XII SIMPÓSIO DE RECURSOS HÍDRICOS DO NORDESTE

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Aspectos da Gestão dos RH no Canadá

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New approach : Integrated Water Resources Management

"a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems"

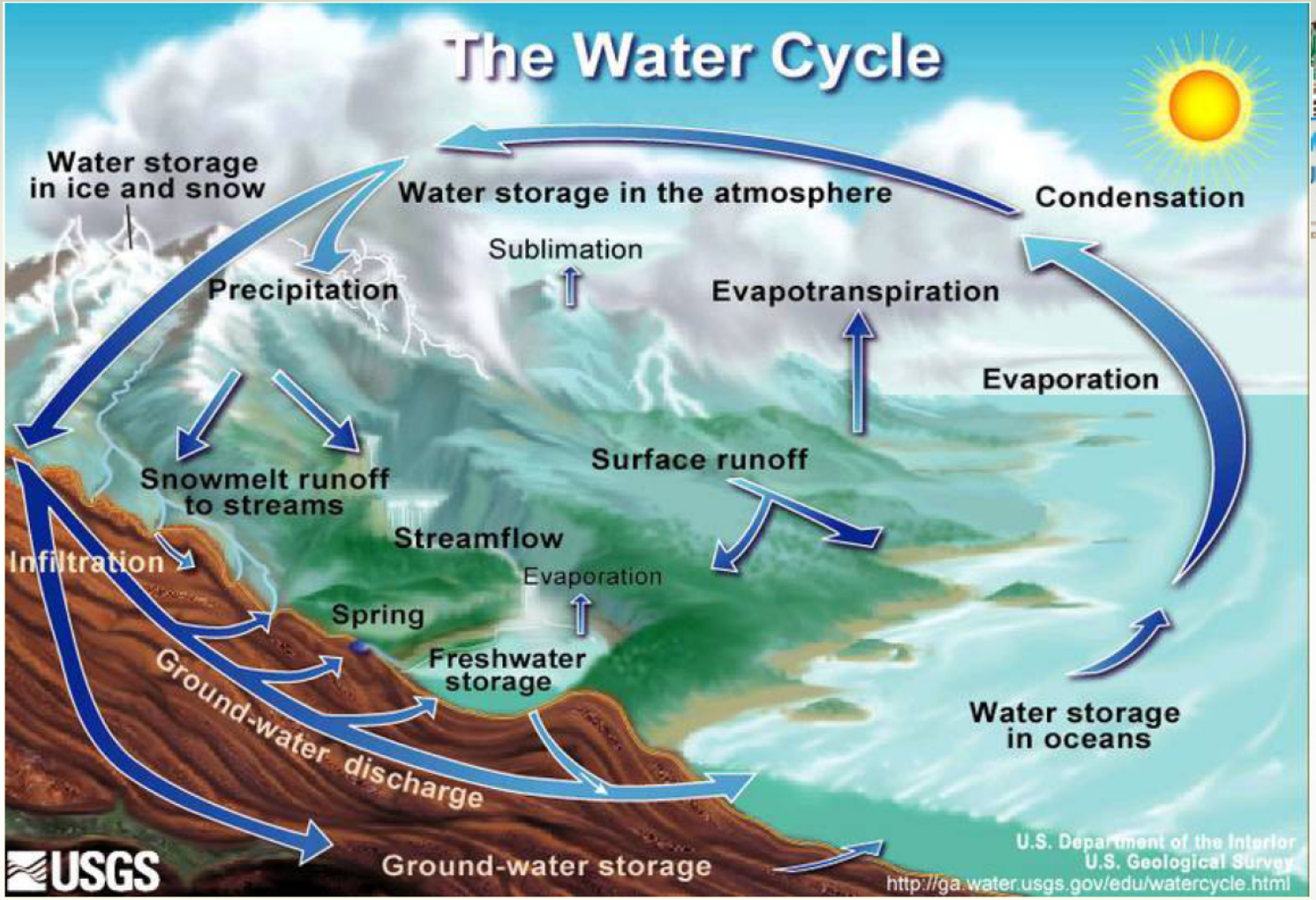
Global Water Partnership. (2000). Integrated water resources management. Stockholm, Sweden: Global Water Partnership.

Governance concepts

- *Legitimacy* of the organization's authority to govern
- *Transparency* in the decision-making process
- *Accountability* of actors and their responsibilities, including integrity concerns
- *Inclusiveness* of the different stakeholders
- *Fairness* in the service delivery or allocation of uses
- *Integration* of water policy making at horizontal and vertical levels
- *Capacity* of organizations and individuals managing water
- *Adaptability* to a changing environment

Source : OECD (2011).

What and where are the water resources we want to manage?

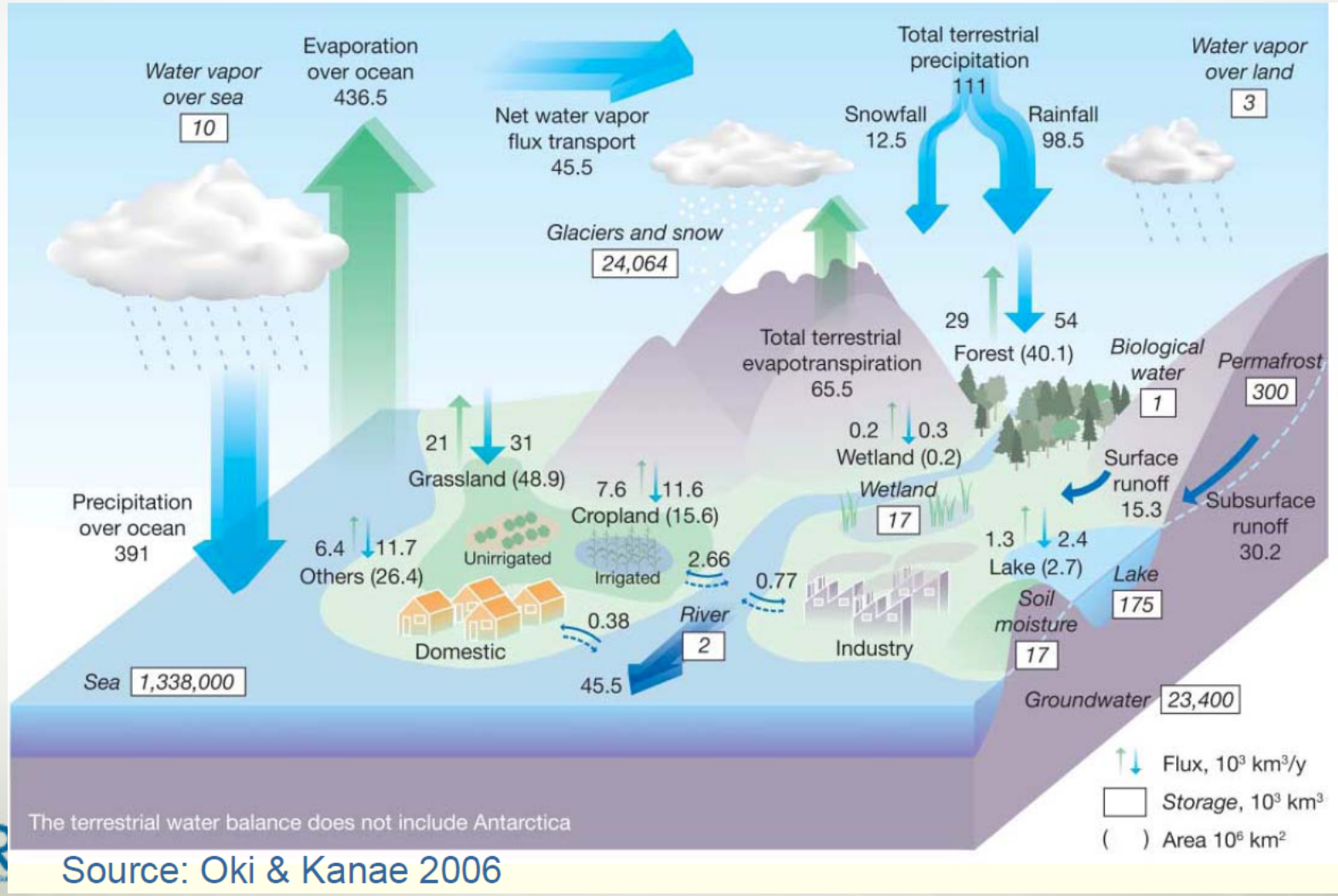


The water balance:

