Water Sustainability for the Future

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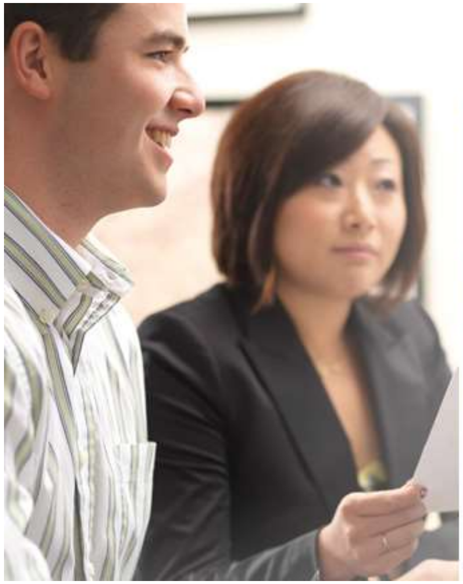


Contents

What is the role of water in the biosphere?

A vital natural resource

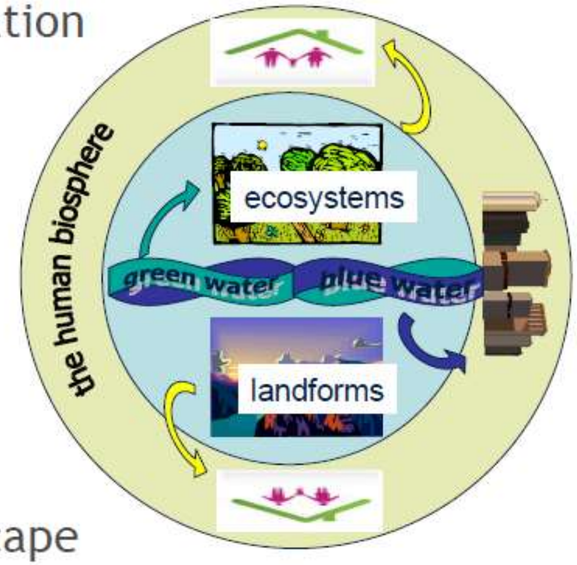
Consumption and sanitation

Energy

Industry

Food production

Environment and landscape



"This is a crucial century. The Earth has existed for 45 million centuries. But this is the first when one species, ours, can determine for good or ill – the future of the entire biosphere"
Professor Sir Martin Rees – 2010 BBC Reith Lectures

Global water security – Is it achievable? What are the consequences of failure?

1.4 billion km^3
Total water

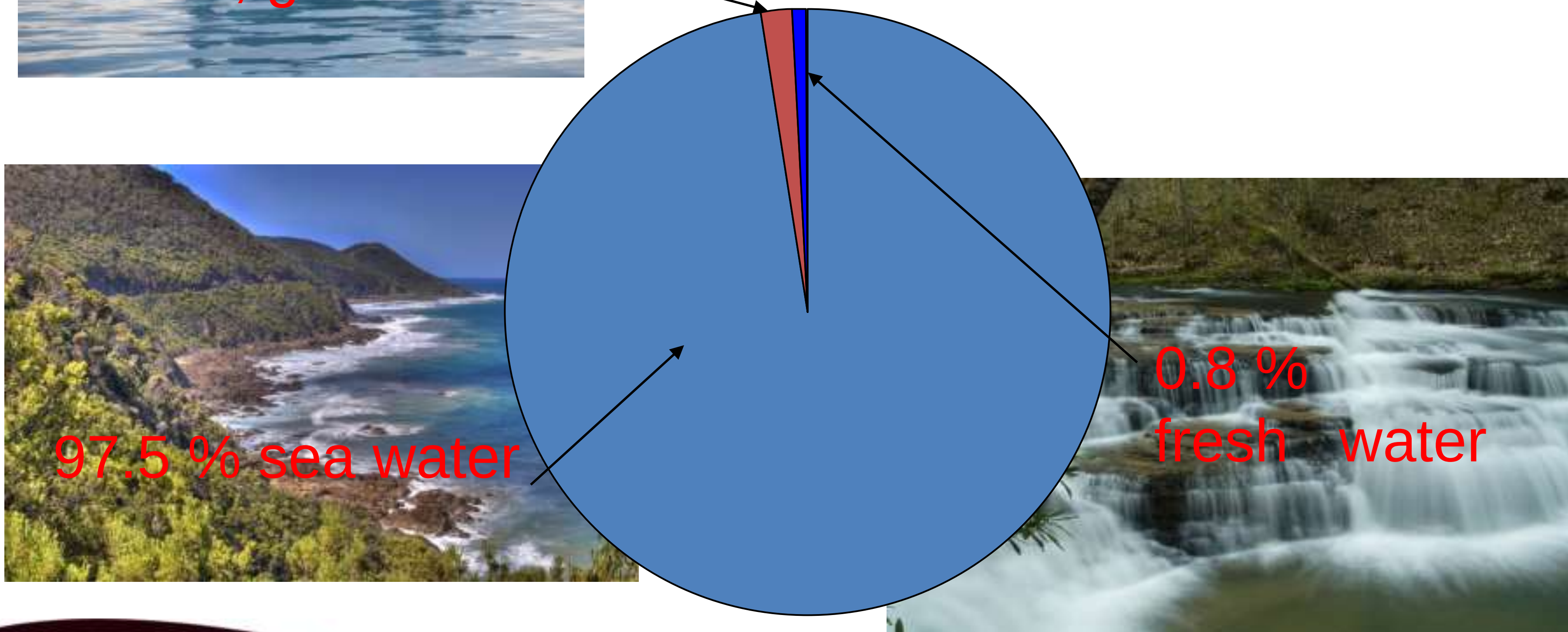
How much water is there?

