

Future challenges to water resources – the geopolitics of sustainability

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Introduction

- **Key challenges:** growing demands, continued diminution in quality, changing climate – are *taxing freshwater sustainability*.
- **In past:** when facing such challenges, we've dammed & diverted streams, overdrawn aquifers, engaged in actions that *alter quality & supply*.
- **Significance:** when we cause harm, and then attempt to fix it, we engage in a *struggle* over power and control over water, and over what values prevail – *if we hope to reverse course, this pattern must change*.

One view of water, power, and values



Global Water Security

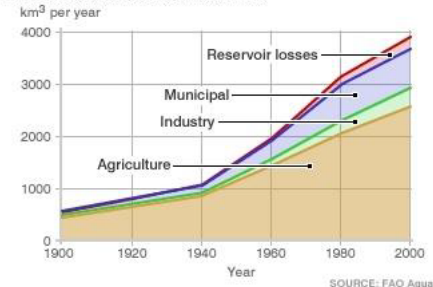
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This is an IC-coordinated paper.



- Over next 30 years, flooding, drought, & pollution will cause *political instability*.
- *Wars over water* unlikely, but chronic tensions will persist (e.g., Mid-East, South Asia).
- Conservation, wastewater re-use, structural measures can address some, but not all these issues – should freshwater be regarded as a strategic issue?

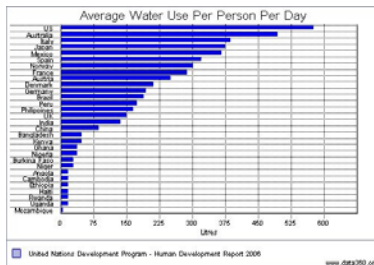
Challenge – growing demands

Estimated annual world water use



- Production of *food and fiber* account for 70% of global water use.
- Since 1900, *global water demands* rose six-fold, more than twice the rate of population growth.

Demand growth uneven - why?



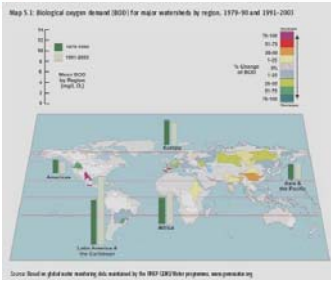
- Developed countries use 10-times more water per person as developing nations.
- Affluence explains some of this, as does agriculture and energy demands.
- Poverty, powerlessness, and a *lack of basic infrastructure* is also an explanation.

“Lack of infrastructure” – another meaning



Woman and children fetching water – Nyaoga, Kenya

Challenge – water quality



• **Increasing BOD* in developing countries due to:**

- **Population growth**
- **Industrialization**
- **Lack of water treatment**

- Worldwide, 1.6 million die annually from diarrheal diseases (e.g., **cholera**) due to lack of safe drinking water/basic sanitation (90% are children < 5).
- 160 million infected with **schistosomiasis** – tens of thousands die annually.
- 500 million suffer **trachoma**; 146 million threatened by blindness.
- Intestinal diseases plague 133 million due to inadequate drinking water, sanitation, hygiene; approximately 1.5 million cases of hepatitis/year.

Sources: *Water for People, Water for Life, UNESCO, 2003; rev. 2010; UNEP, 2010*

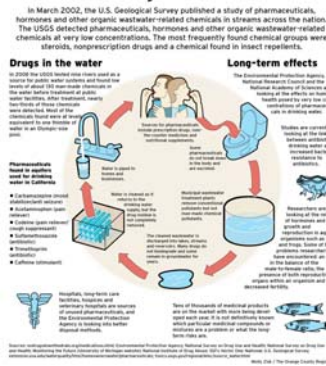
Runoff pollution



Blue green algae blooms caused by nitrogen & phosphorous-laden runoff into **Taihu Lake** – near Yixing, Jiangsu province, China

Contaminants of concern – a growing threat

- **Pharmaceuticals, personal-care products, polymers:** vitamins to pain-relievers, antibiotics, veterinary drugs, fragrances, cosmetics, sun-screens, fire retardants, plastic containers.
- **Major concerns:**
 - Enter environment after human/animal use.
 - Treatment systems generally not equipped to remove, **detect** them.
 - Risks uncertain – include disruption of aquatic endocrine systems, fetal exposures.
 - Number of contaminants growing annually.