Inflow – Outflow = Δ storage

Precipitation – (Evaporation + Runoff) = Δ storage

Global hydrological cycle: stocks and flows



Source: Oki & Kanae 2006

The water balance:

Precipitation – (Evaporation + Runoff) = Δ storage

Precipitation –
driven by climate, seasonal.
Global long term averages:
2 to 12 000 mm/yr

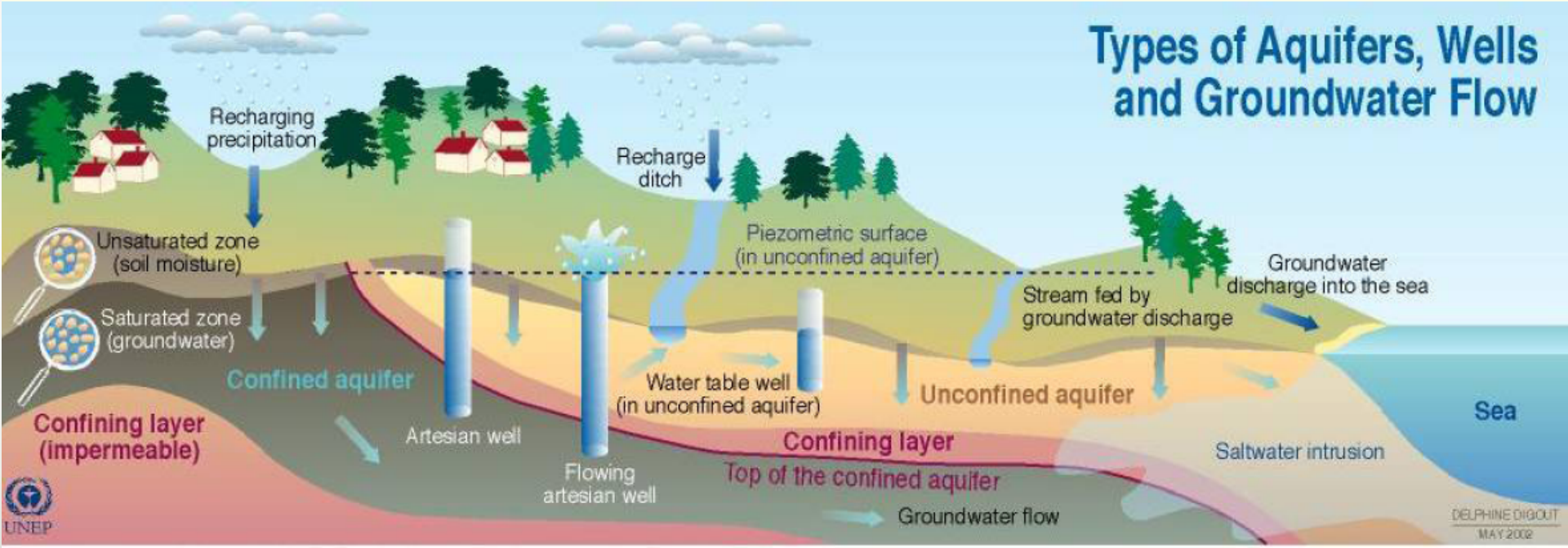
Evaporation –
From open water or land surface, transpiration, evapotranspiration, interception, sublimation.

Runoff –
Overland (fast), Interflow in soil, baseflow (groundwater discharge- slow).
Global long term averages:
0 to 6 000 mm/yr

Storage –
Groundwater (long/fossil), lakes and wetlands (buffers, reservoirs= 1/6 of river discharge), snow (seasonal), ice (long).

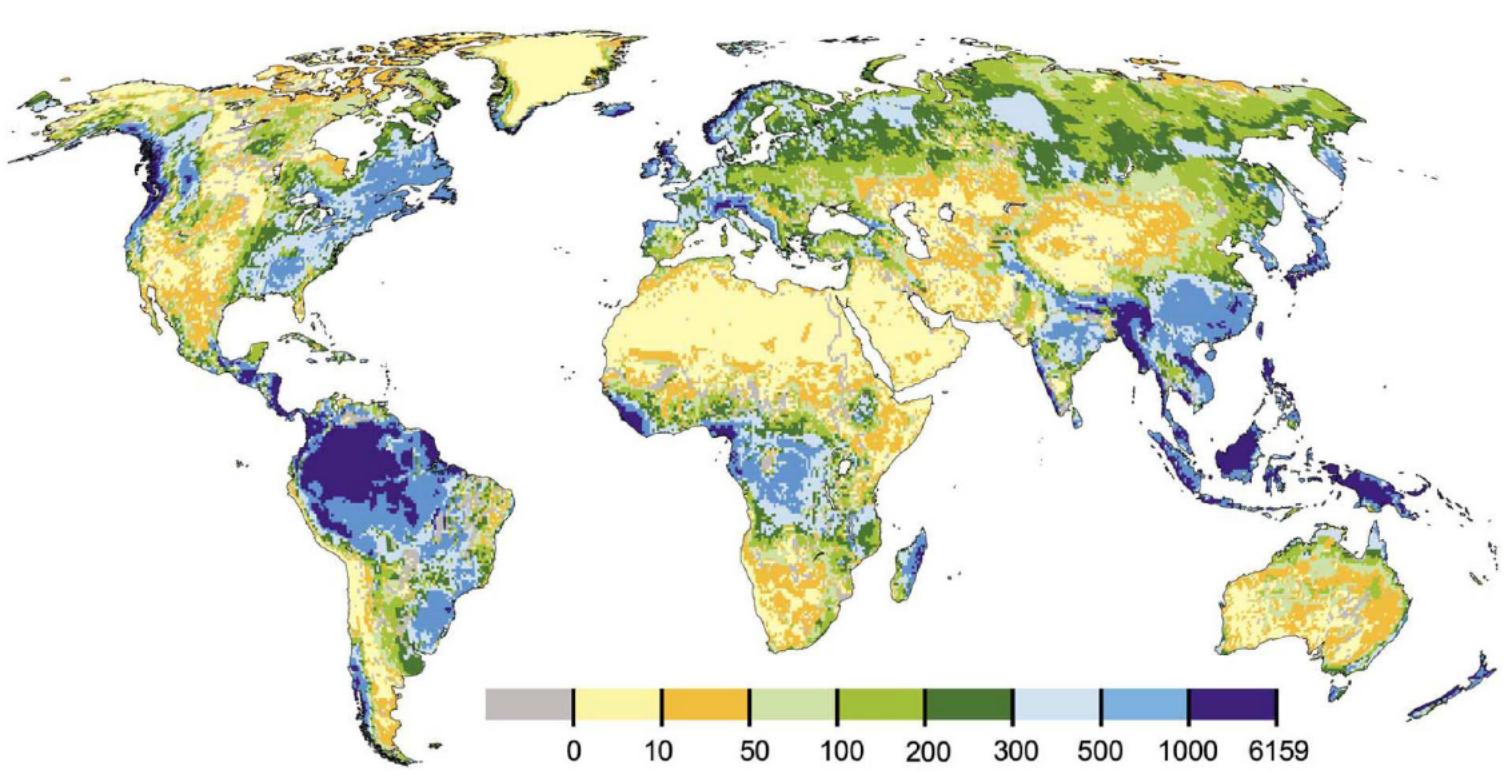
Water Balance

Storage - Groundwater



Source: Environment Canada, 2001 (Adapted from: http://www.ec.ca/water/index.htm).

Average annual runoff (1961-90) in mm/yr



Source: WaterGAP model (Döll et al. 2003)

River discharge = runoff – losses to evaporation and seepage + gains from groundwater

Summary

- Renewable water resources – renewable on an annual basis (total water availability)
- Global water resources are large but unequally distributed in time and space
- Discharge follows precipitation patterns, but is strongly modified by evaporation and storage
- Land use has a strong influence on evapotranspiration and infiltration.

How does society affect and use these water resources?

