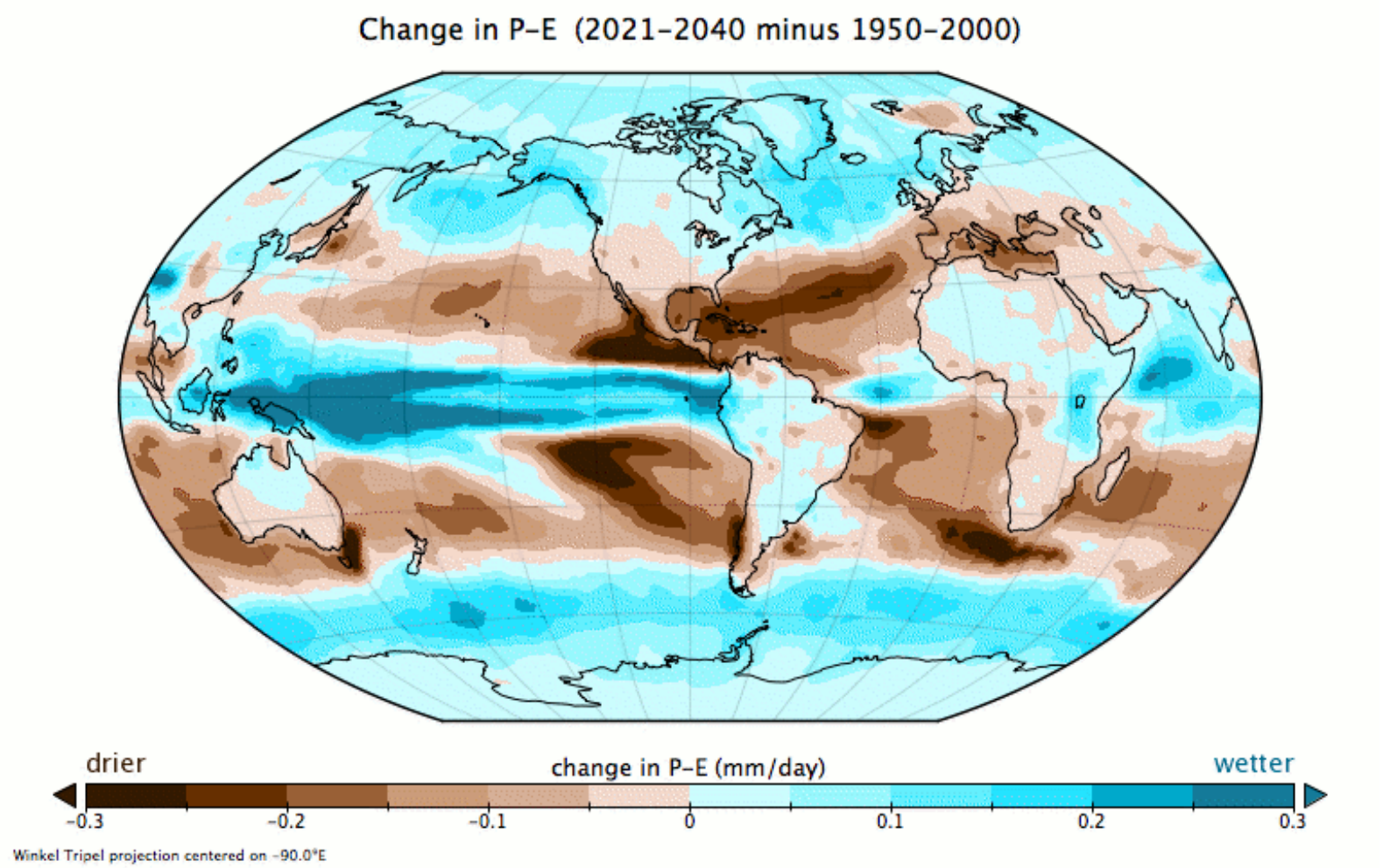
- Integrated water resources management (IWRM) – mostly tested at catchment level
- >400 water sharing agreements (see http://www.transboundarywaters.orst.edu/database/)
- Water laws
  - National
  - State/provincial
- Economy
  - Structure of the economy
  - Water markets & pricing