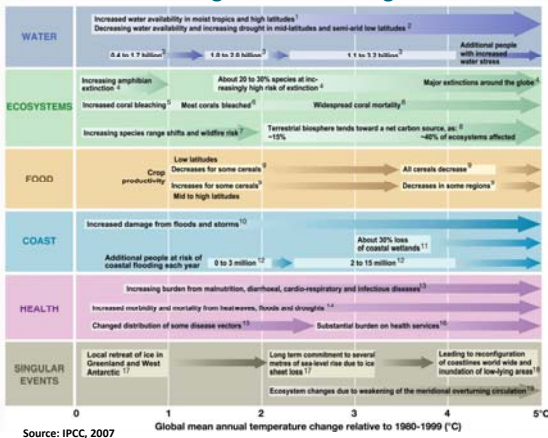


Santa Ana River – Southern California

- Santa Ana Watershed authority has found “ten emerging constituents” — drugs or chemicals for which water-quality standards don’t exist — at sampling sites within 2,650 mile² watershed.
- Substances include active ingredient in pain relievers like Tylenol, BPA – a plastic contaminant, antibiotics, flame retardants.
- Results came from 23 sampling sites, including wastewater treatment plants that feed into river.
- Official re-assurance: SAWA states that amounts are small & water percolates through layers of rock and sand before reaching the deep aquifer – reducing contamination.



Challenge – climate change



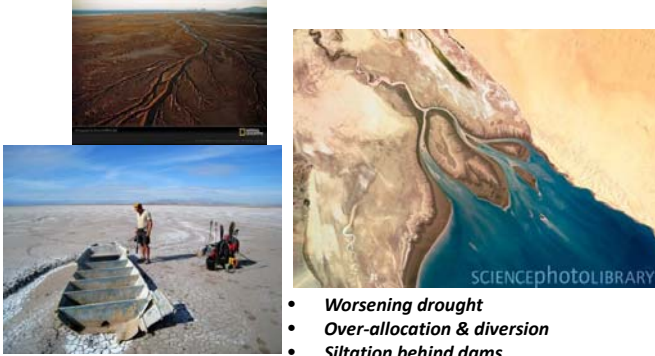
Source: IPCC, 2007

Projected impacts of climate change

- Changes in seasonal distribution and amount of precipitation.
- Increase in precipitation intensity.
- Changes in the balance between snow and rain.
- Increased evapo-transpiration and a reduction in soil moisture.
- Changes in vegetation cover resulting from changes in temperature and precipitation.
- Accelerated melting of glacial ice.
- Increase in fire risk in many areas.
- Increased coastal inundation and wetland loss from sea level rise.
- Effects of CO₂ on plant physiology, leading to reduced transpiration and increased water use efficiency.

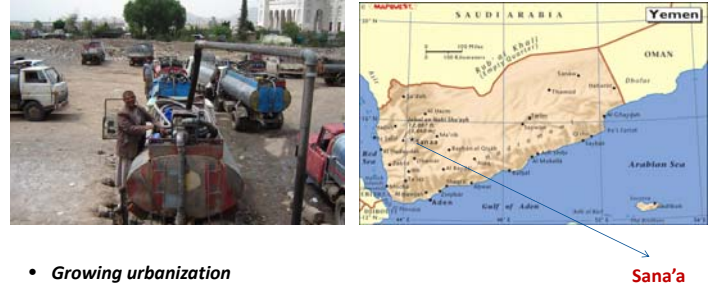
Source: *Climate Institute, 2010* <http://www.climate.org/topics/water.html>

Climate change worsened by human alteration – Colorado delta



- **Worsening drought**
- **Over-allocation & diversion**
- **Siltation behind dams**

Sana'a, Yemen



- **Growing urbanization**
- **Groundwater depletion**
- **Chronic drought**
- **All exacerbated by poverty, civil war, separatist political movements**