Anthropogenic Water Cycle

Anthropogenic Changes

- The general water cycle describes the natural water cycle
- Anthropogenic uses will modify the stocks and flows of the natural cycle due to changes in:
  - Land use → vegetation
    - Evapotranspiration
    - Infiltration
    - Runoff
  - Climate → precipitation
    - Evapotranspiration
    - Infiltration
    - Runoff
- Either without planning or with planning
  = WATER RESOURCES MANAGEMENT

Anthropologic water cycle

Uses:

- Agriculture
- Industry
- Domestic
- Energy
- Resource extraction
- Recreation

U.S. Geological Survey, Department of the Interior/USGS

Anthropological water use

Withdrawals

- Water withdrawals from surface water (rivers, lakes) and groundwater. Groundwater is approx 1/6 of total (plus 200 km^3/ yr of fossil water). Main users India, USA, China.

Consumptive water use

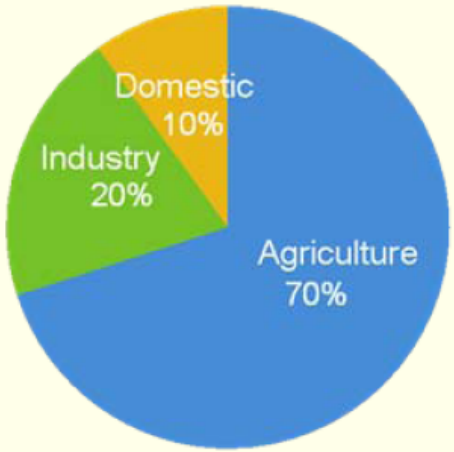
- Consumption is that part of the withdrawn water that is not returned to the river system but "lost" through evapo-transpiration
- Globally approx. 60% of withdrawn water is "consumed". Main consumer is irrigated agriculture (90%)

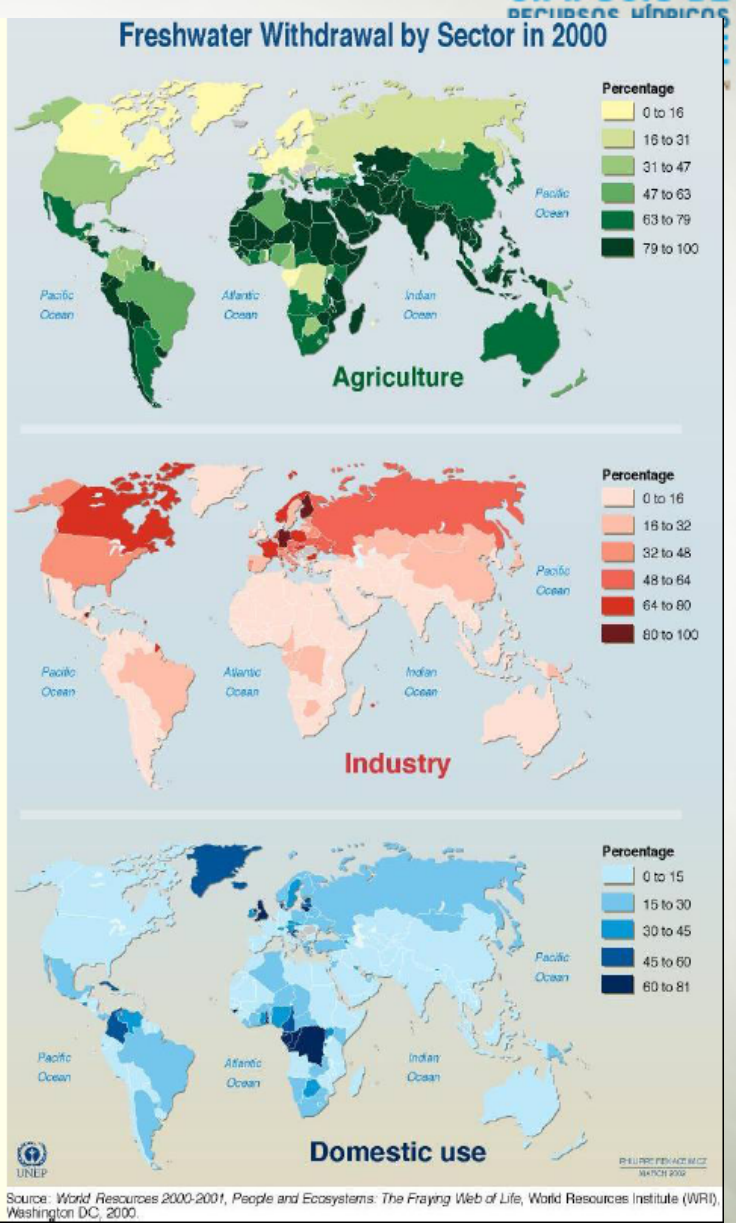
Return flow = withdrawals – consumption

- Typically high (up to 100%) for municipal water use, industry (cooling), hydropower BUT often deteriorated quality (pollution)
- Typically low (down to 0%) for irrigation agriculture

Main water use sectors

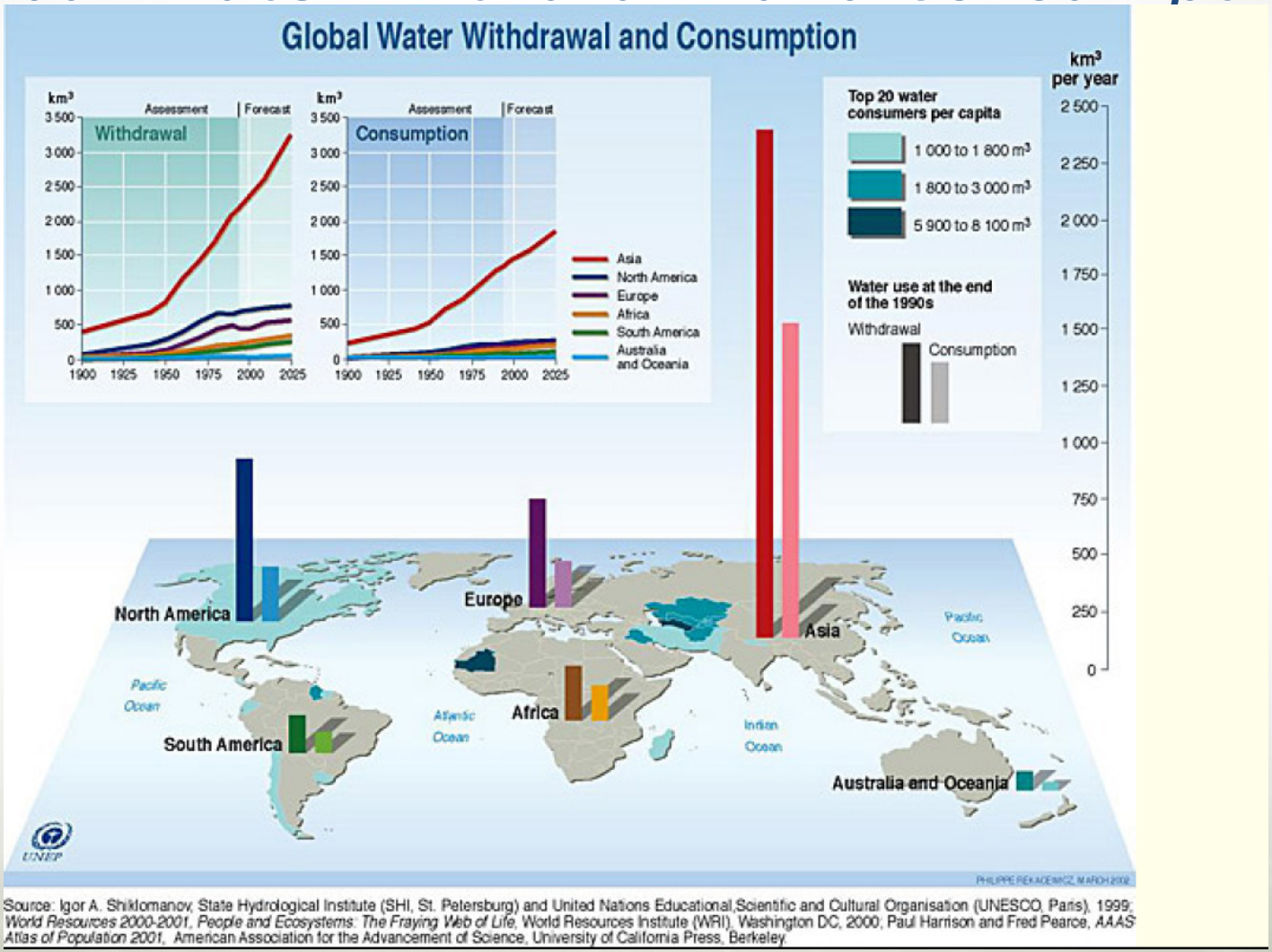
- Agriculture
  - Irrigation (largely consumptive)
  - Livestock
  - Fisheries (aquaculture)
- Industry
  - Cooling (often non-consumptive, but warmer return flow)
  - Production (manufacturing)
  - Hydropower (largely non-consumptive)
  - Mining
- Households (domestic use)
  - Outdoors
  - Indoors
  - Wastewater
- Others
  - Recreation
  - Navigation





Anthropogenic Water Cycle

Global Water Withdrawl and Consumption



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999; *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000; Paul Harrison and Fred Pearce, *AAAS Atlas of Population 2001*, American Association for the Advancement of Science, University of California Press, Berkeley.