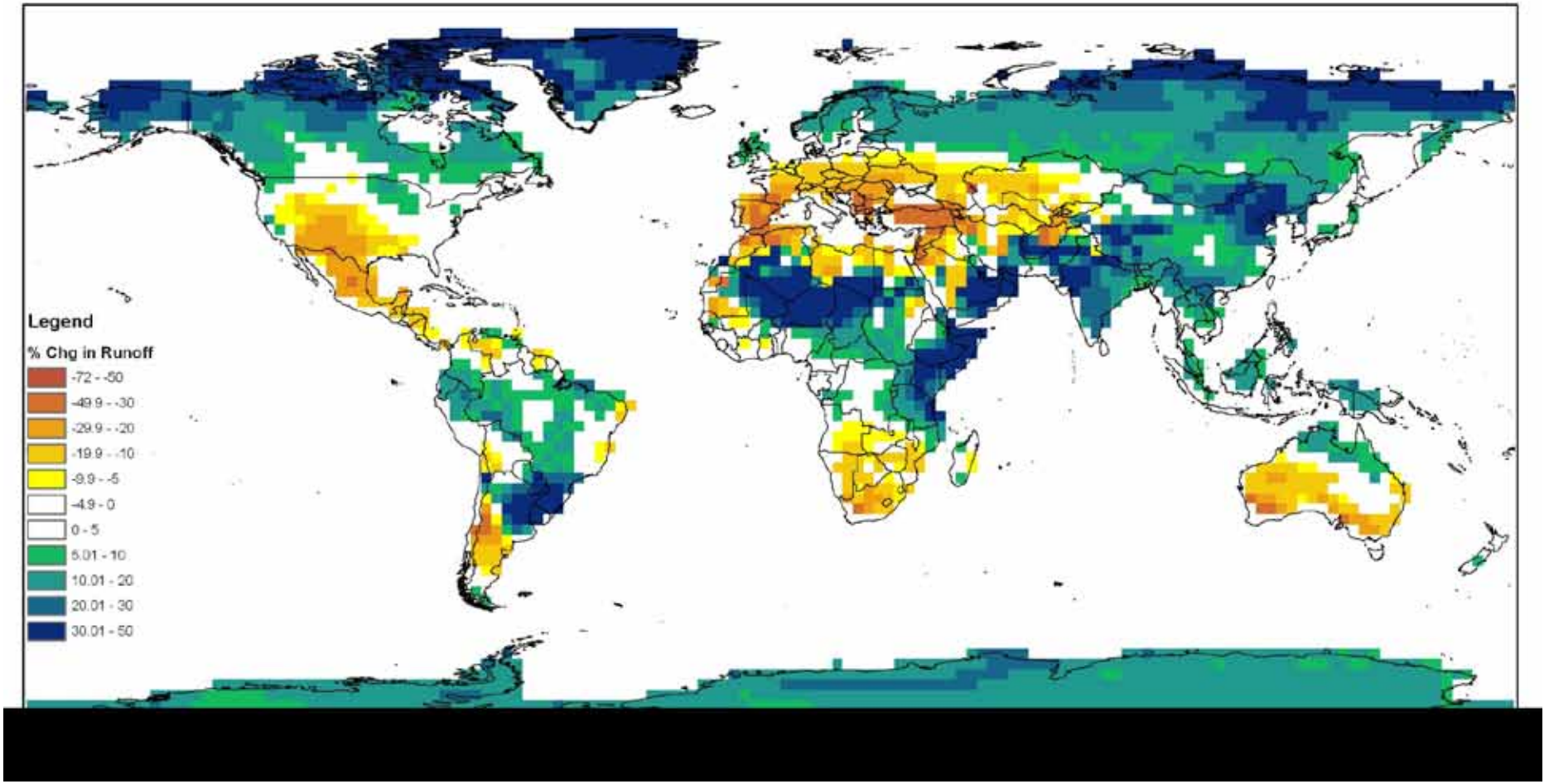
CLIMATE CHANGE

Climate Change: Precip.-Evaporation (~2030)



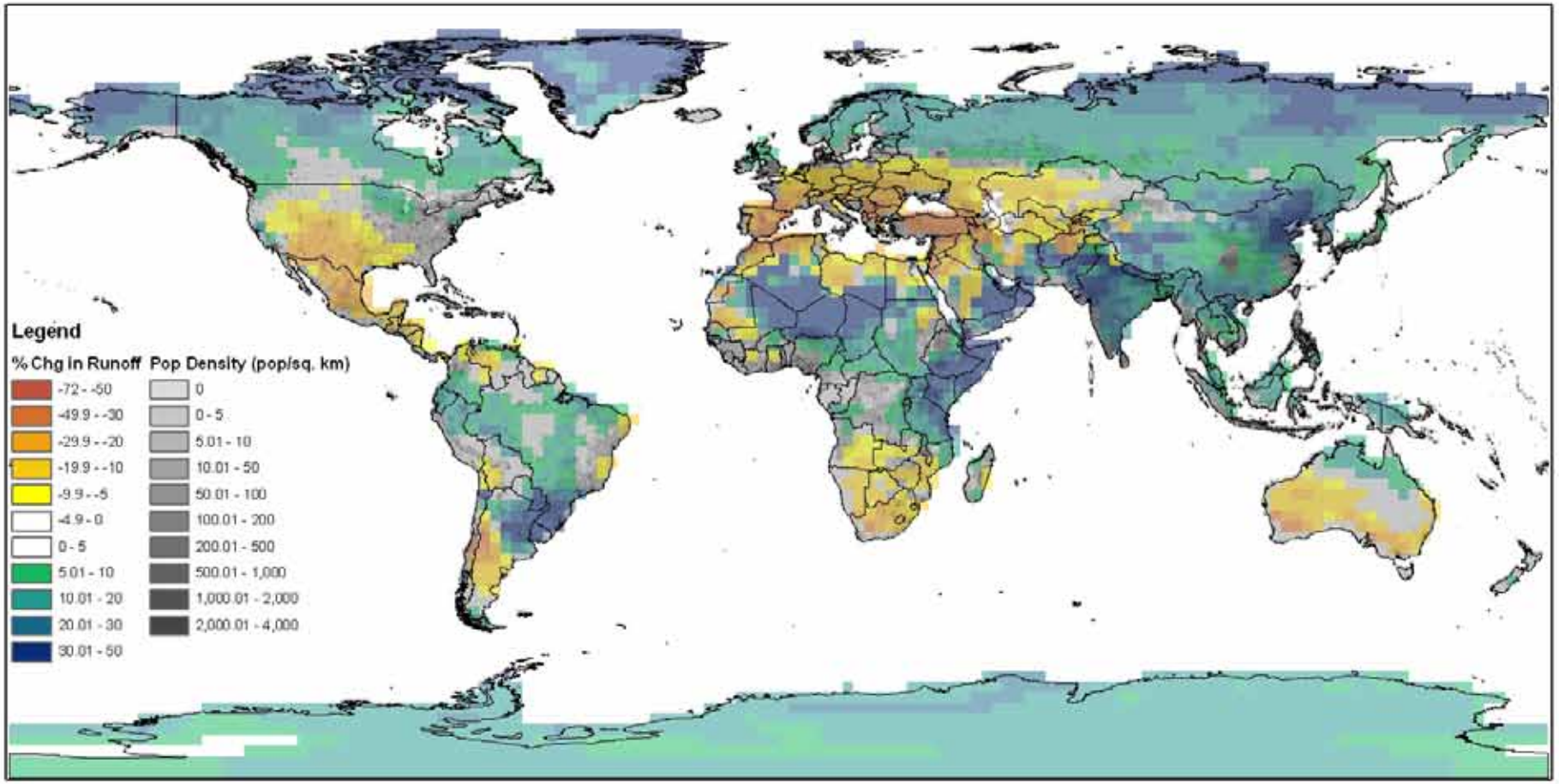
1) wet areas getting wetter
2) dry areas getting drier
3) subtropical dry zones expanding poleward

Climate Change: Projected Change in Runoff (2080)



