Water Challenges and Opportunities

The Scientific Context

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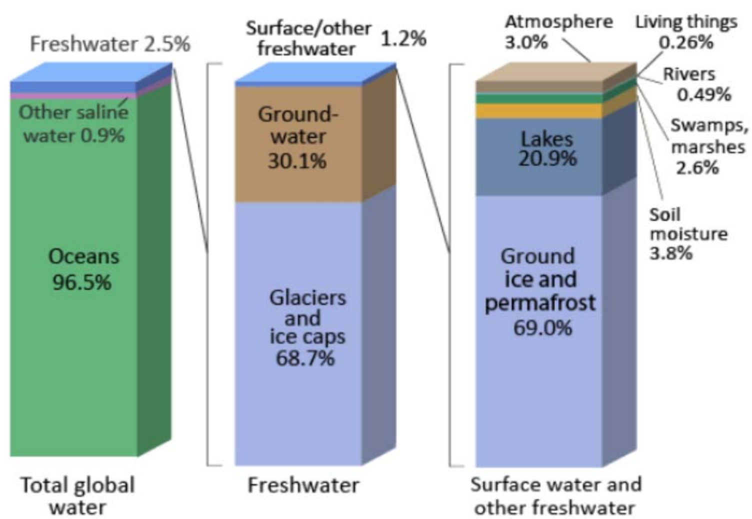
Understanding water as stocks & flows: Here are the world's stocks



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.
NOTE: Numbers are rounded, so percent summations may not add to 100.

The hydrologic cycle: freshwater flows

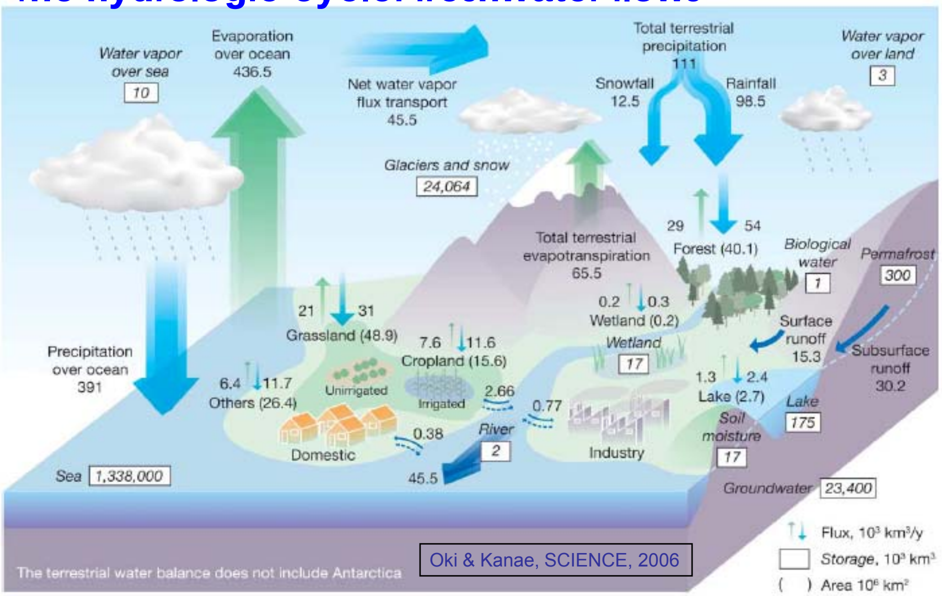


Fig. 1. Global hydrological fluxes (1000 km³/year) and storages (1000 km³) with natural and anthropogenic cycles are synthesized from various sources (*1, 3–5*). Big vertical arrows show total annual precipitation and evapotranspiration over land and ocean (1000 km³/year), which include annual precipitation and evapotranspiration in major landscapes (1000 km³/year) presented by small vertical arrows; parentheses indicate area (million km²). The direct groundwater discharge, which is estimated to be about 10% of total river discharge globally (*6*), is included in river discharge.