35 million km^3
Fresh water

105 thousand km^3
Accessible

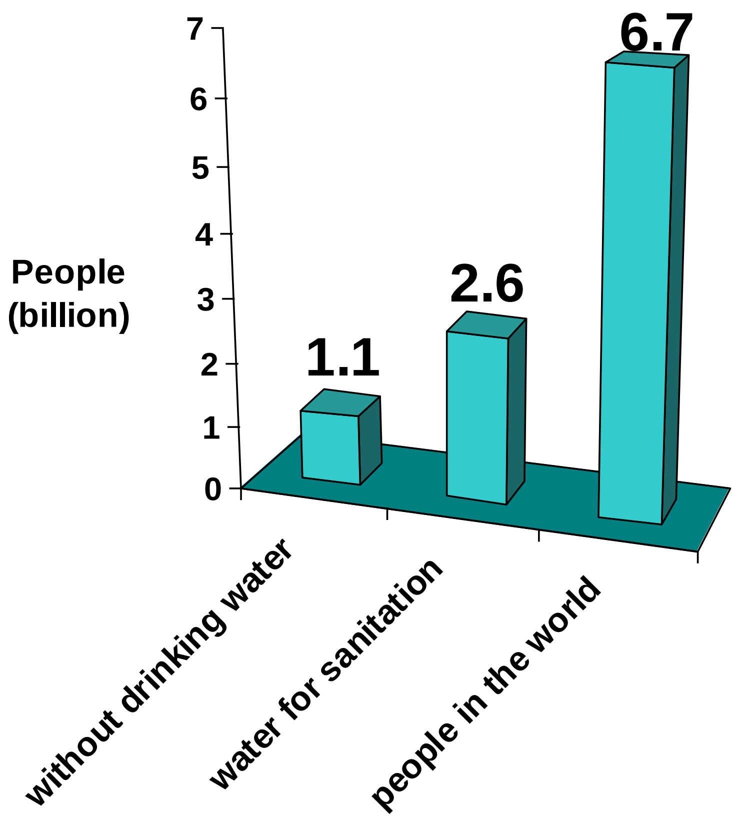
What percentage of the world's water can we drink?

0.8%



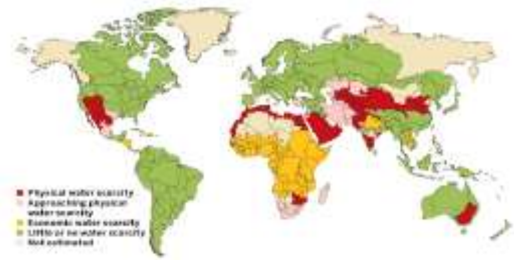
How many people in the world are without access to drinking water?