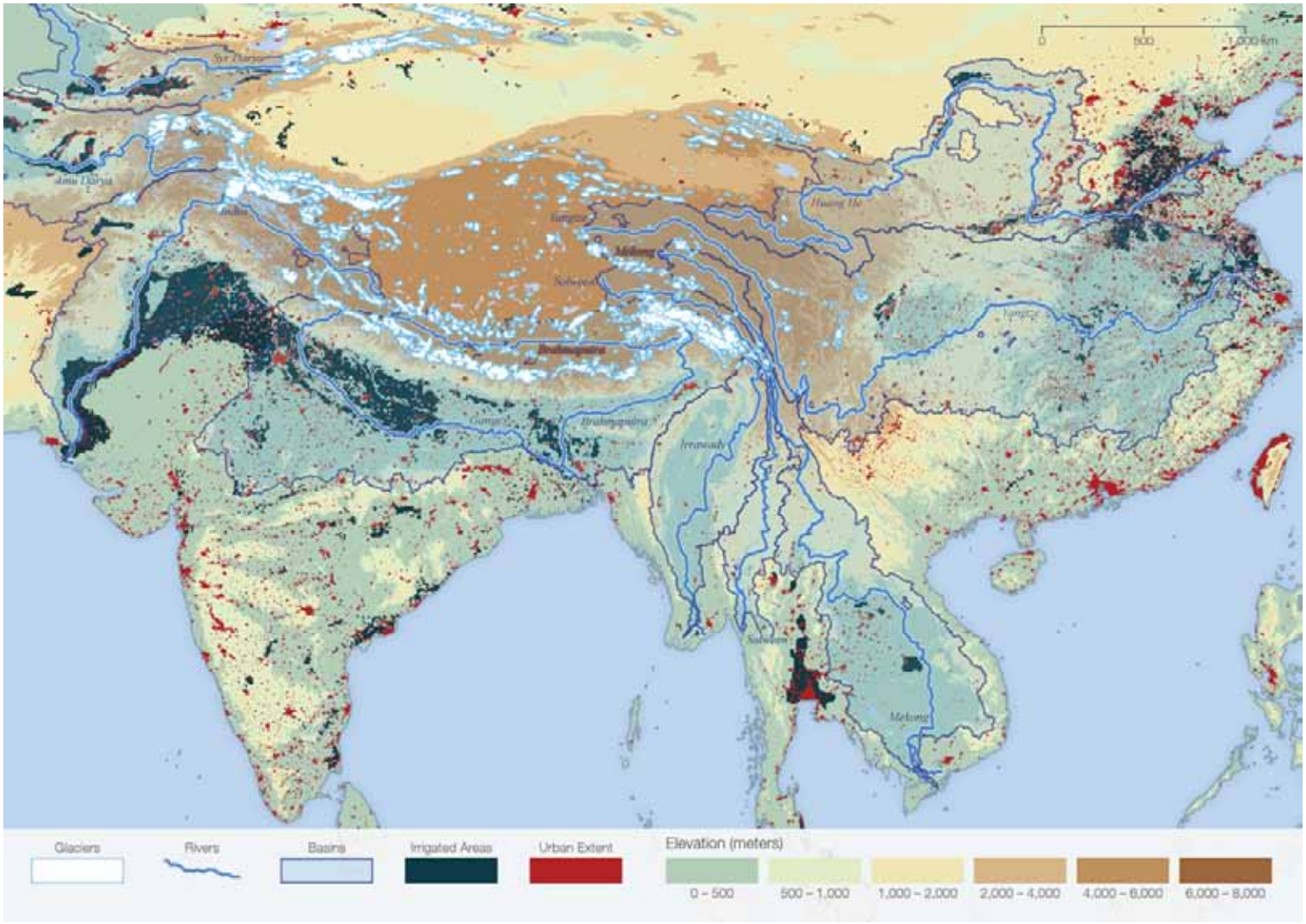
Source: Nohara et al.(2006). Impact of climate change on river runoff. *Journal of Hydrometeorology*. 7: 1076-1089, cited in the IPCC AR4 WG-2 report.

~500 million people live in regions where runoff is projected to decline by more than 20% by 2080

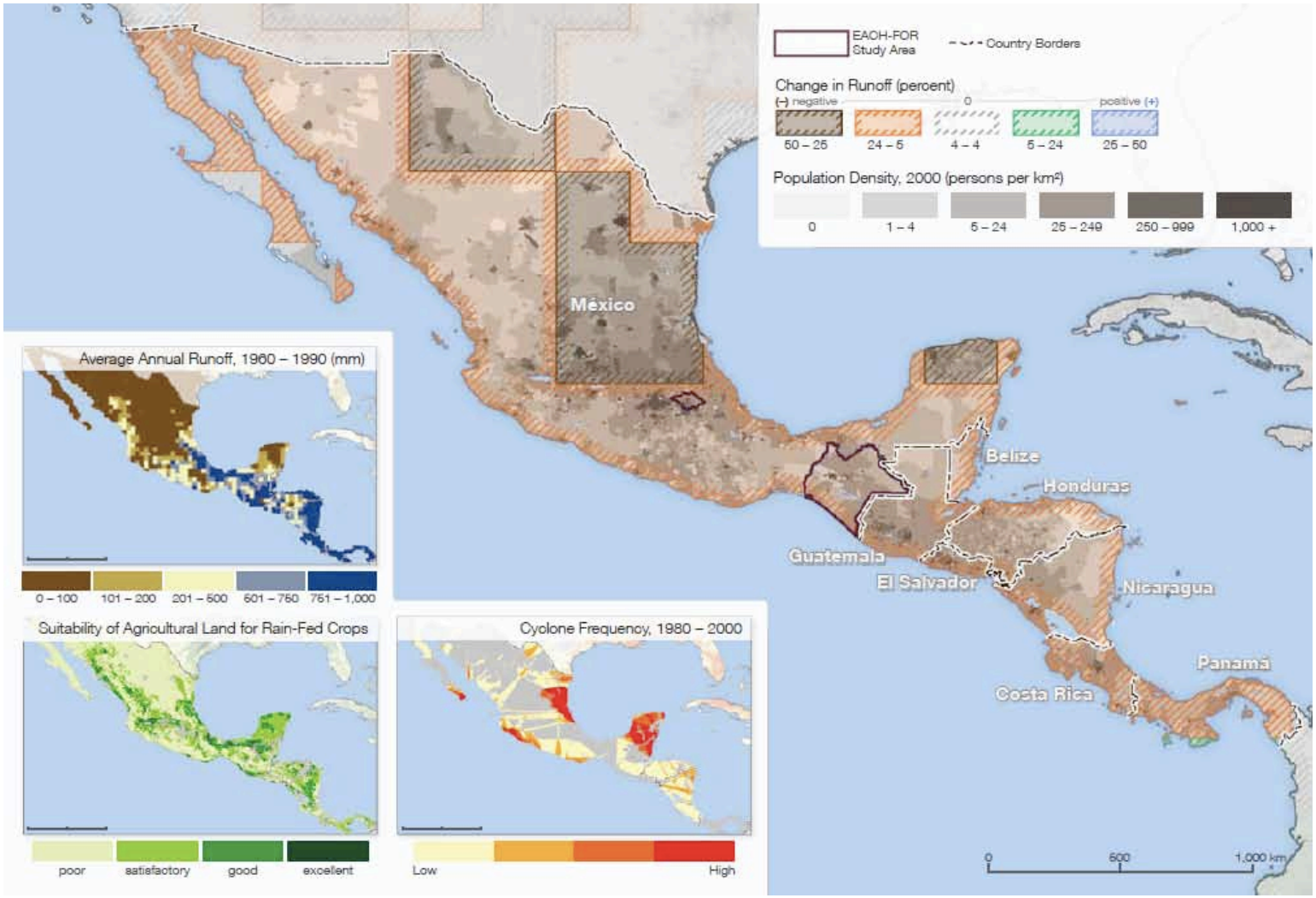


Source: Adamo and de Sherbinin (2009). "The impact of climate change on the spatial distribution of populations and migration." *Proceedings of the Expert Group Meeting on Migration*. New York: UN Population Division.

