Water use: Critical link between hydrosphere & anthroposphere

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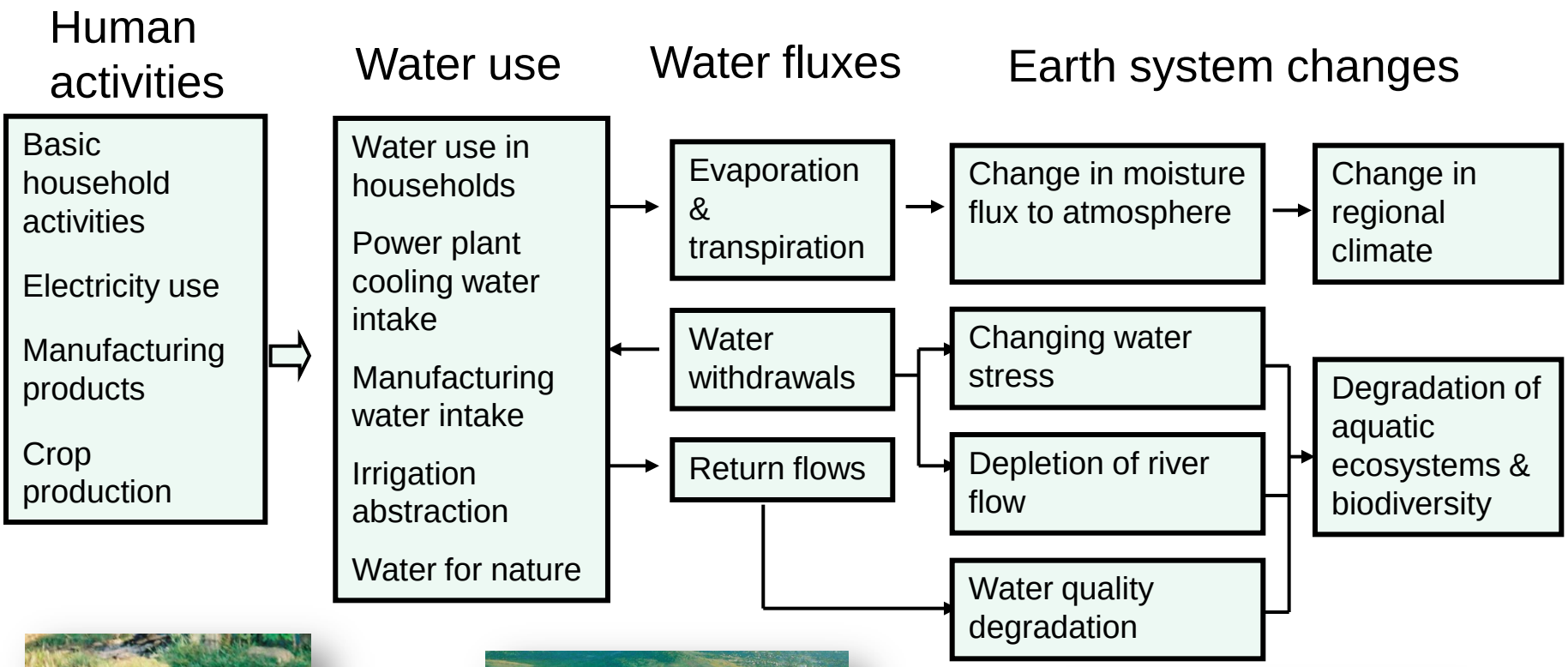
With input from Martina Floerke, CESR

Global Water Use: A Link Between Human Activities & Earth System Changes



W. Use link, & emb

Context for linkages with water:
The Sustainable Development Goals

Goal 6. Ensure availability and sustainable management of water and sanitation for all

By 2030 …

6.1 … drinking water for all

6.2 … adequate sanitation for all

6.3 … improve water quality by … halving the proportion of untreated wastewater and increasing recycling and safe reuse …

6.4 … increase water-use efficiency … and substantially reduce the number of people suffering from water scarcity

6.5 .. implement integrated water resources management at all levels …

6.6 … By 2020, protect and restore water-related ecosystems

Context for linkages with water:
The Sustainable Development Goals

Goal 2. End hunger, achieve *food security* …
(Fish: 10% calories, 16% protein)