Water availability for human needs

- If we want to compare the amount of water available from the hydro cycle to human needs, we need to
  - clarify what part of the 45,000 km^3/yr runoff is actually “available”;
  - clarify how much water humans are using now and might be using in the future.
- With respect to “availability”:
  - Almost 80% of the 45,000 km^3/yr is “storm runoff”, leaving a “stable flow” of only 10,000 km^3/yr.
  - Of this 10,000 km^3/yr, 20% is “geographically inaccessible” (meaning remote from human populations who could use it), leaving 8,000 km^3/yr.
  - But dams currently capture 4,000 km^3/yr of the storm runoff, so the “available” flow is 8,000 + 4,000 = 12,000 km^3/yr.

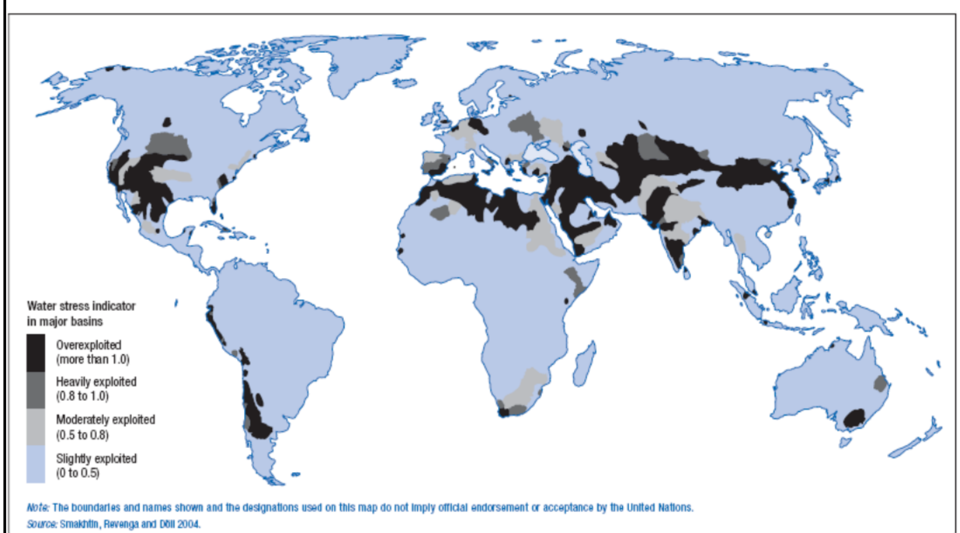
Note: 1 km^3 = 1 billion m^3 = 264 billion gal = 0.8 million acre-feet

Competing uses for water vs availability

	cubic kilometers per year	
Global available flow		12,000
Global withdrawals for human use (2000)		3,600
of which agriculture	*2,400*	
…industry & electric power	*800*	
…domestic	*400*	
of which drinking water	*5*	
Global desalting capacity (2014)		13

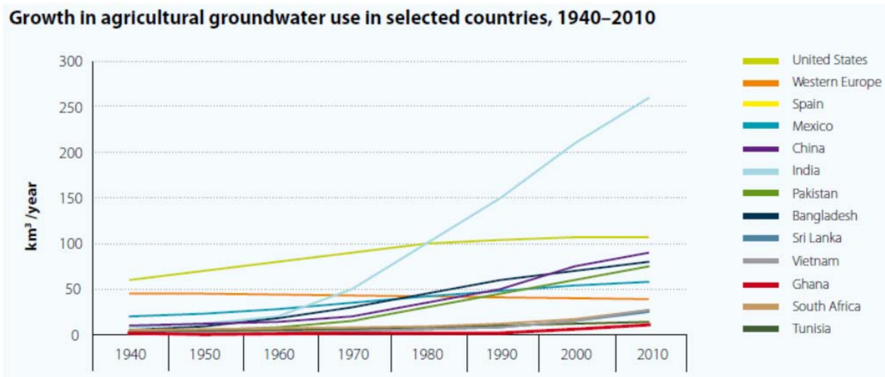
	cubic meters per person per year
Global average withdrawals per person	800
Nigeria…	50
China…	500
Mexico…	800
Italy…	1,000
United States…	2,000