1.1 billion



Four reasons for action

Water scarcity is increasing



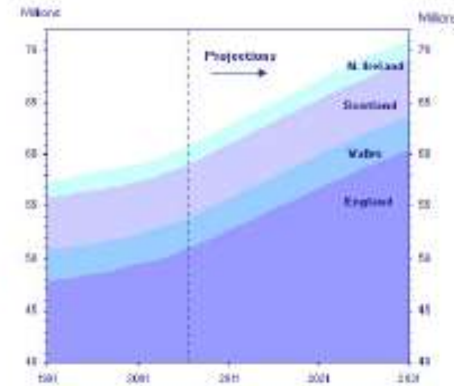
Millennium Development Goals

Conflict

Economic growth

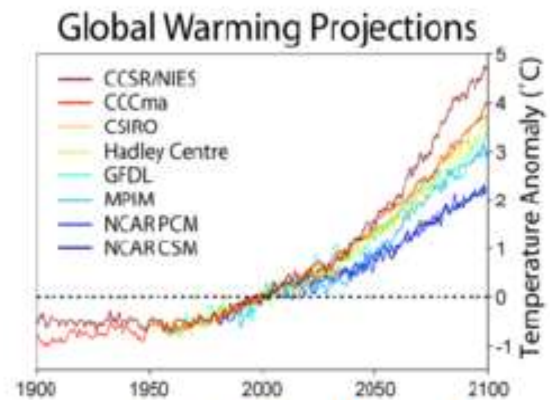
Water in the UK

Population growth



Temperature rise + dryer summers

More winter rain



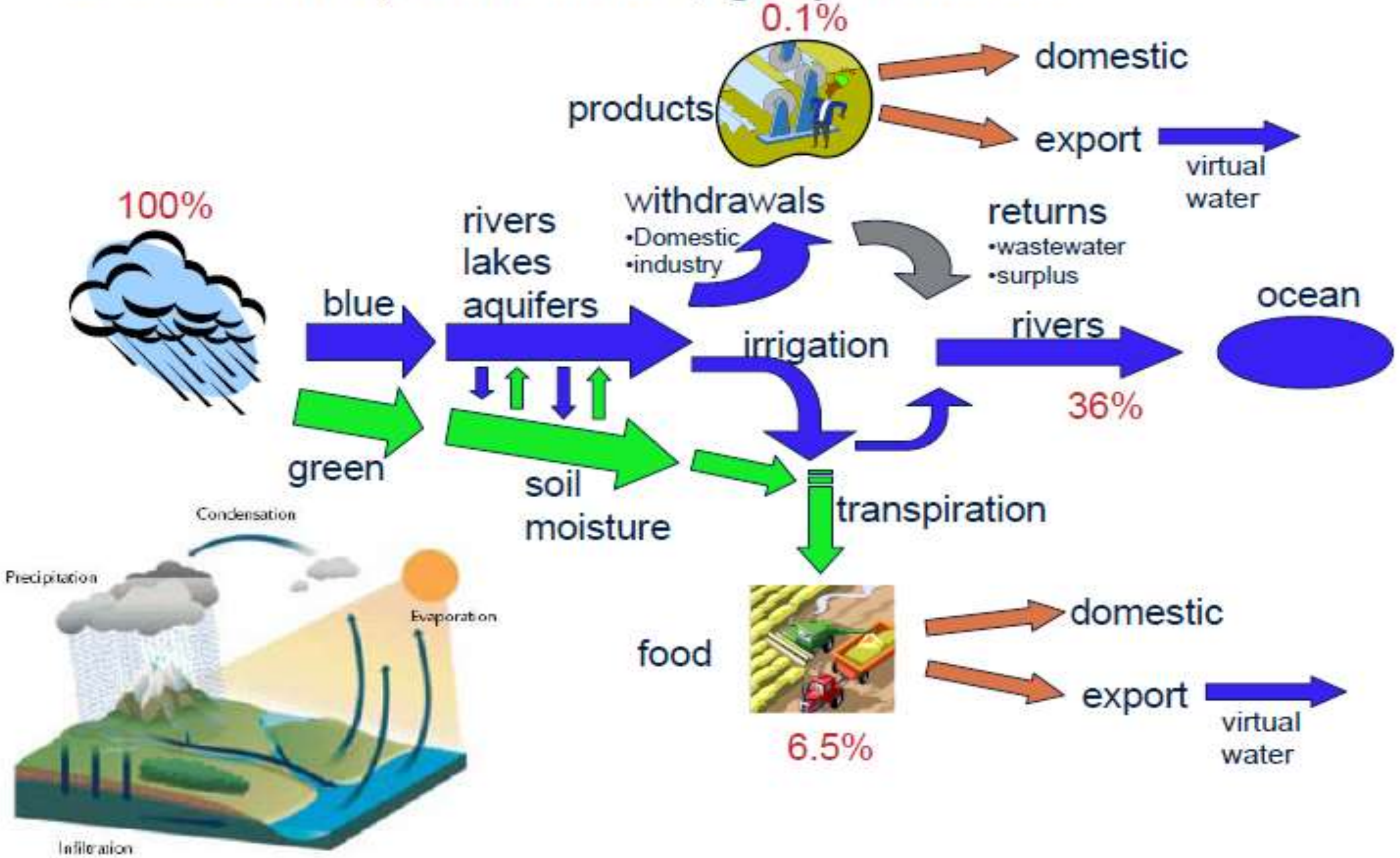
More extreme rain events

Sea level rise

"Adaptation to the impacts of climate change in the UK will only be achieved through a national programme of water storage; from water harvesting and infiltration devices to major projects of Aquifer Storage and Recharge and impounding reservoirs in our wet regions"

Understanding the problem
How do we think about water use?

Green water, blue water, grey water…



Blue water abstraction worldwide

		Africa	Asia	Europe	**Global**
Domestic		7%	6%	13%	**8%**
Industry		5%	8%	54%	**23%**
Agriculture		88%	84%	33%	**69%**