Goal 3. Ensure *healthy lives* and promote well-being for all at all ages

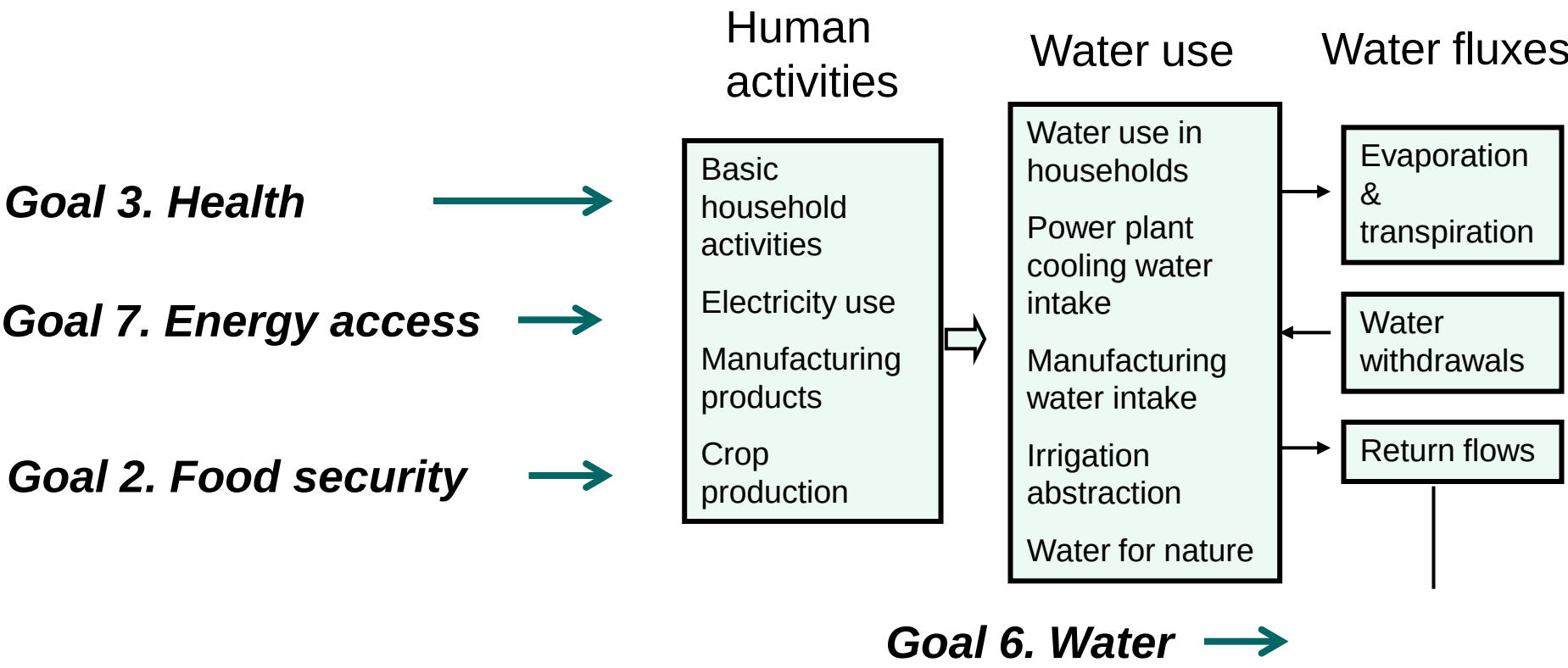
3.3. Combat water-borne diseases

3.9 Reduce deaths and illnesses from water pollution

Goal 7. Ensure access to affordable, reliable, sustainable and modern *energy for all*