Water in Canada

- 20% of global fresh water in lakes, but only 6.5% of it is renewable, 2.6% available to population in southern Canada
- 60% of Canada's fresh water flows north, 1 in 4 municipalities in Canada had water shortage between 1994 and 1999
- 30% of households use groundwater.
- Water Use: 4,400 lcd total and average municipal use 330 l/d in 2001 (includes domestic, commercial, industrial, leaks, firefighting)

Water use and consumption by sector in Canada

Gross water use is the "total amount of water used (intake +recirculation) to carry out an activity."

The 1996 ranking of industrial gross water use:

- #1 Thermal power (40,405 million cubic metres) with (11,655 MCM) recycled,
- #2 Manufacturing (12,996 MCM) with (6,958 MCM) recycled
- #3 Municipal (5,314 MCM),
- #4 Agriculture (4,098 MCM),
- #5 Mining (1,715 MCM) with (1,197 MCM) recycled

Source: Dan Shrubsole and Dianne Draper "On Guard for Thee? Water (Ab)uses and Management in Canada" in *Eau Canada*, Ed. Karen Bakker, UBC Press: 2007.

Water use and consumption by sector in Canada

Water consumption is the amount of water removed from its source and no longer available for use.

- The 1996 ranking of water consumption tells a different story from the gross water use:
- #1 Agriculture (3,036 MCM), gross (4,098 MCM),
- #2 Manufacturing (552 MCM), gross (12,996 MCM)
- #3 Thermal power (508 MCM), gross (40,405 million cubic metres)
- #4 Municipal (119 MCM), gross (5,314 MCM),
- #5 Mining (46 MCM), gross (1,715 MCM)

Source: Dan Shrubsole and Dianne Draper "On Guard for Thee? Water (Ab)uses and Management in Canada" in *Eau Canada*, Ed. Karen Bakker, UBC Press: 2007.

Water use is increasing.

How much is left?
Are we approaching the limits?

Is scarcity of water imposing constraints?

Water stress definitions

1. Absolute water availability
2. Water consumption to water availability
3. Water withdrawals to water availability

However this does not take into account the ability (financial, management) to access the available water.

Summary

- Today ¼ of the world's watershed area is under severe water stress and will increase
- 10% of total runoff is withdrawn each year
- In many industrialized countries withdrawals stabilize or decrease. Main concerns: water quality, protection of ecosystems, climate change
- Developing countries experience big increases in water needs of households and industry, but irrigation remains by far the biggest water user. Main concerns: water supply for food production, climate change.
- Water security is a food policy and food security issue.

Will water stress lead to water crises?

- In high-income countries less likely, because
- Waste water treatment, recycling of industrial water etc. allows for intensive re-use of water resources
- Diminishing water resources can be compensated for through trade
- In low-income countries more likely, because
- The lack of wastewater treatment, etc. causes the quality of water resources to degrade
- Diminishing water resources will lead to continued water emergencies

How do we manage these resources?

Integrated water resources management

- Basin scale planning involving all stakeholders.
- Prioritizing water use based on need to satisfy demands.
- Optimizing trade-offs between sectors.
- Based on models of physical processes, calibrated and validated by monitoring programs.
- Water use scenarios modeling to predict consequences of decisions.
- Decisions: political but should be based on science.

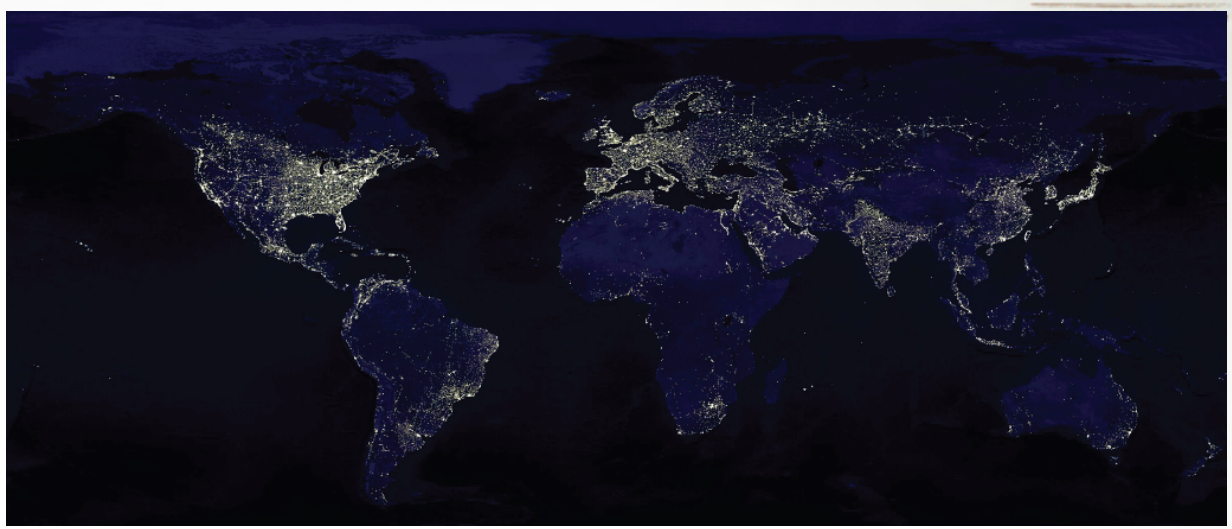
Integrated water resources management

Implementation difficult due to vested interests, inertia in governance systems.

Sectors: Domestic/urban	$\Rightarrow$	drinking water
Agriculture	$\Rightarrow$	food
Industry	$\Rightarrow$	goods, energy
Environment	$\Rightarrow$	water, air, soil, ecosystems

Water use sectors:
Domestic/urban

Total domestic water demand depends on population.



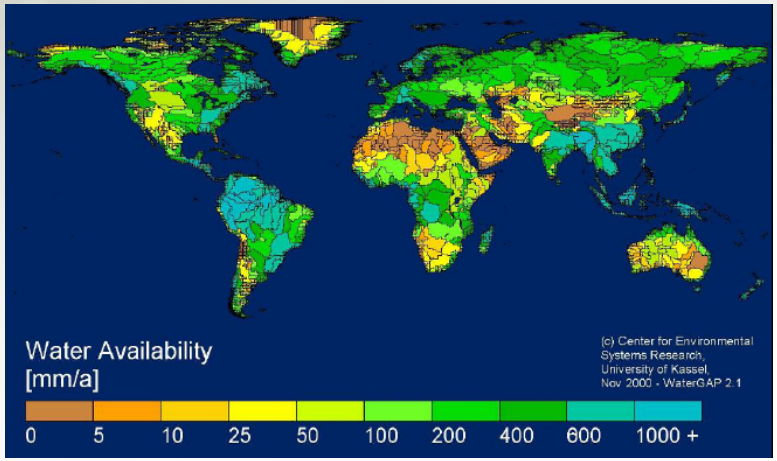
Per capita water use depends on income and accessibility.