Global water scarcity

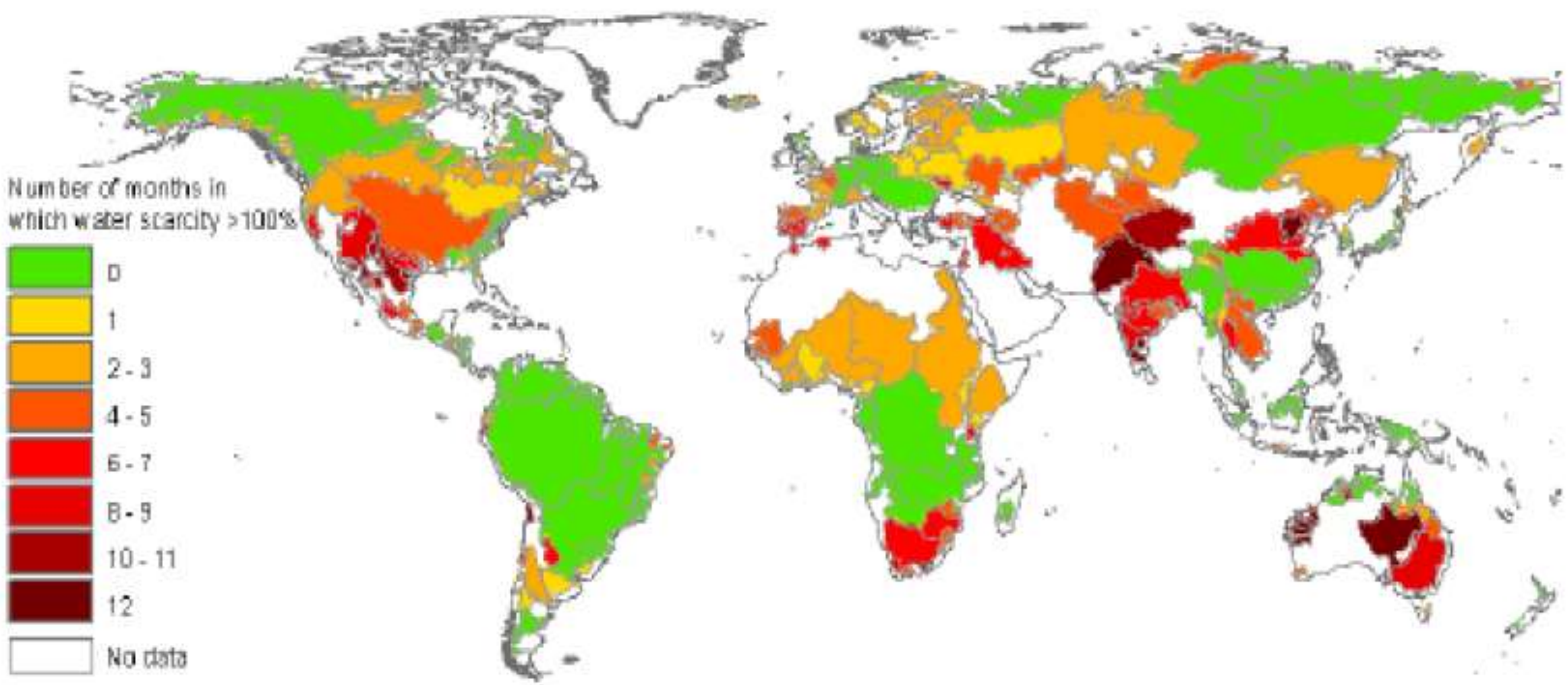


Figure 5. Number of months during the year in which water scarcity exceeds 100% for the world's major river basins. Period 1996-2005.

The planet's renewable water resources