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

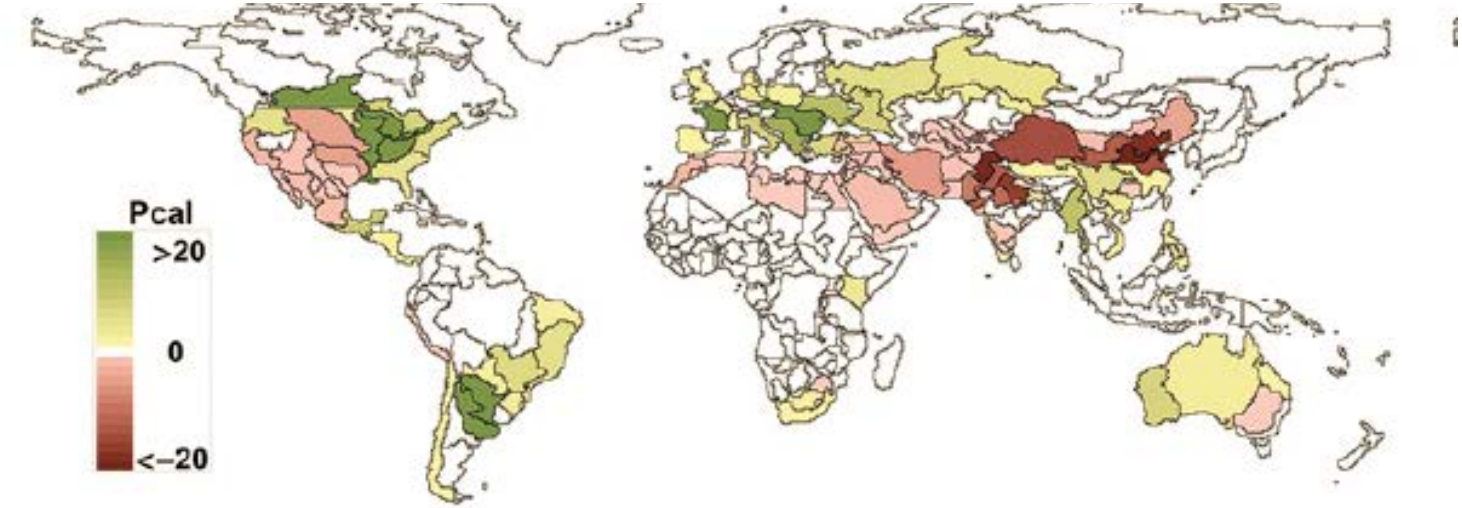
Sustainable development goals: Driving policies and research in the water arena?



Water and Food Security

Irrigation and water sufficiency

Change in crop production due to water surplus or deficit under climate change (SCP 8.5) (2070-2099 vs 1980-2010)



Freshwater limitations: Production loss: 600–2,900 Pcal

Source: ISI-MIP Eliot et al. 2014

- Food security could be affected by climate change and lack of water for irrigation
- Need global perspective to assess scale of problem

Water and Food Security

Improving irrigation efficiency

Case Study: Kansas, USA
(improved pivot irrigation) *Pfeiffer (2013)*

Status Quo

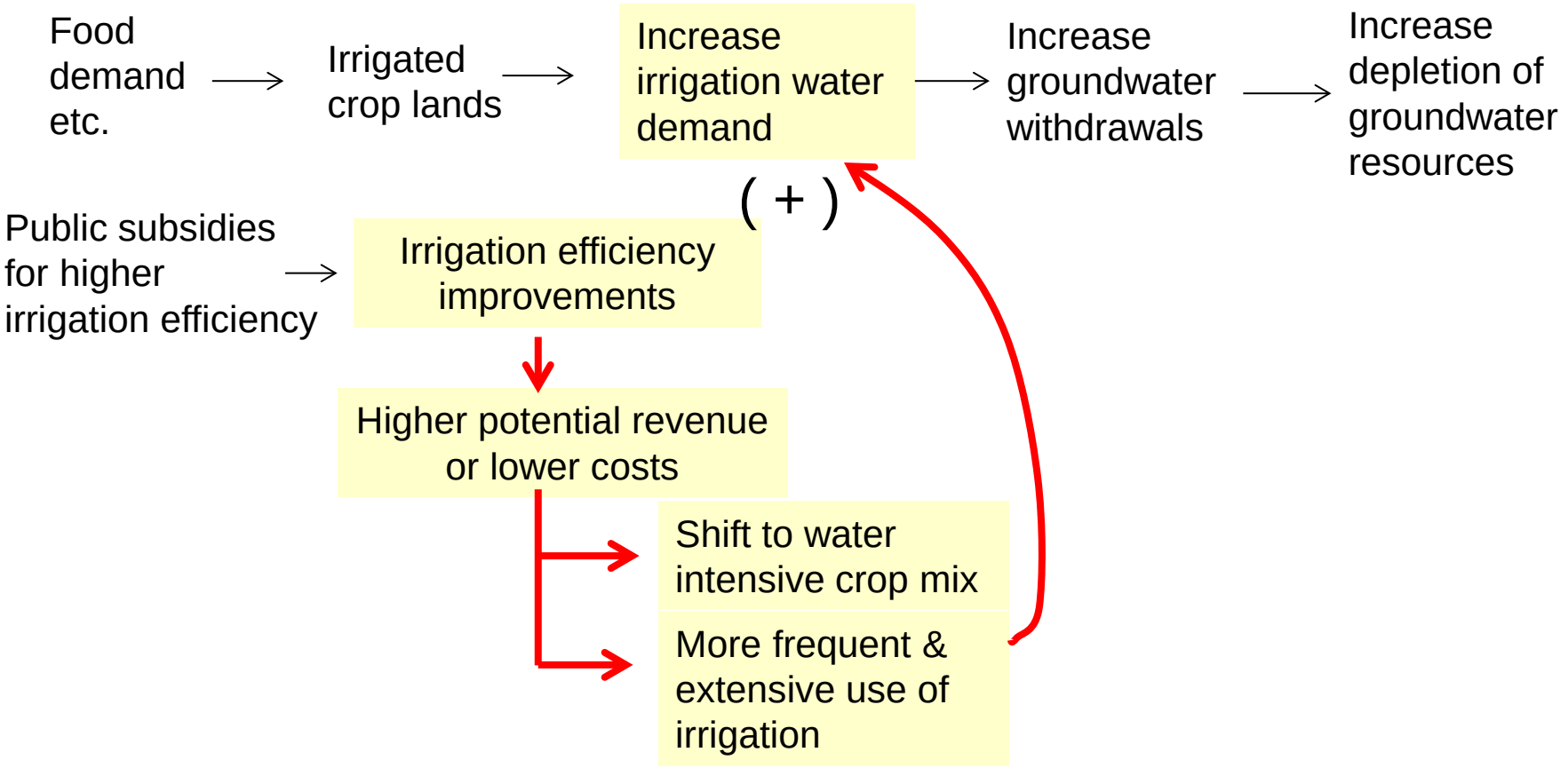
Food demand etc. → Irrigated crop lands → Irrigation water demand → Groundwater withdrawals → Increase depletion of groundwater resources