Past responses – a tale of three rivers

China – Yangtze River



Benefits of Three Gorges

- For centuries, Yangtze has periodically overflowed its banks causing untold property loss and loss-of-life – to “... promote economic development, improve the local environment, benefit reservoir migrants.”
- Has created world's largest hydroelectric facility:
 - Generates 22,500 MW of electricity (equivalent to approx. 15 coal or nuclear plants).
 - **Flood control** of Yangtze River virtually ensured – 1.5 million hectares of land, 15 million people protected from 100 year floods – was tested in July 2010 tropical storm!
 - Year-round **navigation** channel to Shanghai and East China Sea: growth from 9.5 – 60 million tons of cargo/year between 2003-08.
 - Gaining **experience** for other projects on Upper Mekong River, Salween River, upper Yangtze – and in other countries (China has invested in 300 projects in 66 countries).

Environmental and social impacts

- 1.3 – 2 million people displaced; 13 cities, 140 towns, 1,350 villages inundated; 600 km of valley flooded, many archeological sites lost.
- Submergence of hundreds of factories, mines, waste dumps creating effluent, silt, industrial pollutants and rubbish in reservoir.
- Erosion of reservoir and downstream riverbanks causing landslides.
- Scientists estimate annual catches in E. China Sea may be reduced by one million tons due to decline in fresh water and sediment reaching sea.
- Project plagued by corruption, spiraling costs, technological problems, resettlement difficulties – displaced moved to sub-standard homes.

Visualizing the effects



Ecotourism at Three Gorges



Landslide in reservoir

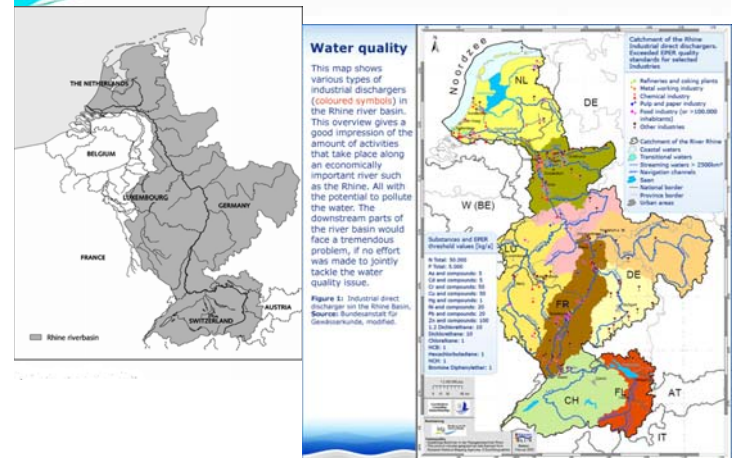


Relocated family waiting for housing

Lessons learned

- *Chinese Academies of Social Sciences and Engineering* concerned about dam's environmental/social impacts; forced a discussion of future projects' costs and risks in a broader discussion of *tradeoffs*.
- *Government now considering*: what is comparative risk of removing more habitat for threatened fish species, versus burning more coal?
- Promises to give more thought to dam impacts on aquatic species as *economic and environmental assets*.
- Promises to give greater foresight to re-location of communities, as well as alternatives to dams as flood control measures – to avert *protests*.
- *Verdict?* Uncertain: government still emphasizes dams, centralized decision-making. However, now committed to greater "multi-purpose" planning (e.g., in-stream flow, water quality, re-forestation to avert flooding).

Rhine River basin



The bucolic Rhine



Castle near Black Forest



Rudesheim, Germany

... And the polluted Rhine



Chemical complex – Wesseling, Germany



Industrial pollution near Cologne



Dead eels following Swiss chemical spill in 1986 near Basel, Switzerland

The Rhine – picturesque and polluted

- In 19th Century, contained one of Europe's most productive salmon fisheries; annual catches of 150,000 fish – by 1958 salmon disappeared entirely.
- 90% of the river's floodplain had been cut-off by development; pollution has killed off river otter, seals, cormorant chicks.
- Channelization has transformed it into an artificial navigation conduit - more river traffic than any other river.
- Quality has deteriorated from potash mining in Alsace (contributing one-third of the river's salt load), runoff from Dutch and German dairy farms, and industrial discharges in Switzerland. 20% of the world's chemical plants line its banks.