Pressure on available flow is not uniform



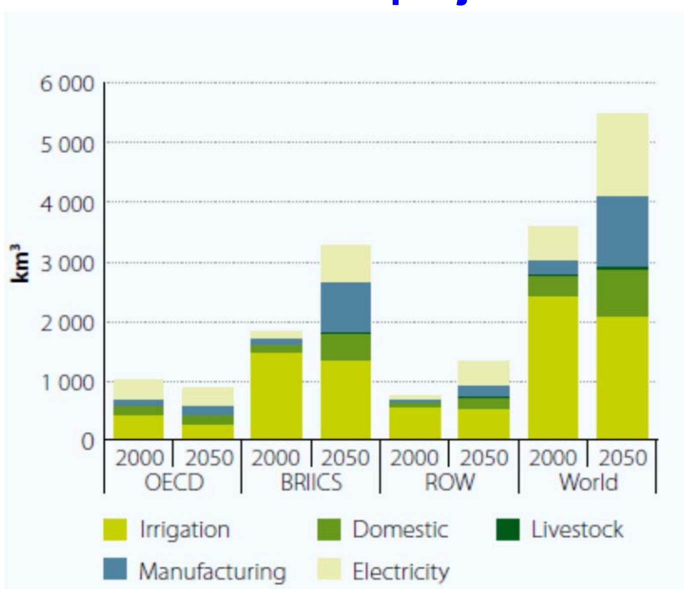
UNDP Human Development Report 2006, p 140, Map 4.1

Demand exceeding surface-water availability leads to rising demand on groundwater



http://unesdoc.unesco.org/images/0023/002318/231823E.pdf

World water demand is projected to rise



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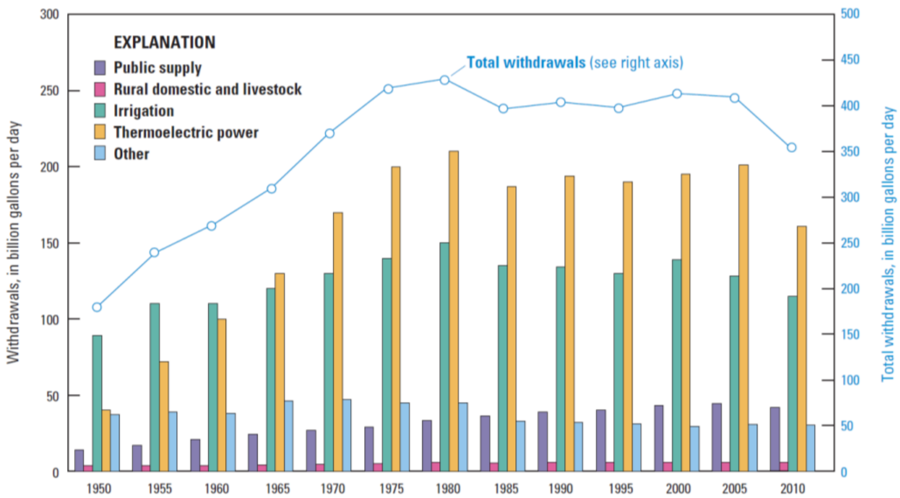
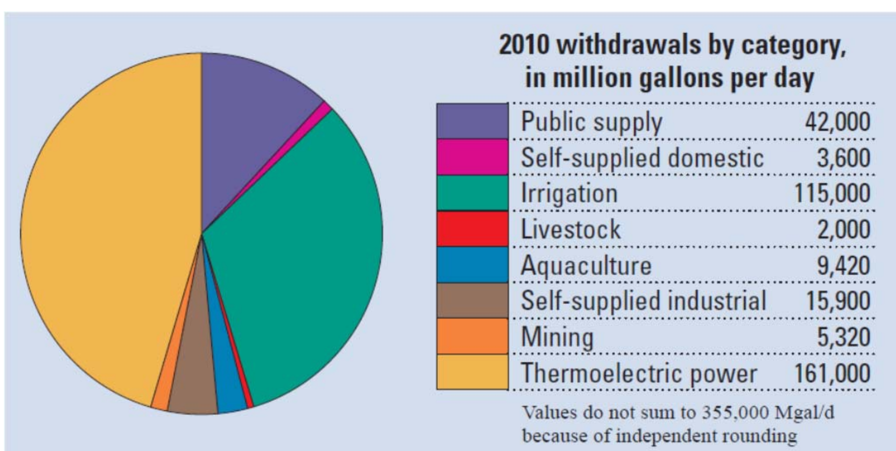
Trends in US water use, 1950-2010