Water and Food Security

Improving irrigation efficiency

Case Study: Kansas, USA
(improved pivot irrigation) *Pfeiffer (2013)*

Rebound effect



Water and Food Security

Improving irrigation efficiency

Case Study: Kansas, USA
(improved pivot irrigation) *Pfeiffer (2013)*

Policies to address the rebound effect

Food demand etc. → Irrigated crop lands → Decrease irrigation water demand → Decrease groundwater withdrawals → Decrease depletion of groundwater resources

(-)

Public subsidies for higher irrigation efficiency → Irrigation efficiency improvements

Irrigation efficiency improvements → Higher potential revenue or lower costs

Restrict water allowances
- decrease water rights
- tax on water extraction

→ Discourage shift to water intensive crops

→ Discourage more frequent & extensive use of irrigation

In systems terminology,

- Rebound effect – systems failure
- Limited view of system and system goals
- Solutions come from broadening system, identifying system goals & critical linkages, accounting for human behavior.

Water and Food Security

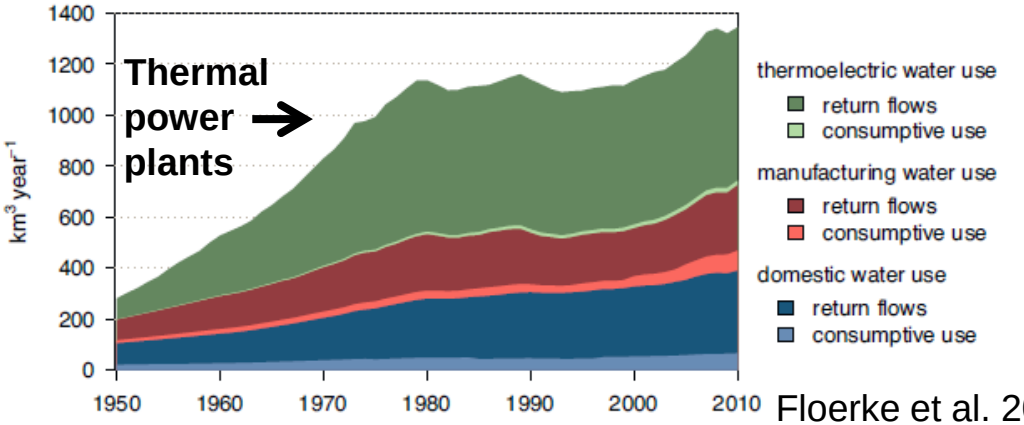
- ✓ Will there be enough water to reach the SDG for food security?
- ✓ Can food security rely on irrigation? Where and when could there be limitations? Under climate change?
- ✓ Tradeoffs between water for irrigation, other uses?
- ✓ Will enough water of *good quali*ty be available for irrigation?
- ✓ What is the potential of efficiency improvements, and will human behavior influence their effectiveness?

Water and Energy Access

1.3 B without access to electricity

Will water limit access to energy?