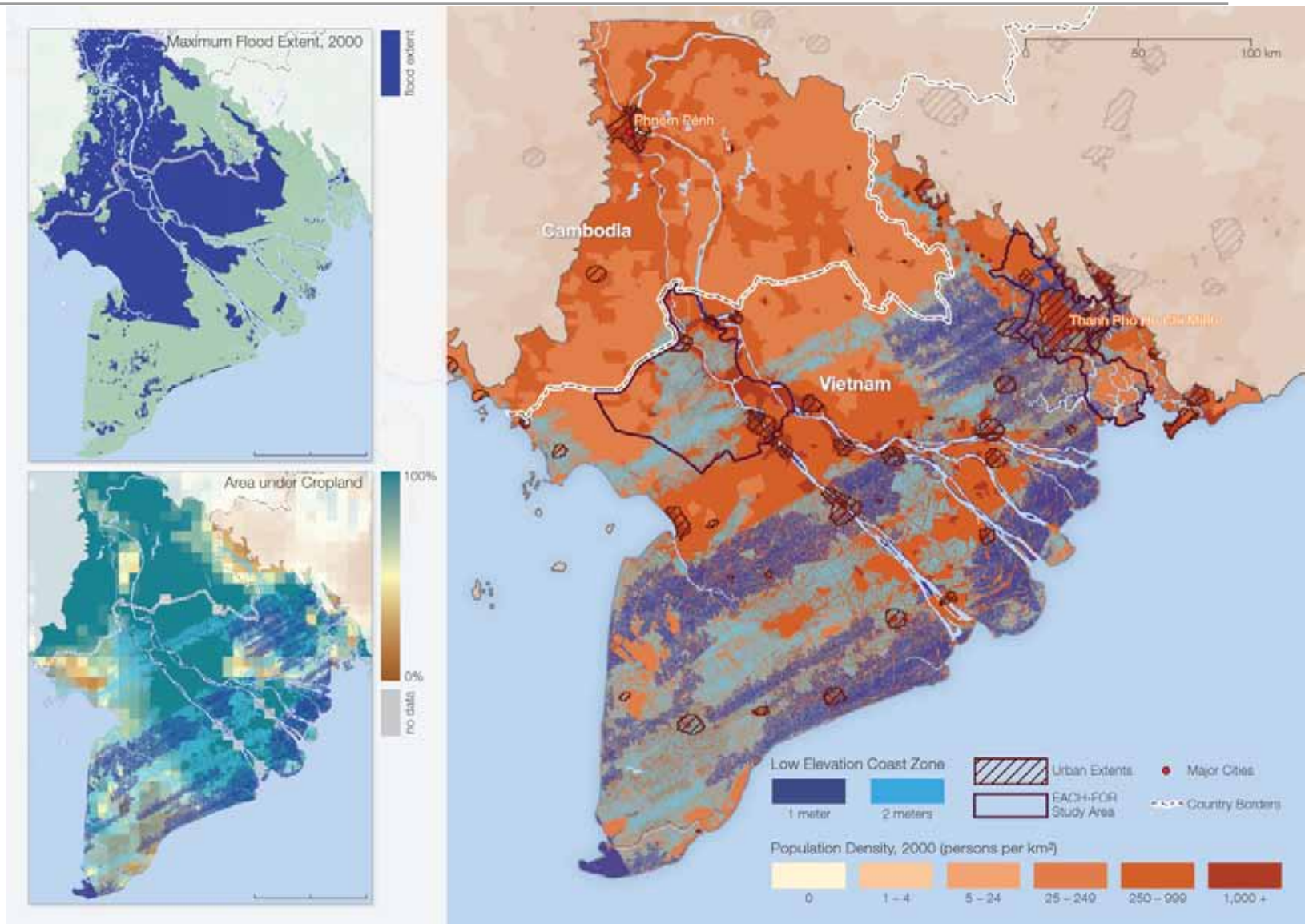
Glacier melt – A quarter of the world s population