Blue water availability

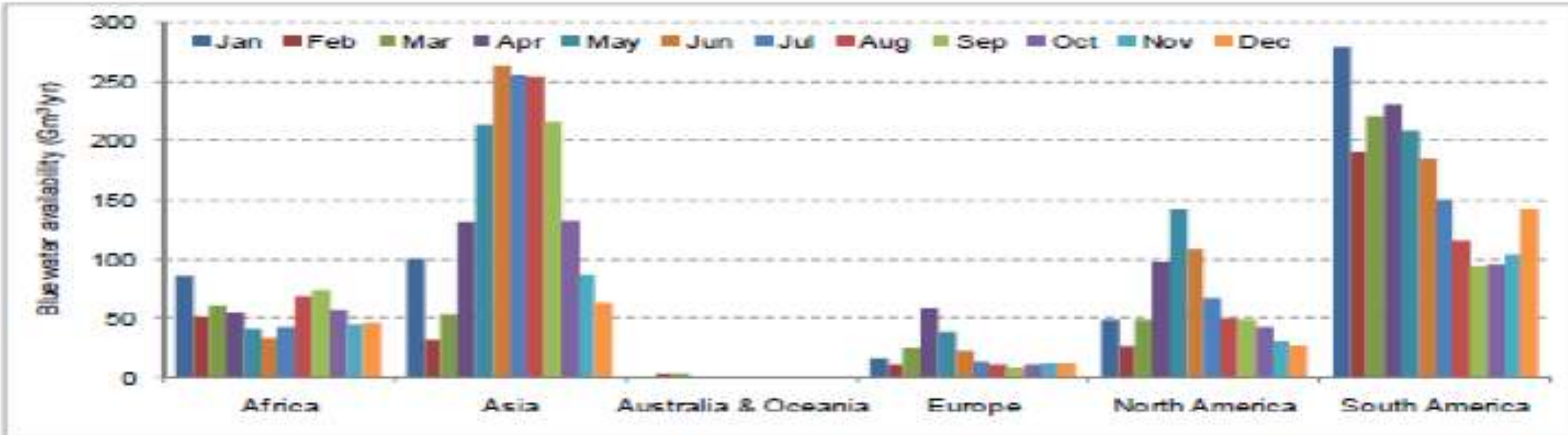


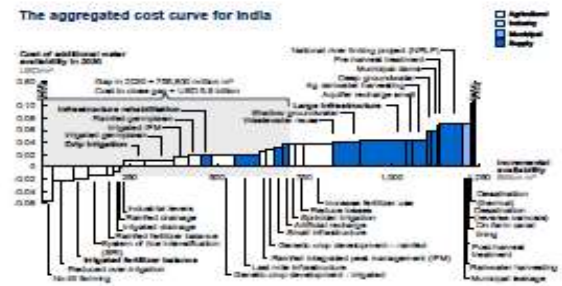
Figure 1. Monthly blue water availability per continent.

Figure 2. Monthly blue water footprint per continent.