Non-agricultural global water use 1950-2010

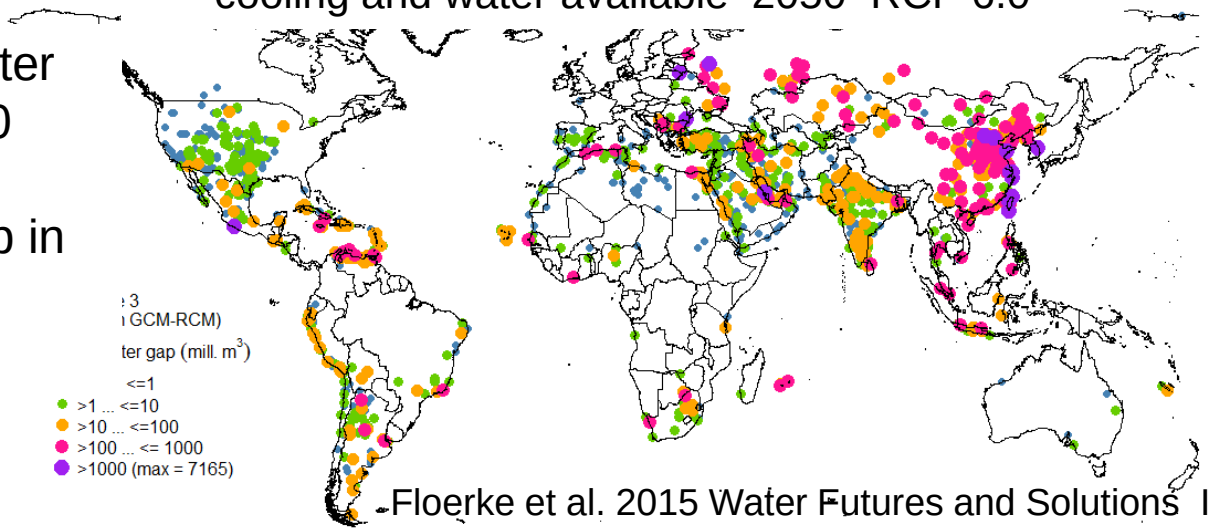


Floerke et al. 2013

Gap between water withdrawals for power plant cooling and water available 2050 RCP 6.0

Gap ≈ 100 km^3/yr of water for power plants in 2050

Possibly substantial gap in providing water for thermoelectric plants



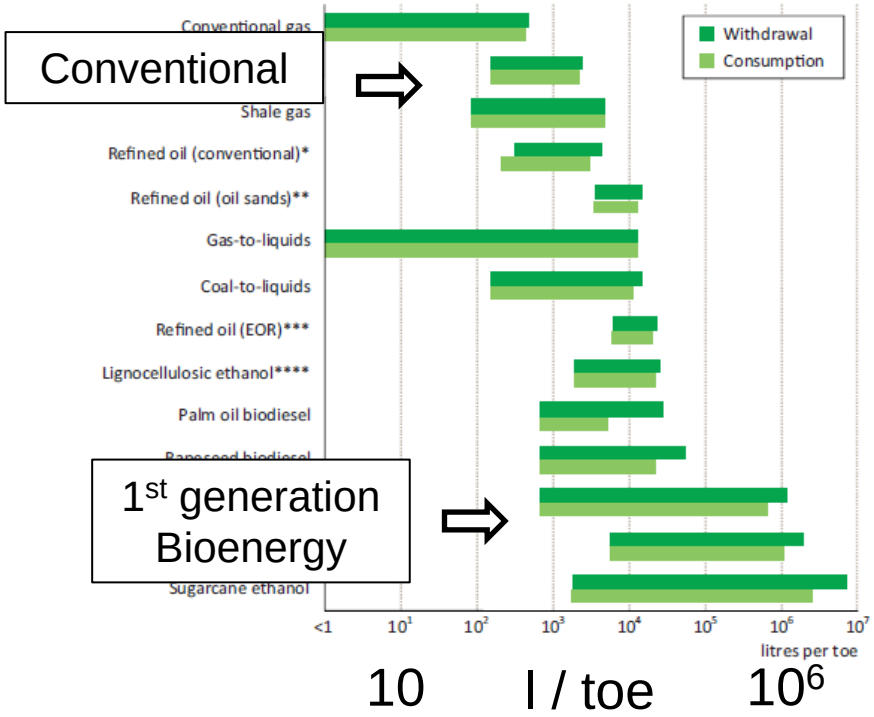
5xB, 3xG

Floerke et al. 2015 Water Futures and Solutions IIASA

Water and Energy Access

Water use – primary energy production (l/toe)