Drying up and moving out - Central America



Living with floods and resettlement – The Mekong Delta

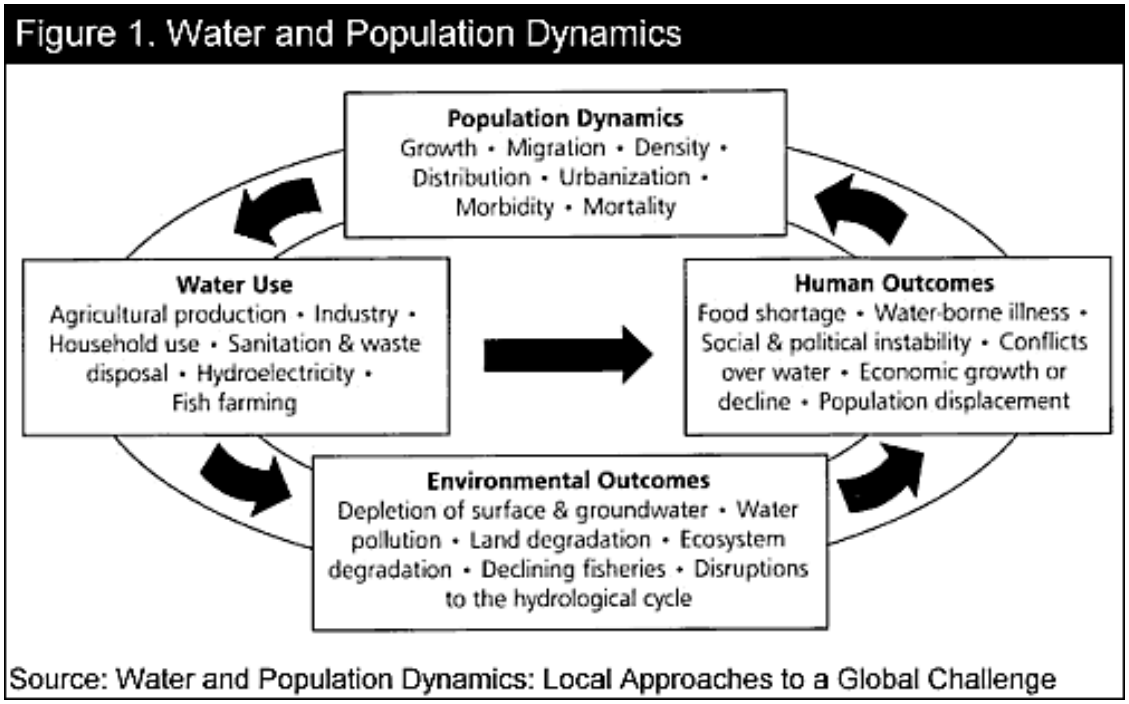


Climate Change Mitigation & Adaptation Impacts

- Biofuel plantations
- Forest plantations
- Hydroelectric power facilities
- Water transfer schemes
- Sea wall construction