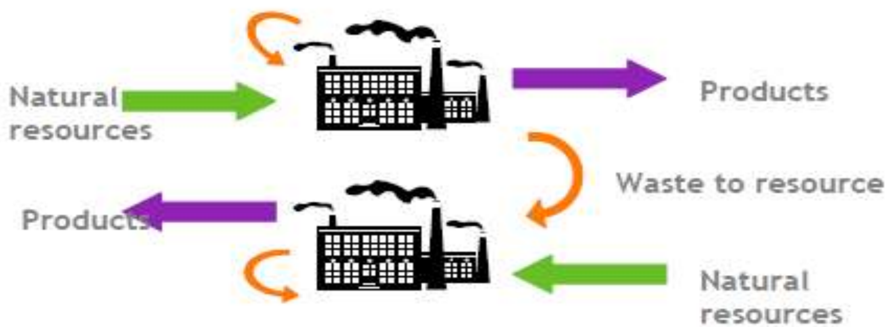
Possible solutions

How can we manage water scarcity?

Prioritized investment



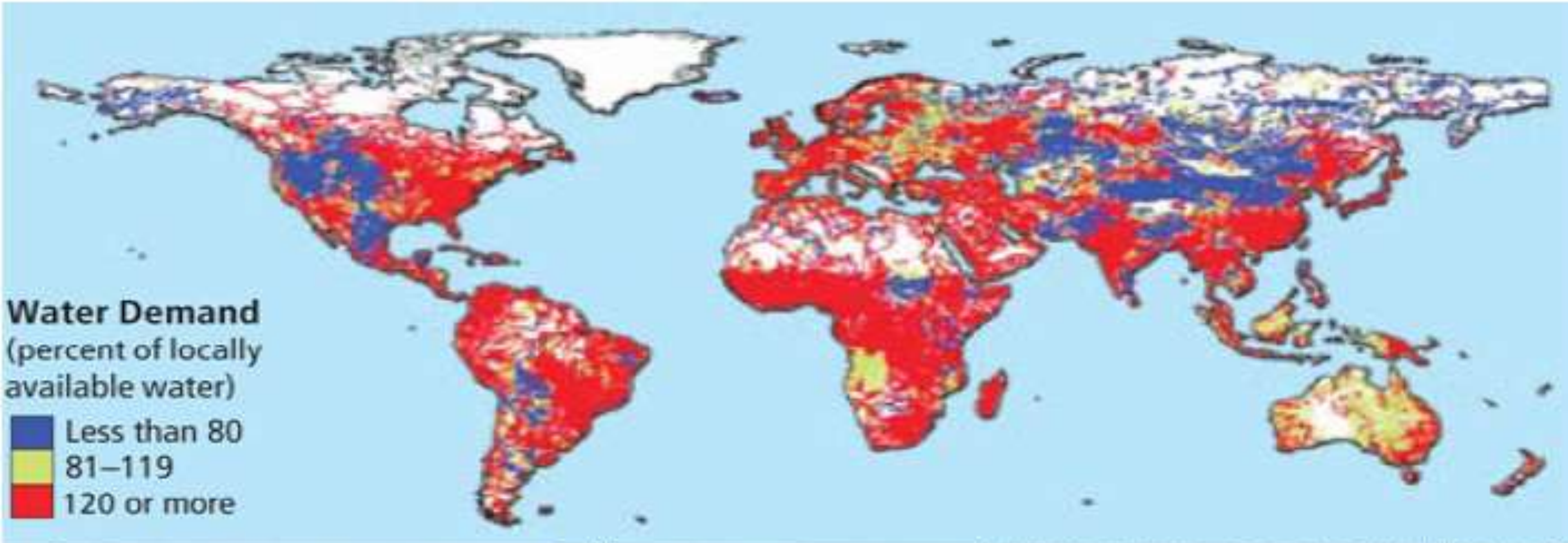
“Industrial Symbiosis”

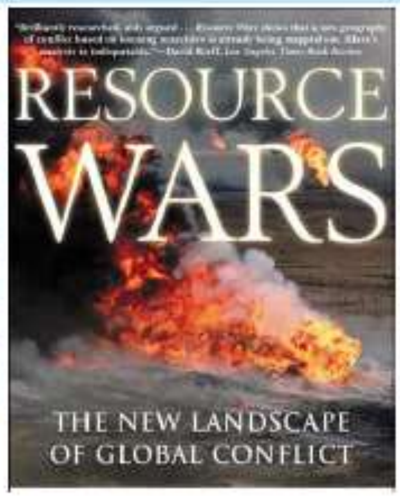


What would global water security look like?