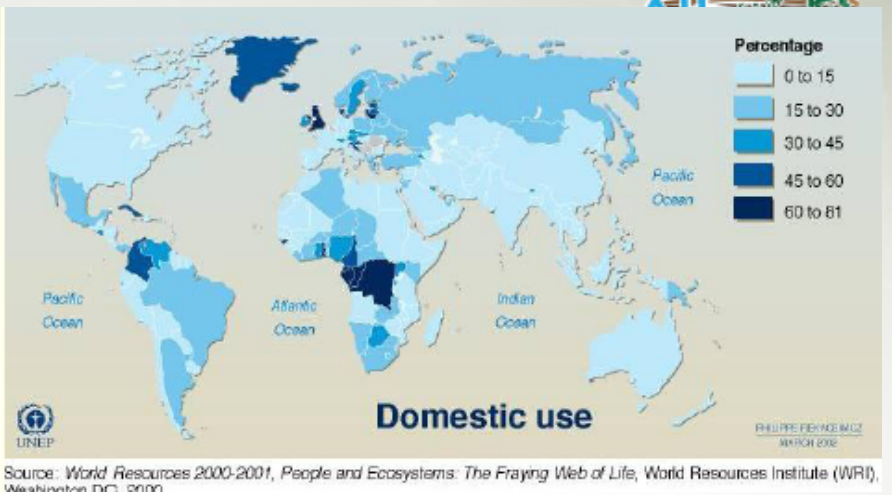
Stand tap, Buea, Cameroon

In-house piped supply, middle to high income = 300 l/day/capita

Standpipe supply = 20 l/day/capita

Domestic/urban





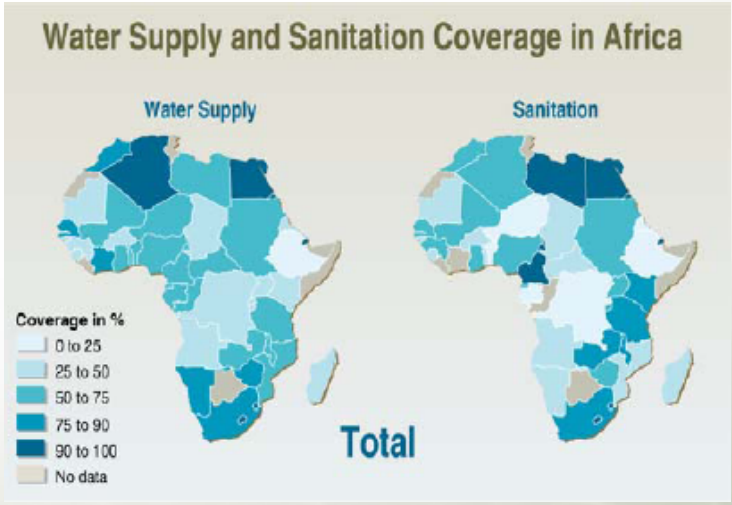
Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI),

Domestic use as % of total water use

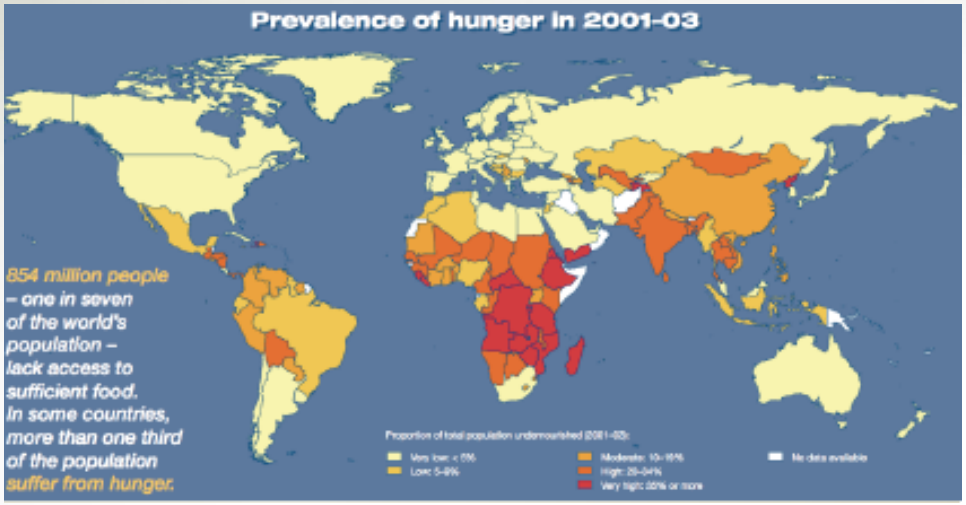
In areas of water scarcity, domestic supply may be limited by water resources.

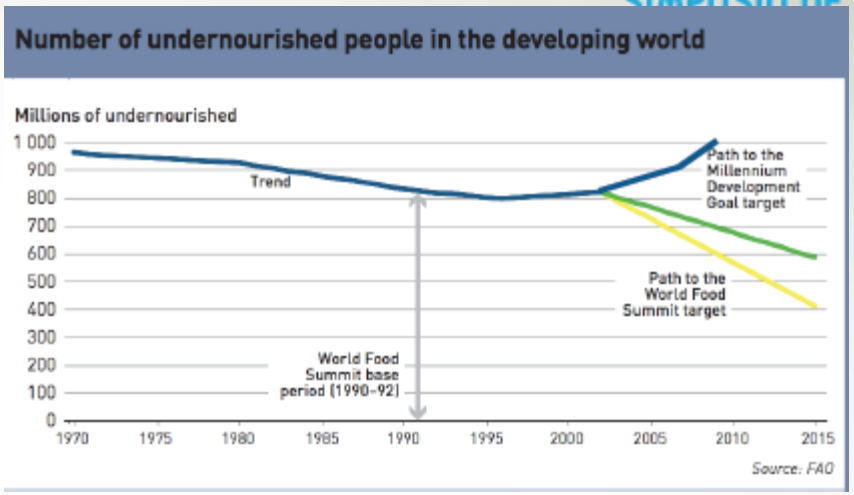
In other areas, domestic water supply is limited by financial and governance constraints.

Choices: Should we be polluting our water by choosing water borne sanitation?