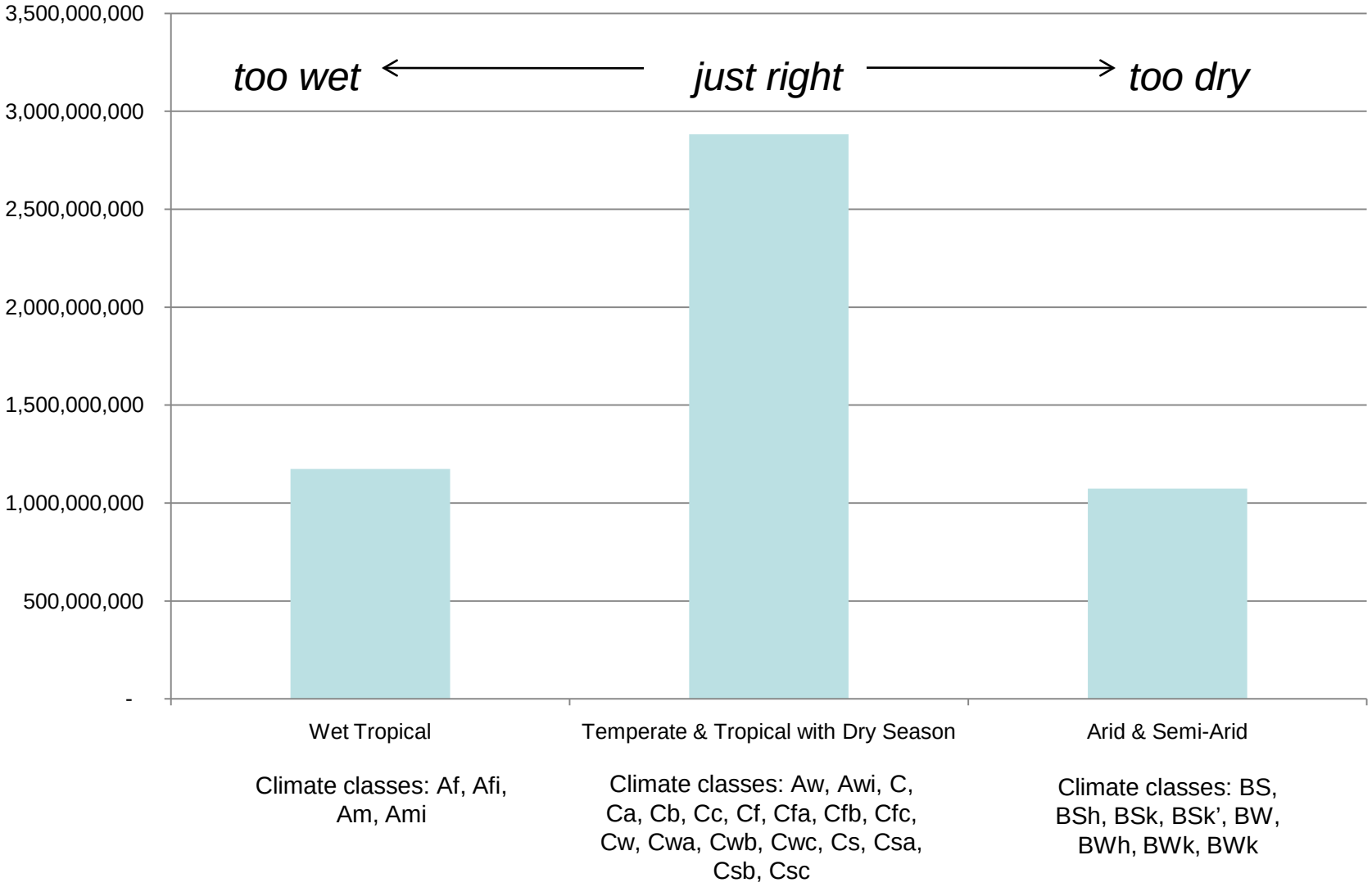
RECIPROCAL LINKAGES

Linkages are Reciprocal – Not Just One Way



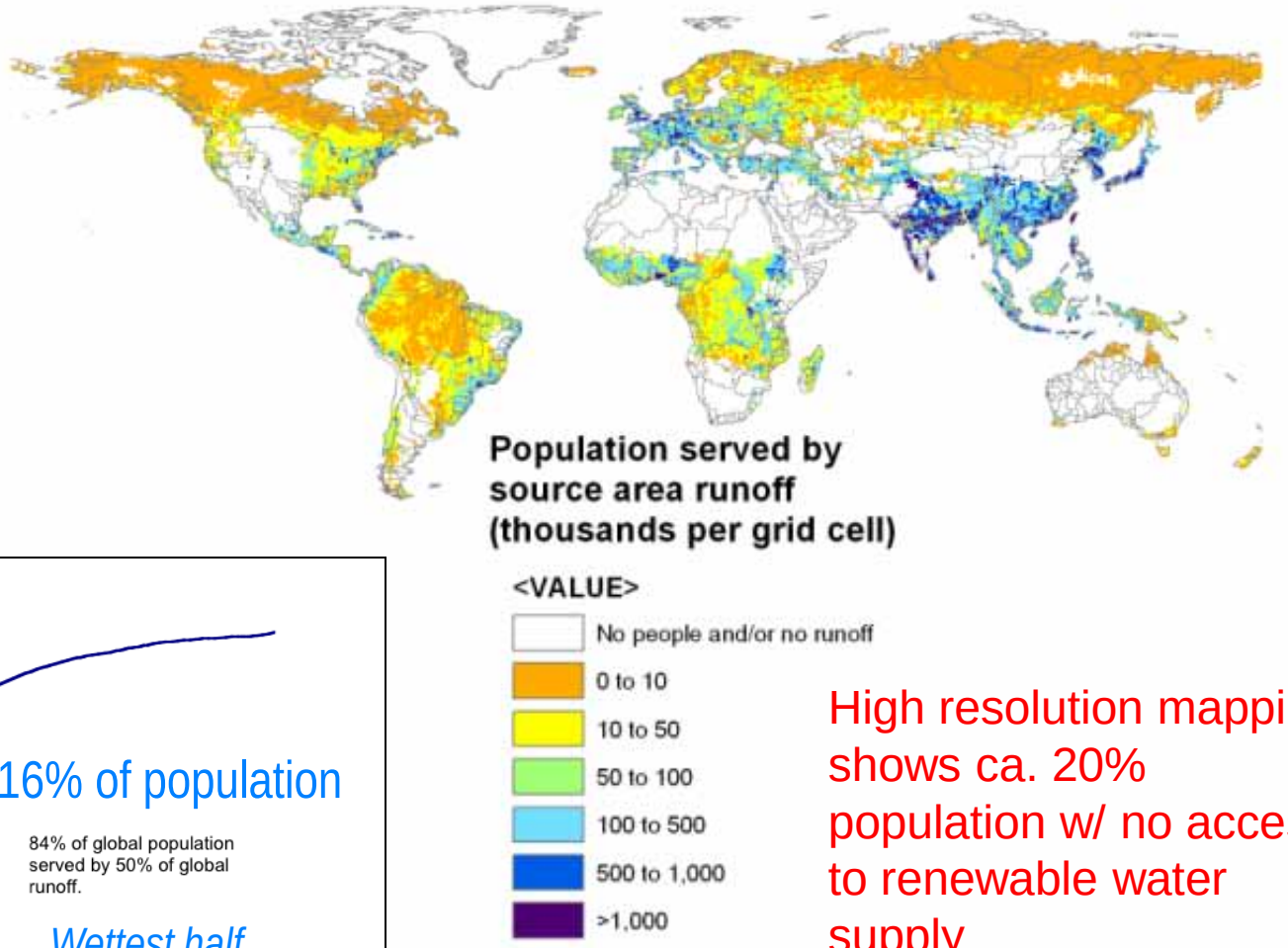
Source: de Sherbinin & Dompka (eds.). 1998. *Water and Population Dynamics: Local Approaches to a Global Challenge*. Washington, DC: AAAS.

Population by Köppen Climate Classification

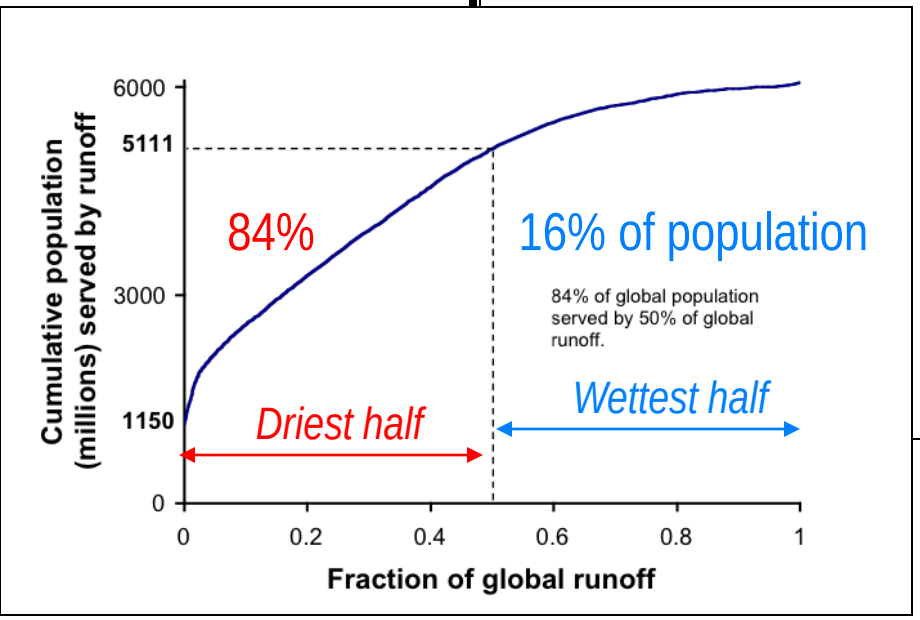


Note: Cold and Polar climate classes excluded; source data from CIESIN's *Population, Landscape and Climate Estimates v.2*