What's been done?

- 1990s – following several chemical spills, ICPR adopted a *Convention on Protection of the Rhine* (1999) committing countries to firm water quality objectives, restoration of North Sea fisheries. NGOs serve on ICPR assemblies, working groups, and ministerial councils alongside governments.
- Have changes helped?
 - Water quality remains poor but is gradually improving – heavy metals have been reduced, oxygen levels are increasing, salmon *not* re-appearing.
 - Pollution management and in-stream flows still managed by individual countries – cleanup efforts continue to be hampered by the reluctance of national regulators to grant ICPR independent enforcement power.
 - Improvements thus far can be attributed to *public outrage at accidents*, demands to *improve the river as an amenity* and tourist attraction.



Los Angeles River



Near Griffith Park (c. 1900)



Walking the stream bed, 1912



Flooding – Arroyo Seco (1913)



Flood of 1941

Los Angeles River



- *Los Angeles was built on a river, not the ocean*
- *Until 1913 –river was principal source of local supplies*
- *1930s, Corps of Engineers channelized river to mitigate floods*
- *50 miles of river is encased in concrete – can it be restored?*

Restoring the Los Angeles River “virtually”



- *Los Angeles River Revitalization Master Plan – lessons*
 - Changing *urban needs* affect how we *value* rivers.
 - Initial settlement – *exploit & use*
 - Industrialization – *harness & control*
 - Post-industrialization – *restore & renew*
- *Key question – whose values will predominate; “gentrified urbanism” or “equitable re-development?”*

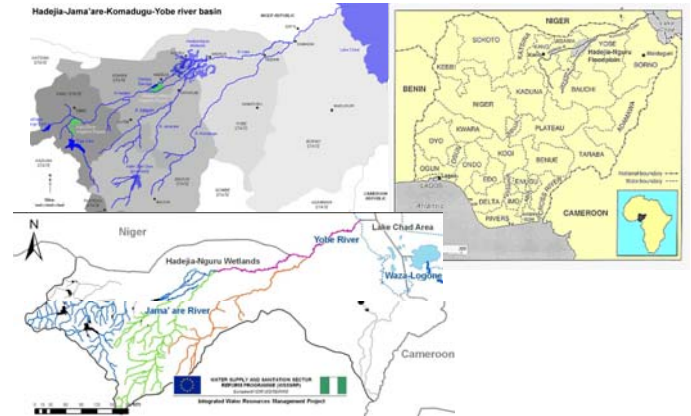
Doing things differently – the future

- Giving voice to the voiceless
- Rethinking the value of water
- Adaptive management – floods and water supply

Giving the voiceless a voice

- **Dublin Statement on Water and Sustainable Development (1992):** 150+ countries convened to generate a cooperative vision for “water justice.” Conclusions?
 - Water is a *finite, vulnerable resource*, essential to sustain life & the environment.
 - Its development & management should be based on a *participatory approach, involving users at all levels*.
 - *Women* play a central part in the *provision, management and safeguarding* of water.
 - Water has a *value* in all its uses & should be recognized as a public good.
- **Significance?** (we must) “. . . consider financial requirements for water-related programs, in accordance with these principles . . . (we) must include realistic targets for implementation . . . internal and external resources needed.

Hadejia-Jama'are Basin



Hadejia-Jama'are Basin –challenges

- Climate variability – (drought and flooding) recurrent problems.
- Basin residents rely on subsistence farming, small scale fisheries.
- In 1970s two major dams built to ensure irrigation supply, flood control – generated unanticipated “cascading” impacts:
 - Silt backed-up behind dams; water released earlier to dilute silt.
 - Earlier releases led to downstream *floods*.
 - Floods encouraged infestation of *typha grass*, clogging streams.
 - *Agriculture and local fisheries declined*.
 - Farmers compensated by digging small channels to reduce floods; *led to more erosion, lower agricultural productivity*.