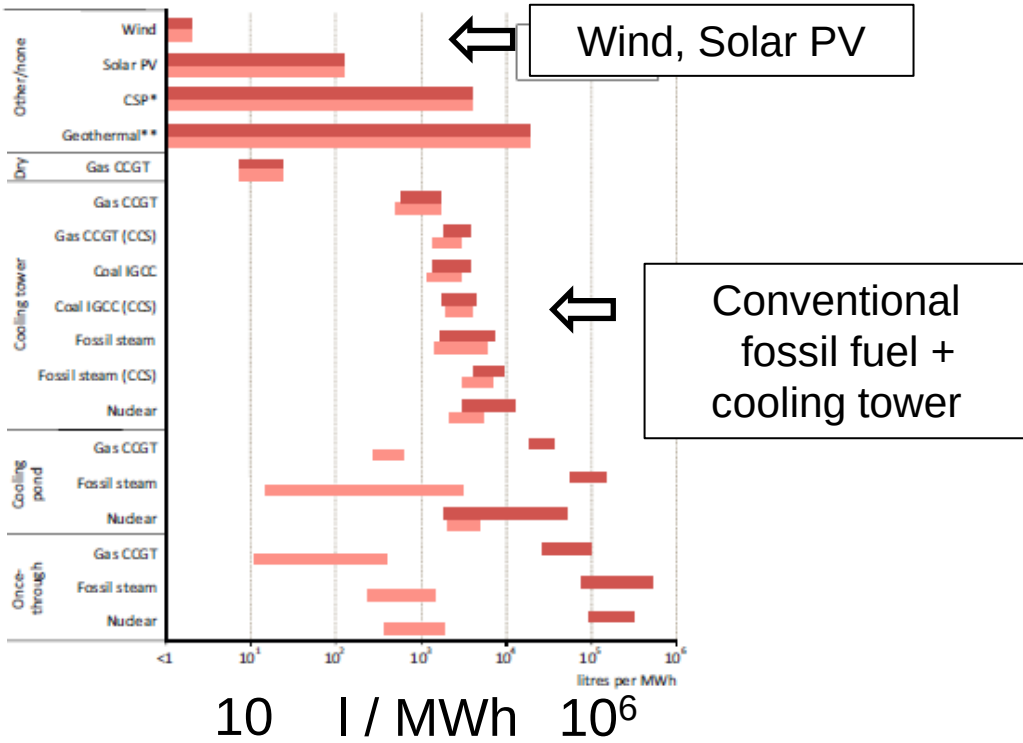
IEA 2012 World Energy Outlook



10 l / toe 10^6

Water use – electricity generation (l/MWh)

IEA 2012 World Energy Outlook



10 l / MWh 10^6

1000,100x,..

10000,10

Water and Energy Access

Key questions

- ✓ Will water scarcity encourage an *Energiewende* in the rest of the world?
- ✓ Will there be enough water to reach the SDG goal for energy access?
- ✓ Where and when could water limit energy production?
- ✓ What are impacts of water on energy under climate change, changed climate variability?
- ✓ How does human behavior affect water use, acceptance of new water policies?
- ✓ What are trends?

Scenario analysis

Indispensable tool – link different scales

Combine qualitative knowledge from stakeholders with quantitative knowledge from models and experts