Humans Interacting w/ the Global Water Cycle-- *The Picture Today*



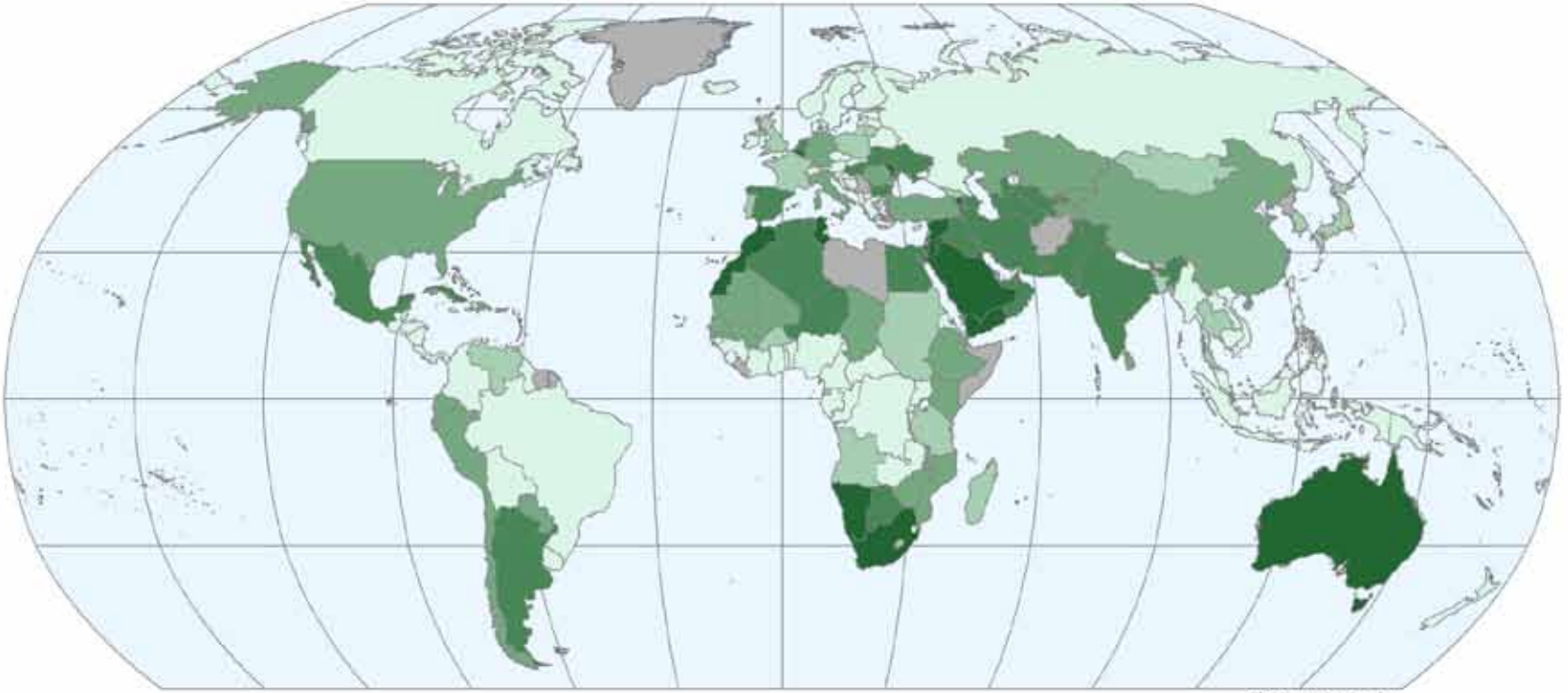
High resolution mapping shows ca. 20% population w/ no access to renewable water supply



- Importance of upstream source areas: note Amazon/S. Asian contrast
- Notion of tradeoffs w/in basin

Source: Vörösmarty et al. (2005), Millennium Assessment, Conditions & Trends Working Group

Percent of Territory Under Water Stress (2008 EPI)



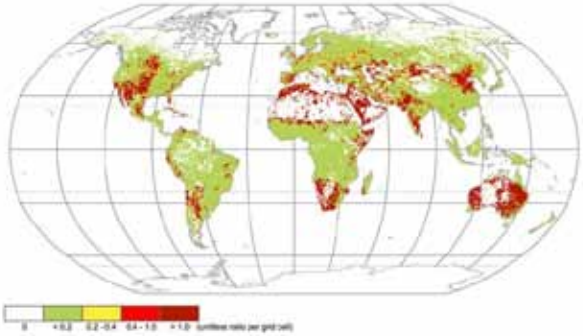
Robinson Projection

Water Policy Scores (ecosystems)

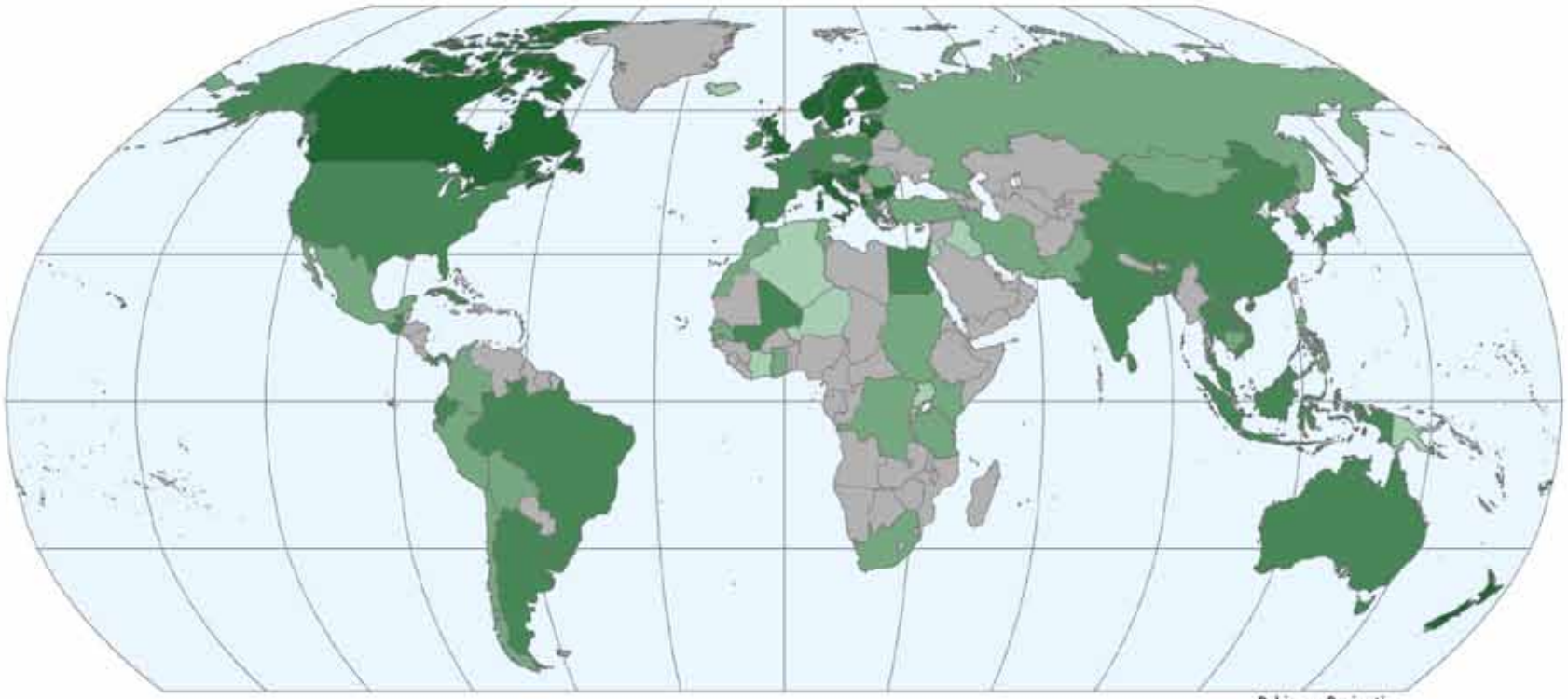
- 0.0 - 4.6
- 4.7 - 12.1
- 12.2 - 23.5
- 23.6 - 42.1
- 42.2 - 90.6
- no data

Water Stress occurs where withdrawals exceed 40% of available supply. The higher the percentage territory suffering from water stress, the more scarce water resources are in a given country.