Agriculture/Food

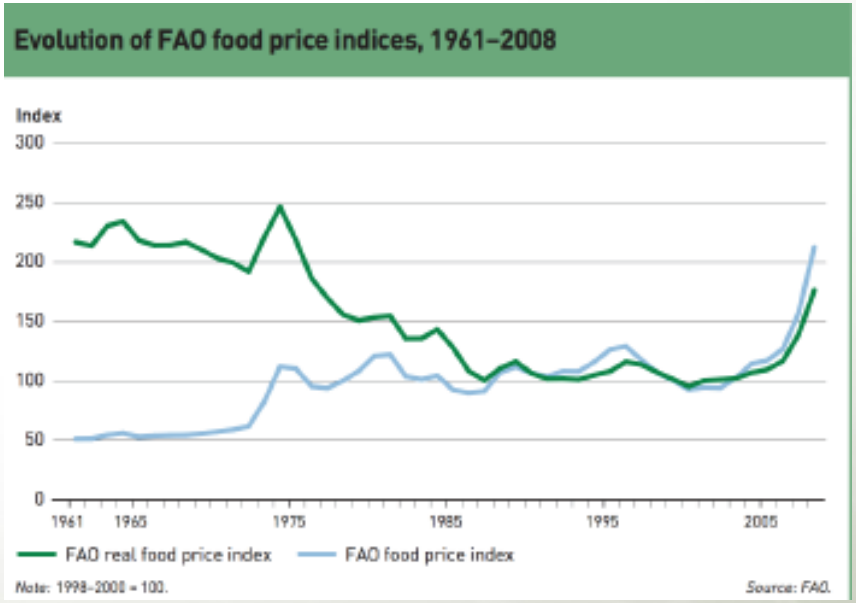




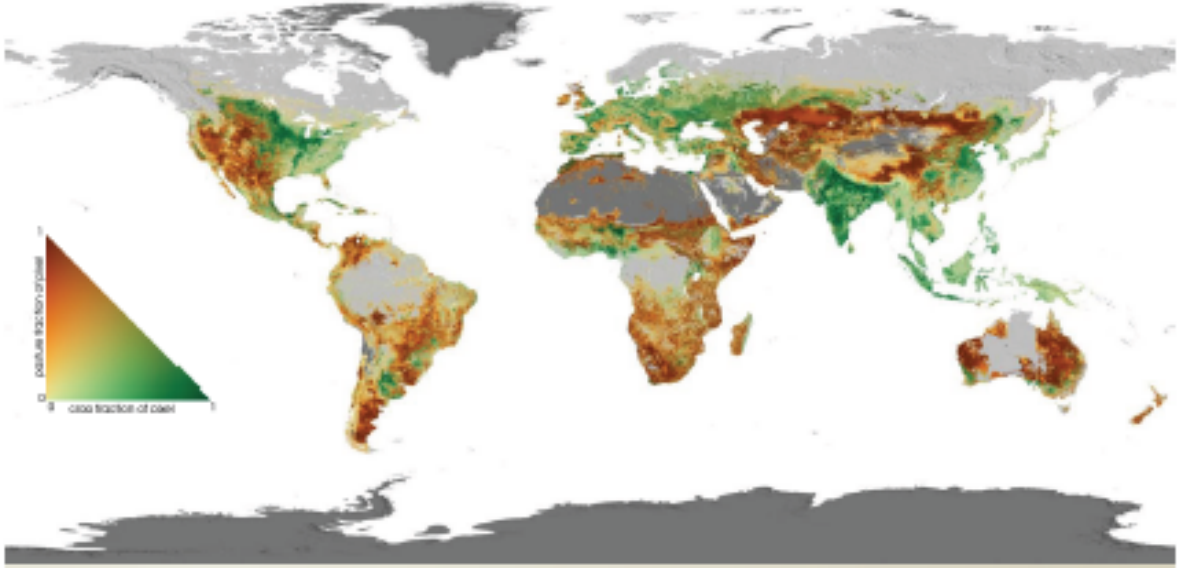
Hunger - in spite of 24% more calories per capita than 1960.

World avg. = 2808 kcal/day/capita (2003)

Improvements now decreasing

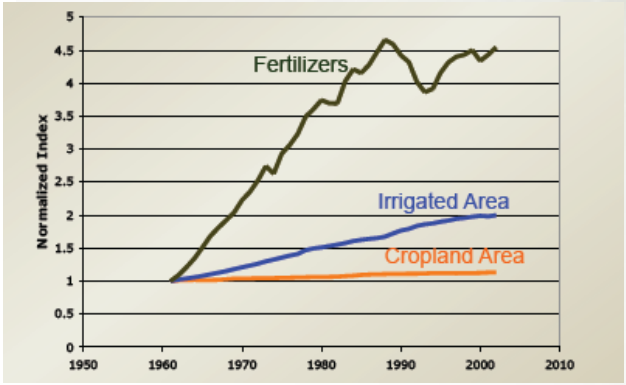


Water use sectors:
Agriculture/Food

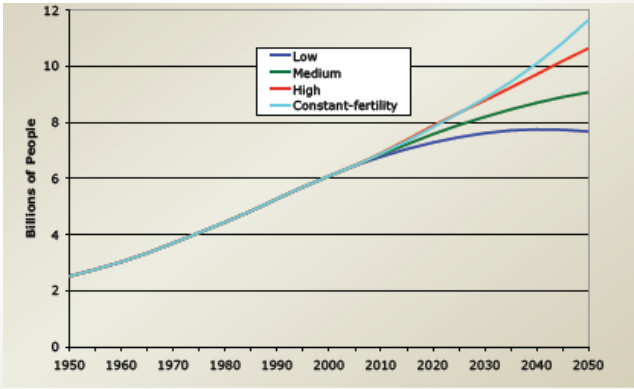


34% of ice-free land surface is used for cultivation or grazing!

Ramankutty et al., 2008



Inputs increasing:
Water use tripled in 50 yrs

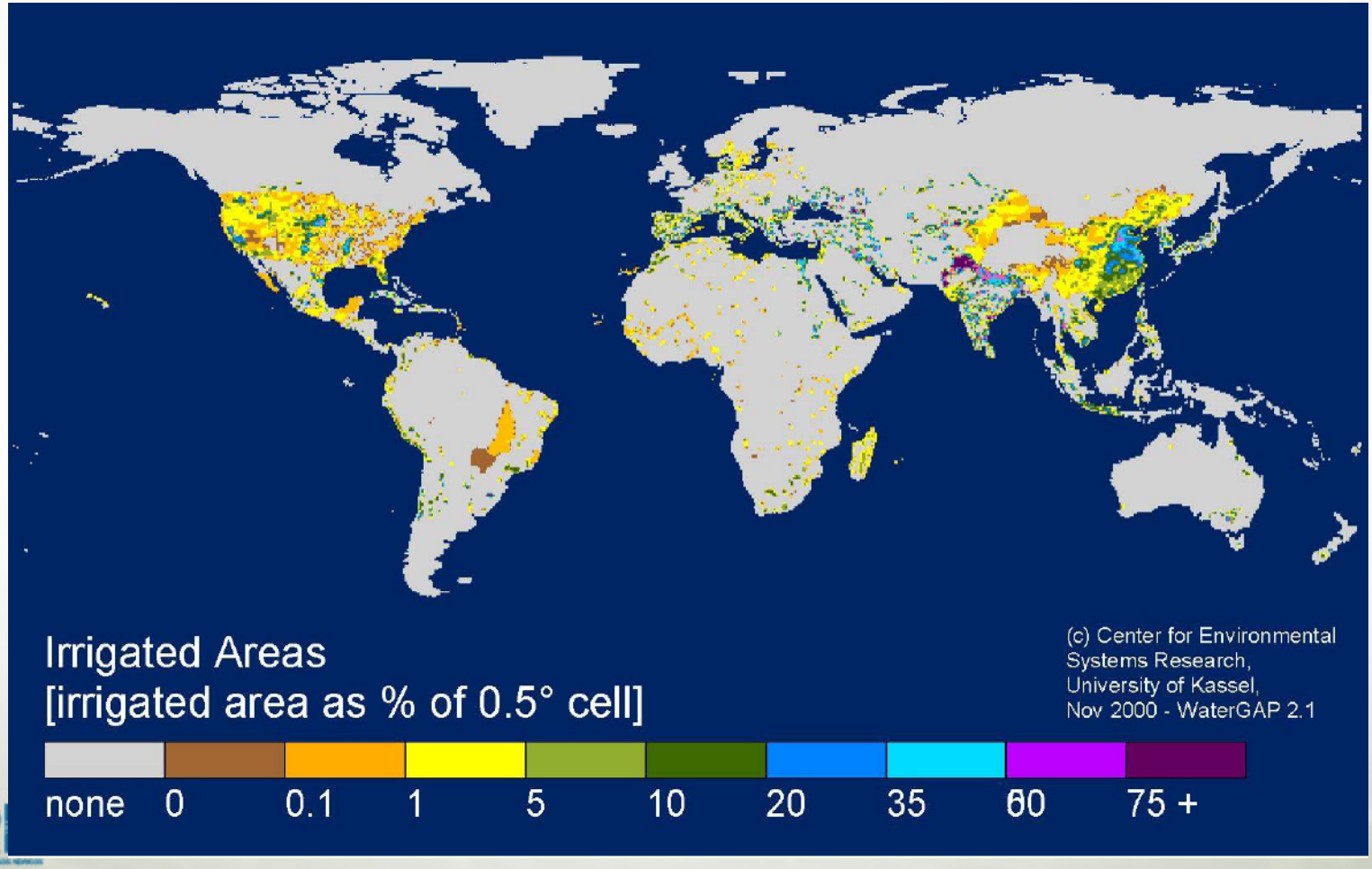


Can we feed the world's population with existing resources?