Hadejia – Jam'are – climate variability



Reforming decisions

- 2002 – *World Conservation Union, UK* partnered with Nigeria to “build local water resources management capacity” in basin – *Joint Wetlands Livelihood* project.
- **Goals:** Improve use of local knowledge, introduce pilot projects, demonstrate best-management practices to restore economy & local ecology:
 - Coordinate projects among different levels of government, preserve existing floodplain income from farming, grazing, non-timber forest products, fishing.
 - Preserve wetlands to restore dry-season grazing, groundwater recharge, waterfowl habitat – during drought.
 - Provide local level forums comprised of farmers, women's groups, others – engage in community-level training, apply local knowledge.
- Local stakeholders support projects because they directly participate in management & policy making.

Hadejia-Nguru wetlands – local-scale rice farming



Participatory innovations



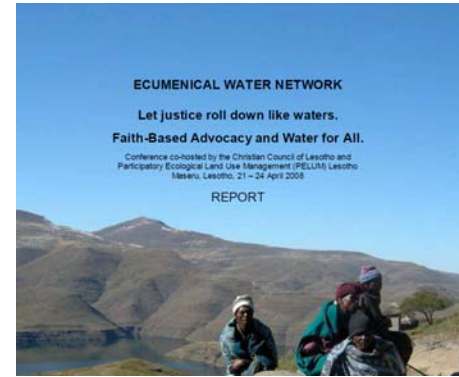
Watershed management "game" – farmers serve as students, role-play solutions to local problems –



Break-out discussions – comparing solutions and reaching accord – JWL Hadeja office, Dauchi, Nigeria.

- Session 1 – users brainstorm methods to maintain income and production with less water.
- Session 2 – users prioritize methods by voting – results become basis for by-laws to be followed by farmers.
- Session 3 – users discuss how institutions should assist in conflict resolution, provide additional information, support agreements.
- Session 4 – users review, reflect, conduct evaluation and specify actions.

Rethinking the value of freshwater – stewardship



Implementing water stewardship

Eco-Islam hits Zanzibar fishermen

By Daniel Dickinson
BBC News, Pemba, Tanzania 2/17/2005

- The Koran is not widely known as a source of guidance on environmental and conservation issues, but that has not stopped one development organization in Tanzania from using it to help conserve an island marine park.
- Religious leaders have been asked to promote conservation messages using the texts of the Koran - an approach which has proved a great deal more successful than government regulations. The island of Misali is just a small dot in the Indian Ocean off the coast of Pemba.
- Destructive fishing methods were damaging the corals and harming species that lived there. Government bans had little impact. The fishermen who launch their wooden dugout canoe from the windswept shores of Misali, like 99% of the population of the Zanzibar archipelago, are Muslims.
- Once they realized that catches were falling dramatically, the non-governmental organization Care International stepped in to persuade them to take better care of their environment - through a scheme based on Islamic principles.

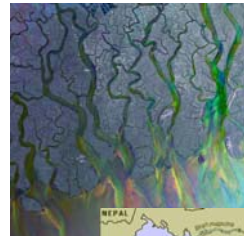


Fishing methods were destroying marine wildlife on the coral reef.



Tourism, too, will benefit from the new scheme to protect marine life.

Adaptive management – Bengali delta flooding



Coastal detail



Ganges delta



Delta challenges

- 160 million residents, by 2050, 220 million – chronic flooding from cyclones, tropical storms has killed thousands.
- Sea level rise worsens floods –may displace 15% of population.
- Ganges, Brahmaputra Rivers constantly shift, making it difficult to secure banks, protect farmland.
- In 1990s, World Bank project, backed by France, Japan, US, proposed 8,000 km of dikes to control rivers:
 - \$10 billion proposal opposed by farmers whose land would be taken.
 - Massive Dutch-style dikes to hold back sea, cyclone-induced waves, even less practical, according to IPCC – local soils too unstable.