(I4) Mean Annual Relative Water Stress Index



Water Quality Index (2008 EPI)



Robinson Projection

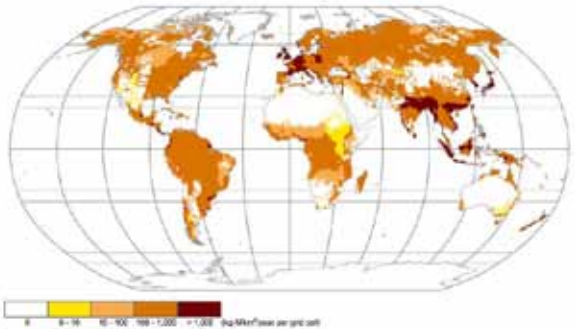
Water Policy Scores (ecosystems)

- No Data
- 0 - 28.45
- 28.46 - 57.27
- 57.28 - 80.54
- 80.55 - 99.0
- no data

Index Description:

The Water Quality Index of the 2008 EPI is a unitless score based on a theoretical range from 0 to 100 (0 represents the farthest from the target and 100 represents the attainment of the target). Scores are averaged from UNEP-GEMS/Water monitoring station data for each country across the following parameters: Dissolved Oxygen, pH, Electrical Conductivity, Total Nitrogen, and Total Phosphorus.

(I2) Total Nitrogen Flux



Australia: The perfect storm

Drying & Warming Climate

Growing Urban Demand

Over-allocation to Irrigation

The Environmental Flows Imperative

8

Water Scarcity Factors

Uncapped Groundwater Extraction

Bushfire Recovery Impacts

Expanding Plantations

Expanding Farm Dams

Source: David Lemon, CSIRO

Australian Government Bureau of Meteorology

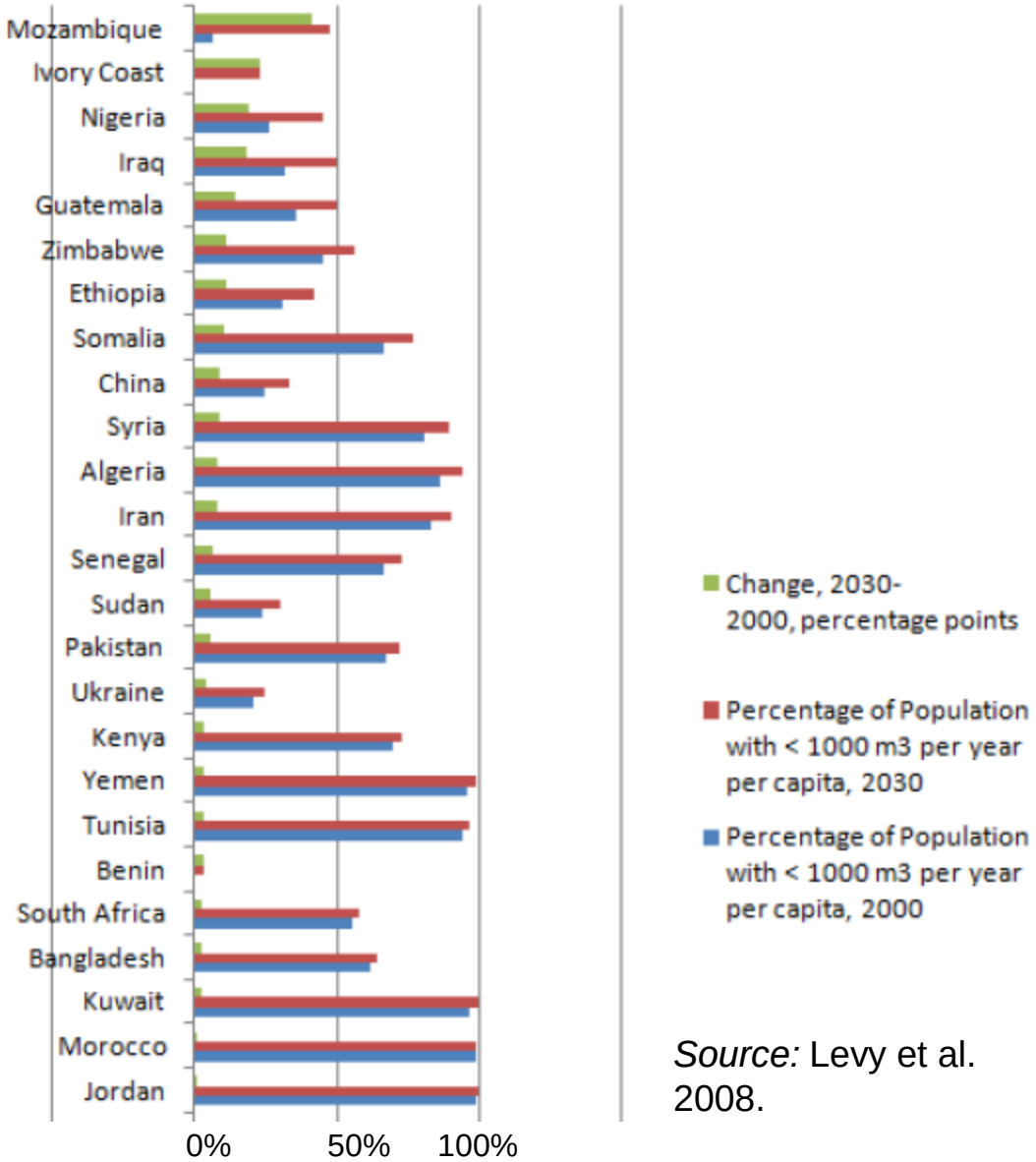
Water Information DATA › INFORMATION › INSIGHT

National Research FLAGSHIPS CSIRO

Conclusions

- We live in the antrhopocene
- Human impacts are ubiquitous
- Some countries/regions are like to experience significant water-related stress in 21st C.
  - China
  - India
  - Australia
  - Middle East
  - Central America
  - The Mediterranean basin

Countries with two or more risk factors (dangerous neighborhood, crisis history, low capacity), by % population with <1,000 m3



Source: Levy et al. 2008.