Population increasing

Global irrigation areas

18% of agricultural area is irrigated and
it yields 33% of world's food

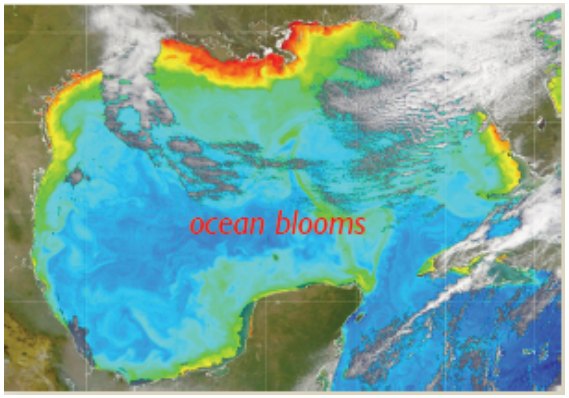


Agriculture/Food

Constraints:

- Increasing yields reaching a plateau (including potential GM efforts).
- Cultivatable land decreasing due to desertification.
- Reaching the limits of increasing irrigated areas – losing existing irrigated areas to to salination.

- Excess nutrient pollution of water resources due to N and P.



- Biofuels = US biofuel production caused 70% of world grain price increase (motivation is energy security)

28.7% or 119 million tons of corn in US used for ethanol production (2010)

Agriculture/Food

Choices:

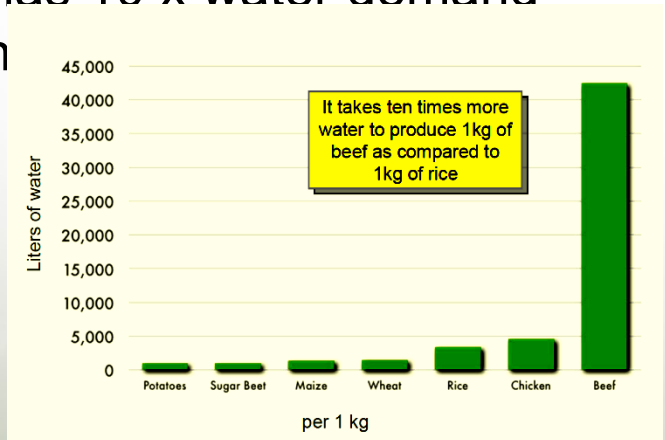
- What crop types? ⇒ water requirements.
- What tillage method ? ⇒ conservation of water and topsoil.
- What irrigation method? ⇒ water use efficiency.

Increase in agricultural land?
⇒ deforestation
⇒ reduced water resources.

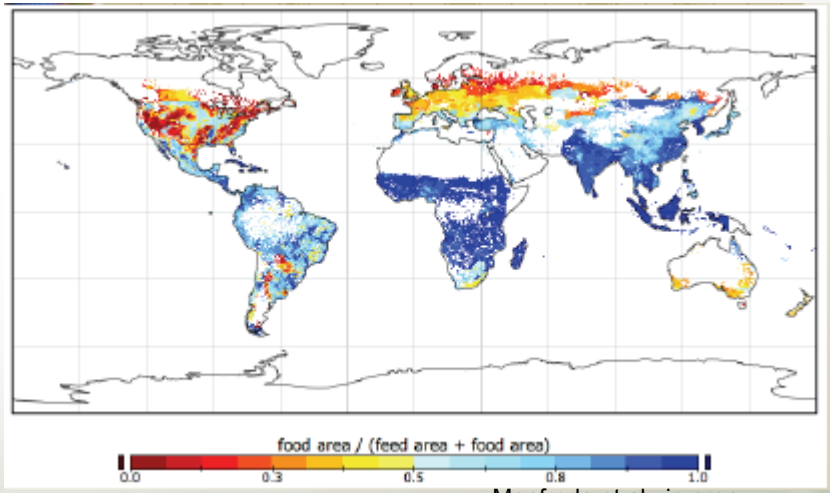
Care of agricultural land?
⇒ land ownership
⇒ education

Diet?

Increase in income ⇒ increase in meat consumption (meat has 10 x water demand of grain



Food area/(Food +feed area)



Monfreda et al., in prep.

Water use sectors:
Industry/Energy

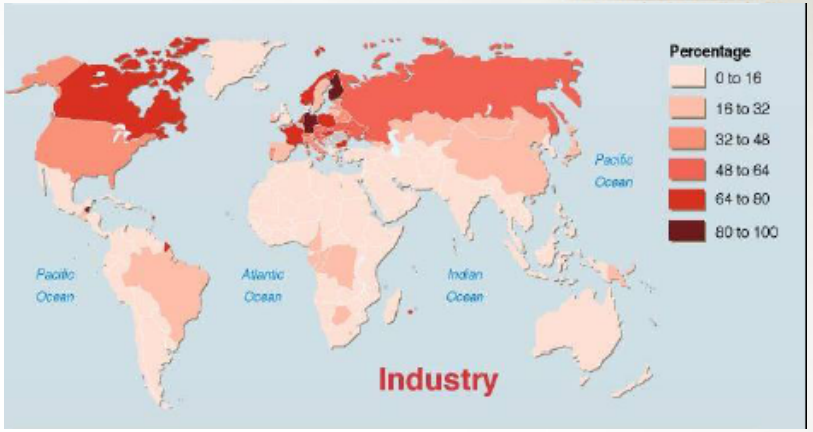
Industrial water use higher in developed countries.

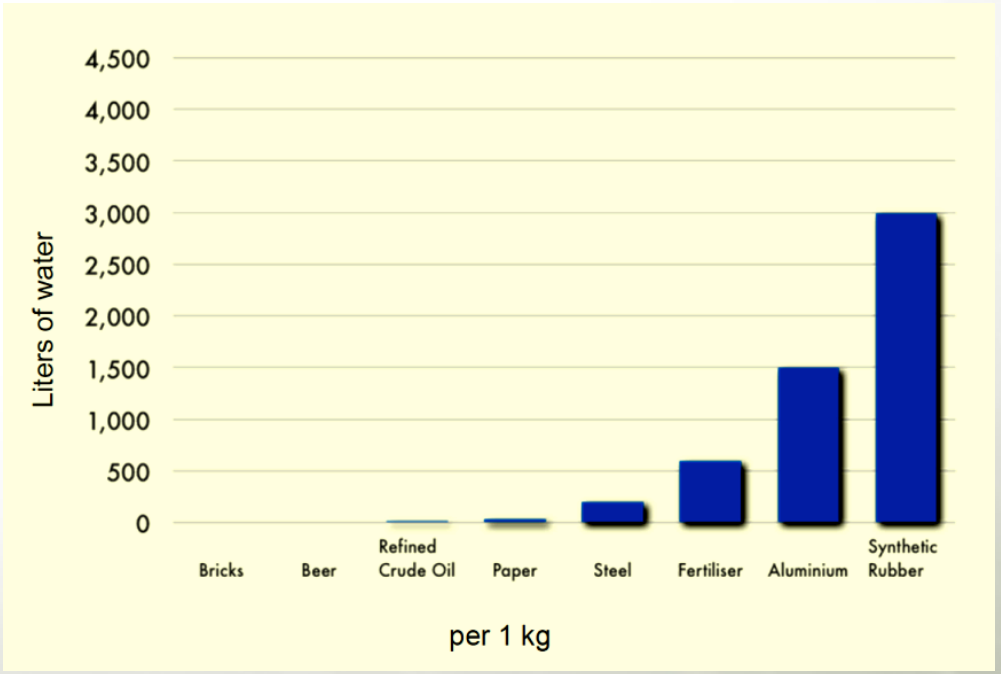
Important concern is its effect on water quality.

Manufacturing - What production method?

Mining - large water use for extraction and processing. What production method?

Energy – water used for fuel processing, cooling.