Need to sum up experience in scenario analysis in water arena

Water and Health

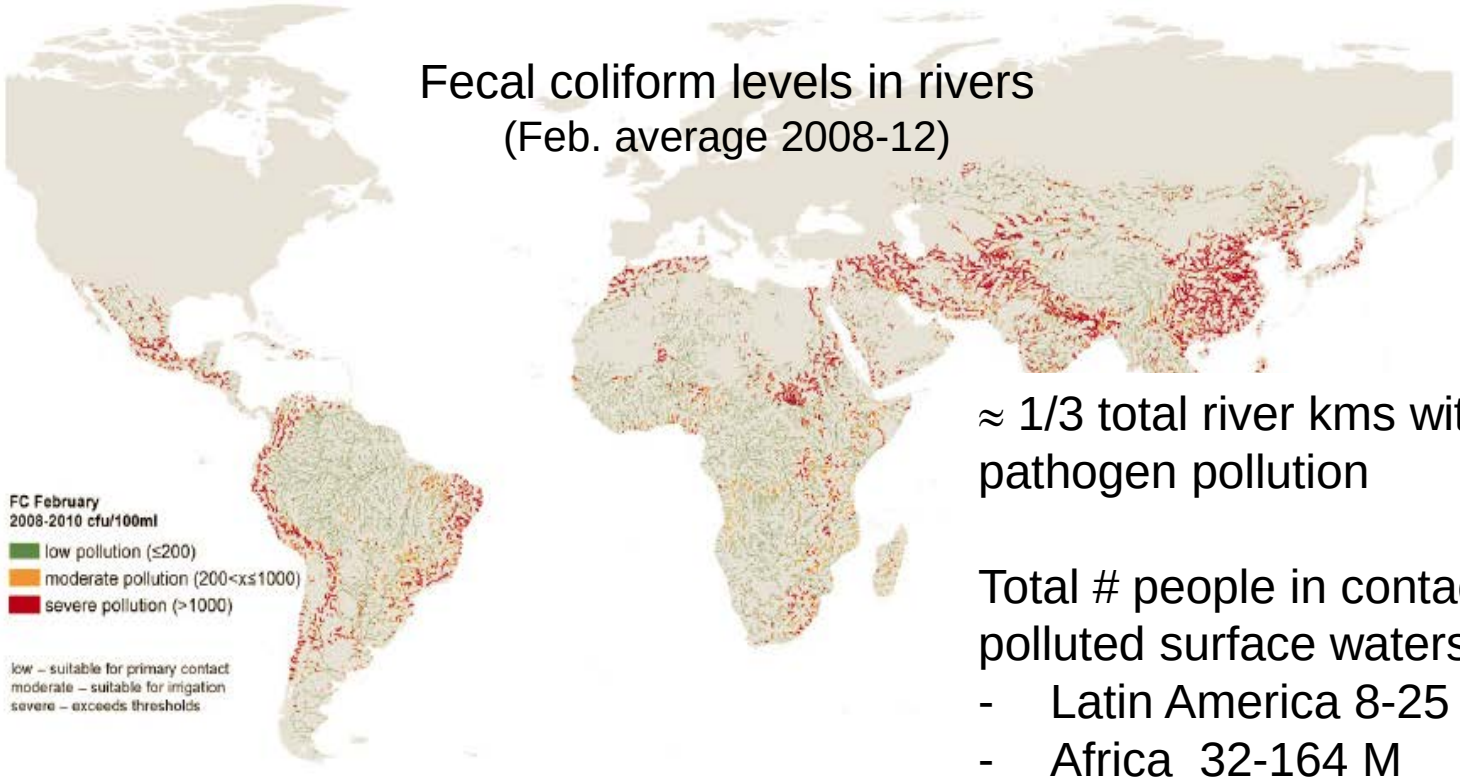
Health risks of contact with surface waters

Water pollution class	Faecal coliform concentration (cfu/100 ml)	Description
Low pollution	$x \leq 200$	Generally suitable for contact (including, e.g. swimming and bathing)
Moderate pollution	$200 < x \leq 1000$	Only suitable for contact during irrigation and fishing activities, but not for other contact
Severe pollution	$x > 1000$	Generally unsuitable for contact

Wq, 4 B /yr 2 M
Since 1990 >2B

Water and Health

Health risks of contact with surface waters



Fecal coliform levels in rivers
(Feb. average 2008-12)

≈ 1/3 total river kms with severe pathogen pollution

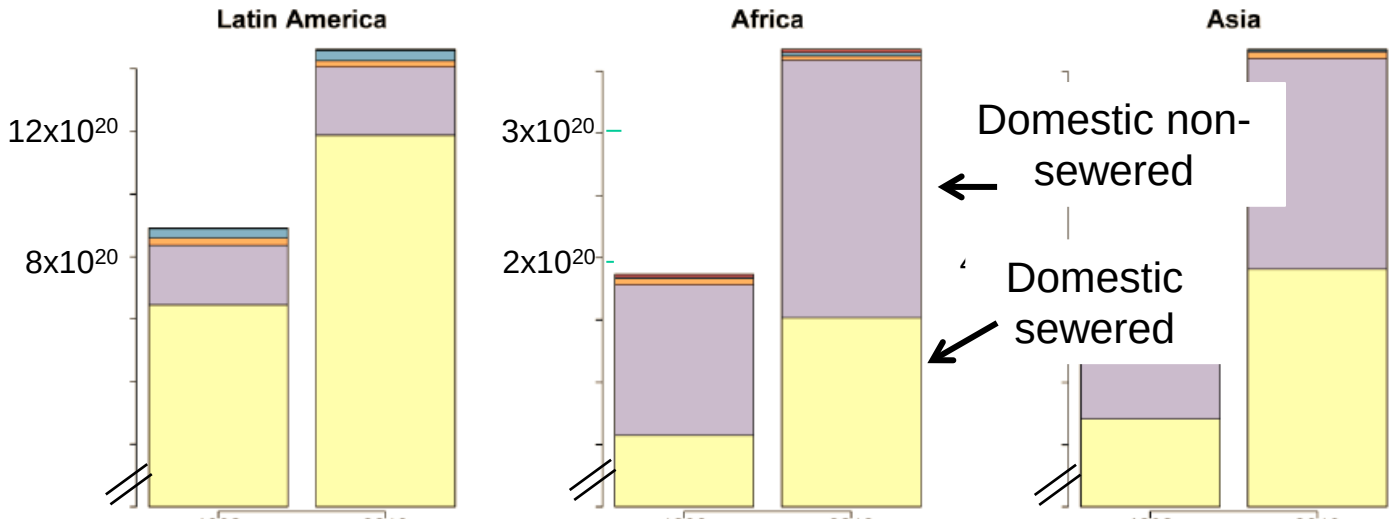
Total # people in contact with polluted surface waters