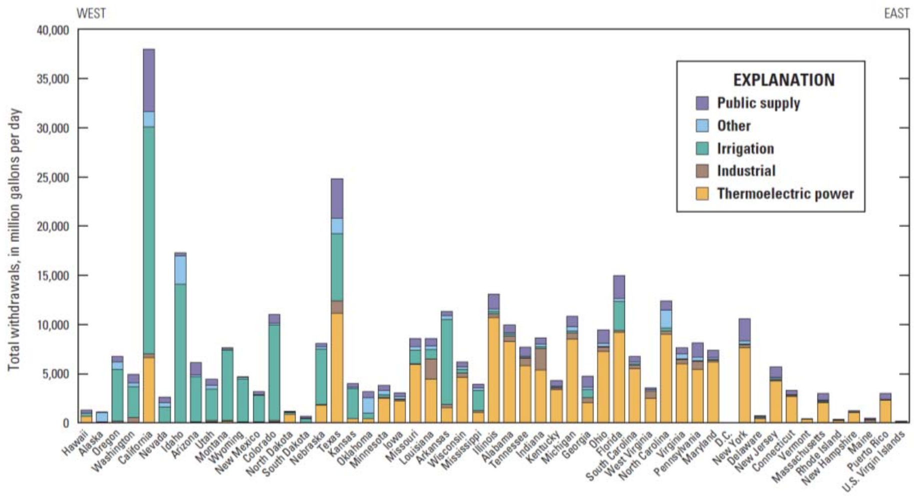
USGS, 2014

US water withdrawals in 2010



USGS, 2014

US water withdrawals in 2010



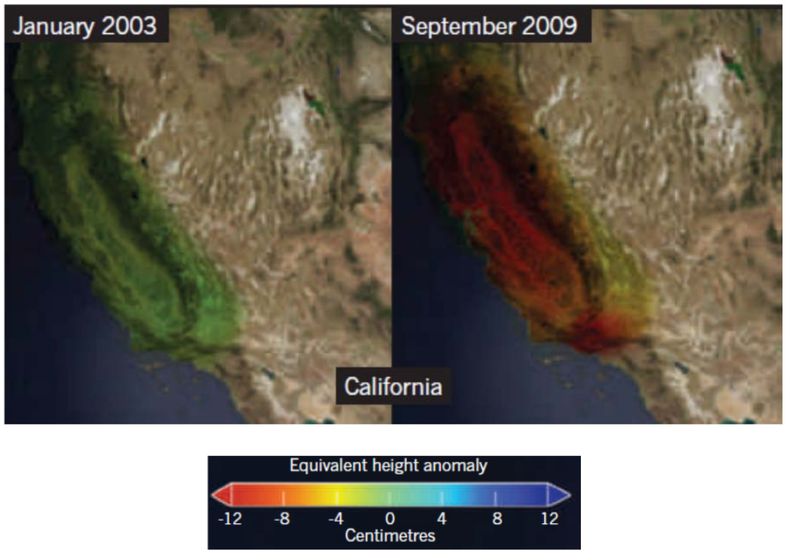
USGS, 2014

Climate-change / water interactions

Global climate change is…

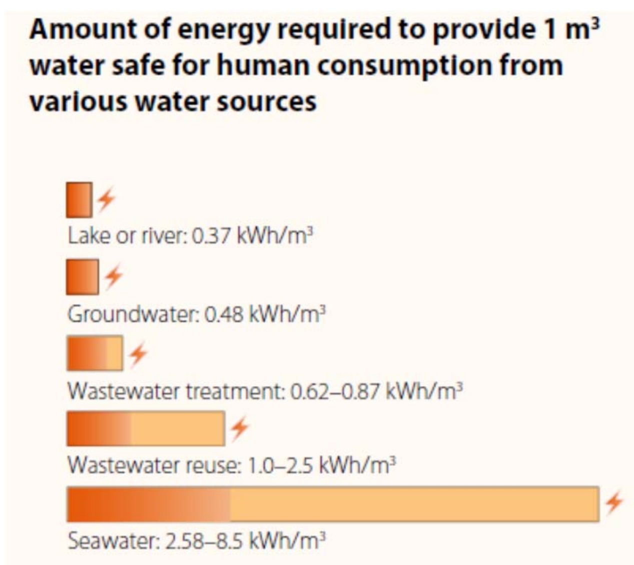
- increasing precipitation on the average while accentuating both floods & droughts
- reducing snowpack & accelerating snowmelt, increasing losses to storm runoff
- melting the Himalayan glaciers that stabilize the flows of the great rivers of China and India
- reducing summer soil moisture in mid-continents, increasing irrigation needs
- warming surface waters, resulting in reduced dissolved oxygen & waste-assimilation capacity, changes in species composition, and improved habitat for disease vectors
- raising sea level, imperiling estuaries, deltas, and coastal aquifers

Groundwater depletion under drought



K. Bourzac, NATURE, 26 September 2013

Energy and water are intertwined



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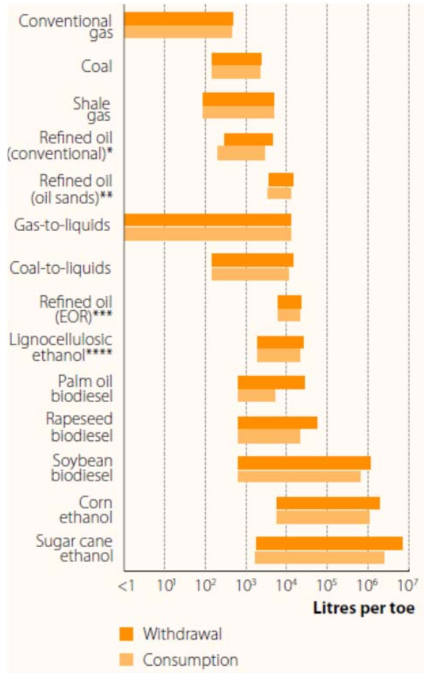
Water needed to get energy

Numbers here do not include water withdrawals for power-plant cooling: 17% of water withdrawals globally, 46% of withdrawals in the USA.

** The minimum is for primary recovery; the maximum is for secondary recovery. ** The minimum is for in-situ production, the maximum is for surface mining. *** Includes carbon dioxide injection, steam injection and alkaline injection and in-situ combustion. **** Excludes water use for crop residues allocated to food production.*

Note: toe, tonne of oil equivalent (1 toe = 11.63 MWh = 41.9 GJ). Ranges shown are for 'source-to-carrier' primary energy production, which includes withdrawals and consumption for extraction, processing and transport. Water use for biofuels production varies considerably because of differences in irrigation needs among regions and crops; the minimum for each crop represents non-irrigated crops whose only water requirements are for processing into fuels. EOR, enhanced oil recovery. For numeric ranges, see http://www.worldenergyoutlook.org.



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Challenges of water quality match or exceed those of water quantity

SOME INSTRUCTIVE NUMBERS ABOUT LEAD

(concentrations is parts per billion = micrograms per liter)

River water in prehistoric times	0.02
River water in modern times	3
FDA bottled-water standard	5
EPA "action level" for tap water	15
Level exceeded in 600 US systems[1]	40
Highest levels in US tap water	500-5,000+
EPA "hazardous waste" threshold	5,000

[1] USA Today survey using EPA data, 3-17-16