Flooding impacts

Some Causes of Flooding in Bangladesh



Locally-adaptive management

- In some areas villagers and farmers people have begun re-building programs to evade annual floodwaters.
- NGOs have developed local-scale, low-tech adaptation measures:
 - UK-based *Practical Action* – 2-foot-high concrete plinths topped with inexpensive jute panel walled homes –less likely to be washed away by tropical storms.
 - US-based CARE helps people along coast rediscover forgotten farming techniques such as Baira cultivation, floating gardens suited to areas subject to lengthy inundation.
 - Salt-tolerant varieties of rice introduced; some paddies converted to shrimp, crab ponds.
 - Family planning efforts showing progress – fertility rates < 2/3 since 1977.
- Illustrate how incorporating voices of those impacted by flood produces innovations more likely to be appropriately – and economically – scaled.

Flood adaptation innovations



Proposed agricultural mats – US architect Christopher Kouttron



Floating farm

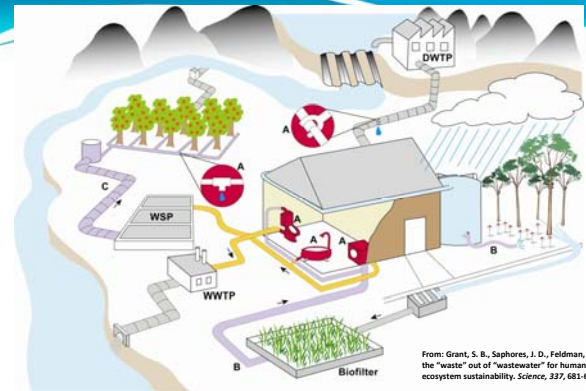


"Stilt" homes – Gazipara, Bangladesh

Adaptive management – New York City & climate change



- City, local universities, NGOs evaluating climate adaptation methods.
- Questions guiding adaptation:
 - How will sea-level rise, storm surges affect infrastructure?
 - How will higher temperatures, lower precipitation affect supply?
 - What capital planning needs must be met to adapt?
- City also pursuing aggressive conservation (residential use reduced 30% since 1978); repairs to aqueduct system.



From: Grant, S. B., Saphores, J. D., Feldman, D. L. (2012). Taking the "waste" out of "wastewater" for human water security and ecosystem sustainability. *Science*, 337, 681-686.

TAKING URBAN ADAPTATION SERIOUSLY: substitution (A), regeneration (B), reduction (C) at household scale. **Substitution** includes watering garden with rainwater from a tank; flushing toilets and washing laundry with treated storm-water effluent from a biofilter. For **regeneration**, a waste stabilization pond (WSP) transforms household sewage into high-quality water for irrigating an orchard. **Reduction** includes repairing leaks in distribution system, drip irrigation, dual-flush toilet, low-flow shower rose, front-loading clothes washer. Other infrastructure shown includes conventional drinking water plant (DWTWP); conventional wastewater treatment plant (WWTP); river diversion (supplying the orchard).

Conclusion – facing the future

- In past, predominant approach to managing water – *hard power*:
 - Began with “hydraulic societies” of antiquity: centrally organized laws, administrative systems to allocate rights of access.
 - Water resources developed via large public works projects which favor economic growth; disfavor equity, environment.
 - Powerful protagonists manage rivers & aquifers; control water use.
- An alternative is *soft power* based on negotiation, partnerships, reliance on local knowledge (e.g., Hadejia-Ja'mare, Bangladesh).

Making soft power work

- **Acknowledge** that decisions over water management made in one location may adversely affect users in another (e.g., Rhine basin).
- **Emphasize** social learning: *solutions that are incremental and reversible if they fail* – may overcome these obstacles (e.g., Bangladesh,).
- **Admit** that no jurisdiction exercises total control over water; groups define problems differently – irrigation, power, public supply, navigation (e.g., Three Gorges Dam).
- **Understand** that authority over water must be tempered by *perceived fairness and accountability*: if groups feel excluded, they won't cooperate.
- Requires “aligning . . . governance to the global challenges of sustainability” (UNEP, 2012).