- Latin America 8-25 M
- Africa 32-164 M
- Asia 31-134 M

Source: *The world's water quality: A pre-study for a worldwide assessment*
Please note: **Preliminary results**

Water and Health

Bacterial loadings to rivers – 1990 and 2010 (# FC organisms/yr)



- Water pollution increasing despite expansion of urban sanitation (sewer collection without wastewater treatment)
- Solving one problem (local sanitation) transfers public health risk to another arena (surface waters) → Need broad systems view
- Can avoid the worst -- Developing countries rapidly going through "traditional" water pollution pathway of developed countries; But ≈ 2/3 of all river reaches in Latin America, Africa and Asia) have *low* level of pathogen pollution; → How to leap frog?

Source: *The world's water quality: A pre-study for a worldwide assessment*
Please note: **Preliminary results**

Water and Health

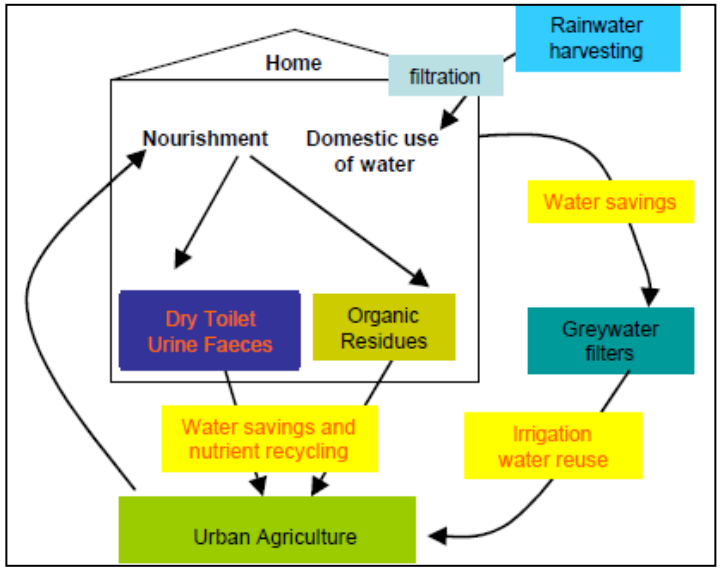
Drawbacks of conventional wastewater treatment

- Energy costs
- Maintenance costs
- Engineering capacity

Local approach: “Ecological sanitation”

Tepoztlán, Morelos, Mexico -- TepozEco pilot program

- Dual water supply for drinking water & service water
- Composting toilets
- Domestic rainwater use, grey water filters (reedbeds, mulch)
- Reuse of purified greywater for irrigation
- Recycling of nutrients



- Human behavior – hygiene and sanitation
- Governance – community participatory approach
- Systems approach

Water and Health

Key questions

- How does water contamination of surface waters hinder achievement the SDG for health?
- What are the specific health threats due to polluted water and where?
- What are trends?
- How to remove barriers to & scale up ecological sanitation?
- What are the governance, human behavior, and other factors that will influence water pollution controls?

Summing Up – Water use as link between society and the earth system

- Sustainable Development Goals (food security, energy access, health)
  - Major driver of water research for next 15 years
- Importance of systems approach
  - Water use as link -- human activities & earth system
  - Policies derived from looking at whole system
- Importance of studying human behavior
- Importance of water quantity & water quality
- Importance of scale & linkage between scales
  - Multilevel: local → river basin → global
  - Tool for linking levels: scenario analysis, models
- Recognizing water as part of a linked global system generates important new questions for the water research community

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