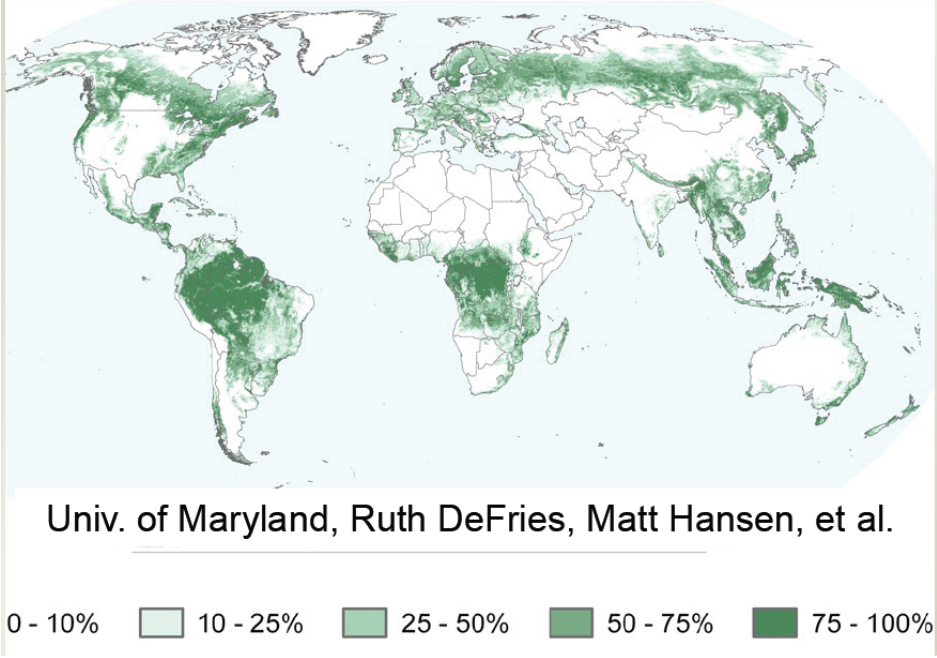


Water use sectors:
Environmental (habitat, forests)

Forest cover is very important for water resources – increased storage as groundwater.

Higher infiltration in forests.
⇒ reduce peak river flows (eg Australian floods).

Trees minimize soil erosion
⇒ Maintain productivity of land, conserve habitats.

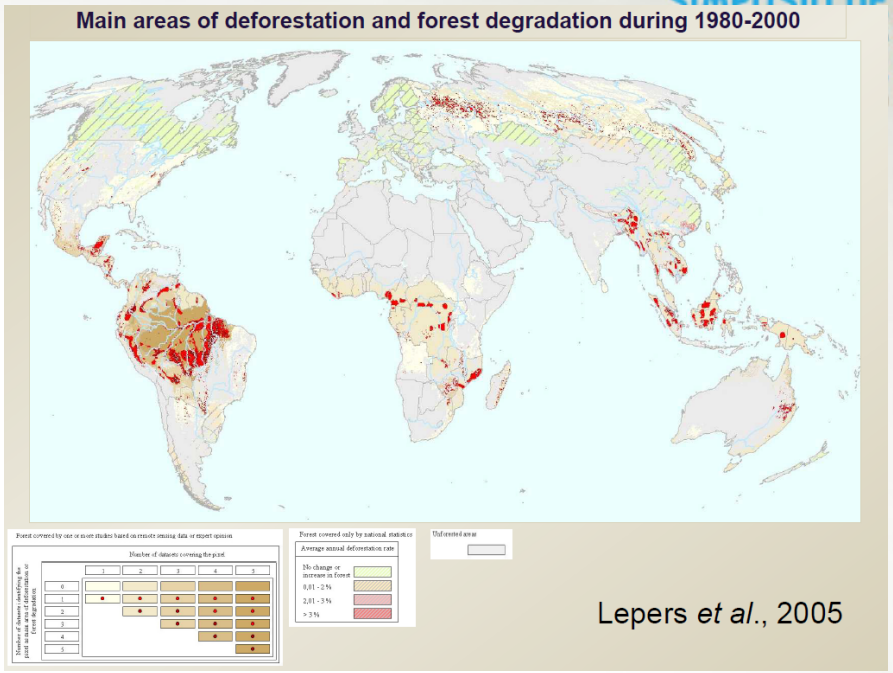


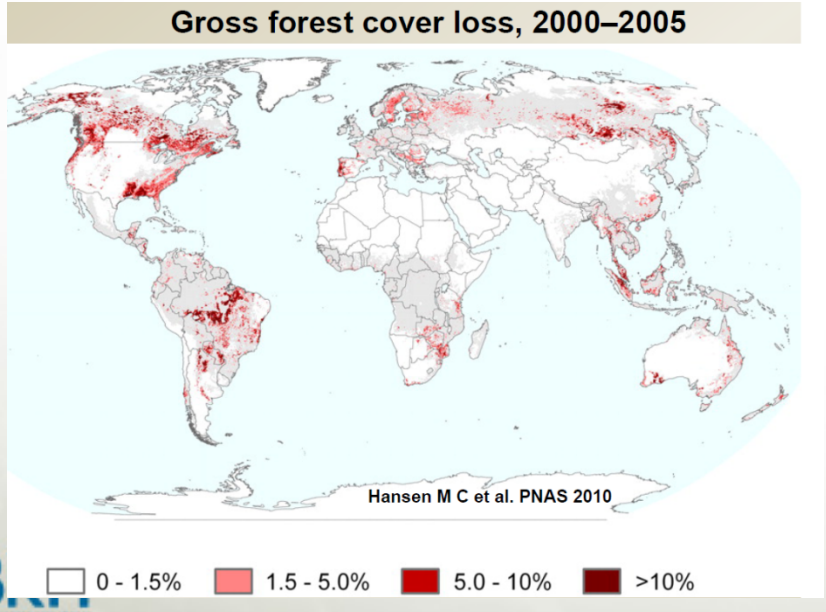
Percentage tree cover

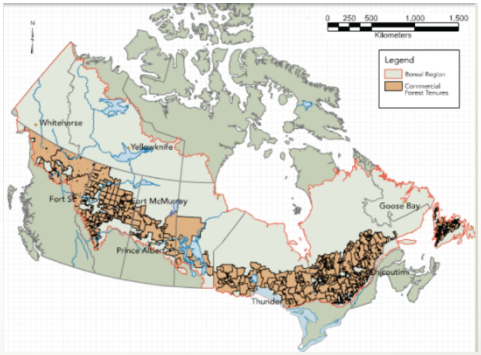
Environmental (habitat, forests)

Deforestation driven by commercial logging or by drive to increase agricultural land.

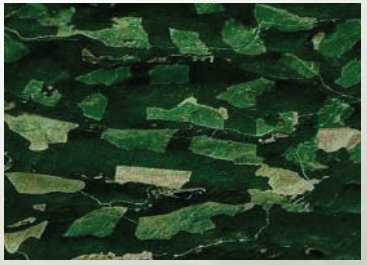
Role of biofuels?







Selective logging?



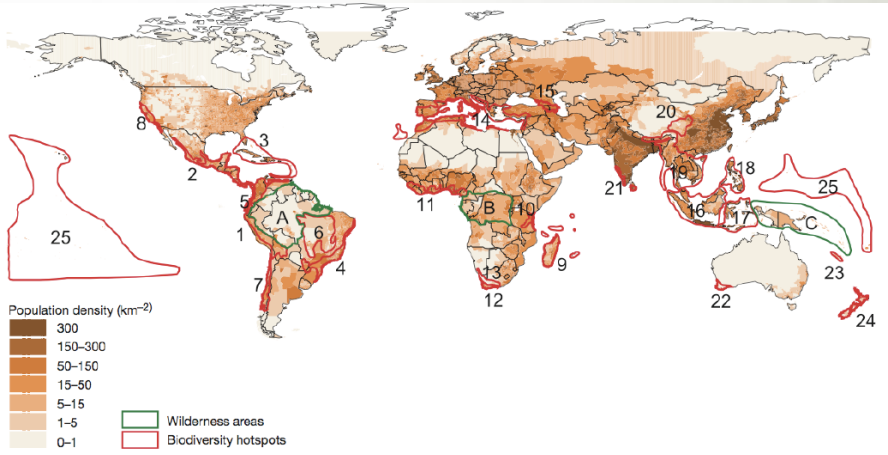
Canada: 20-23% of commercial forests logged

Environmental (habitat, forests)

Loss of forests leads to loss of habitat, loss of biodiversity.

Forests provide ecosystem services
⇒water,
⇒air
⇒CO2 sequestration
⇒climate moderator (eg Amazon)

Biodiversity hotspots



Cincotta et al., 2000

Rivers – maintain minimum flows for river habitat
Wetlands – maintain for flood buffers and habitat

Integrated water resources management

Optimizing water use across sectors.

Domestic/urban ⇒ drinking water

Agriculture ⇒ food

Industry ⇒ goods, energy

Environment ⇒ water, air, soil, ecosystems

Implementation ideally at the basin scale:

e.g. Tenessee Valley Authority

Mexico City Basin