- **Affordable drinking water supplies**
- **Sustainable sources of water for industry**
- **Integrated management of water resources**
- **Policy and trade reforms**
- **Mobilisation of substantial volumes of public and private funding**

…and the alternative?





Behavioural Change – The role of virtual water

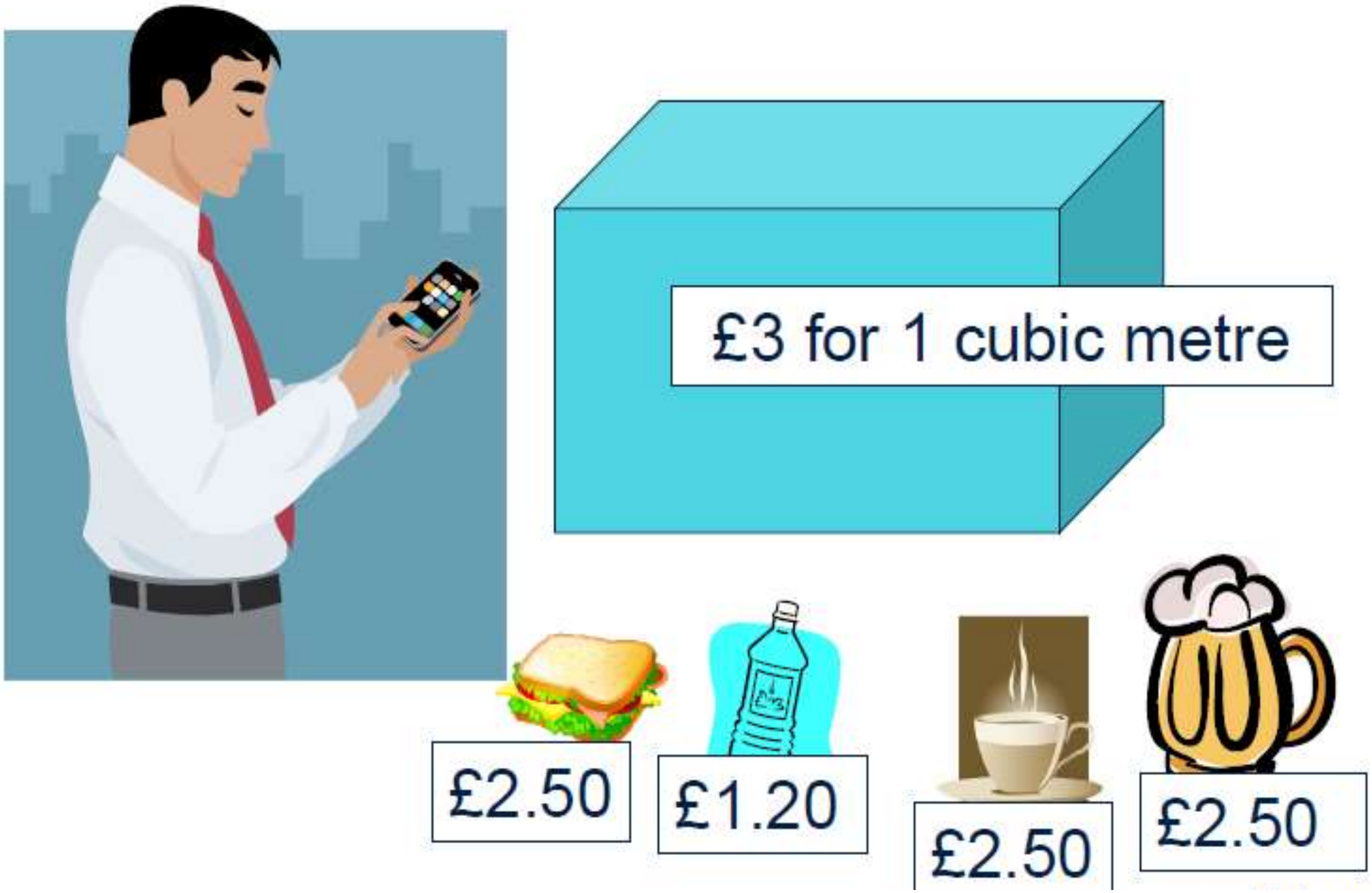
Valuing water

A human right?

or

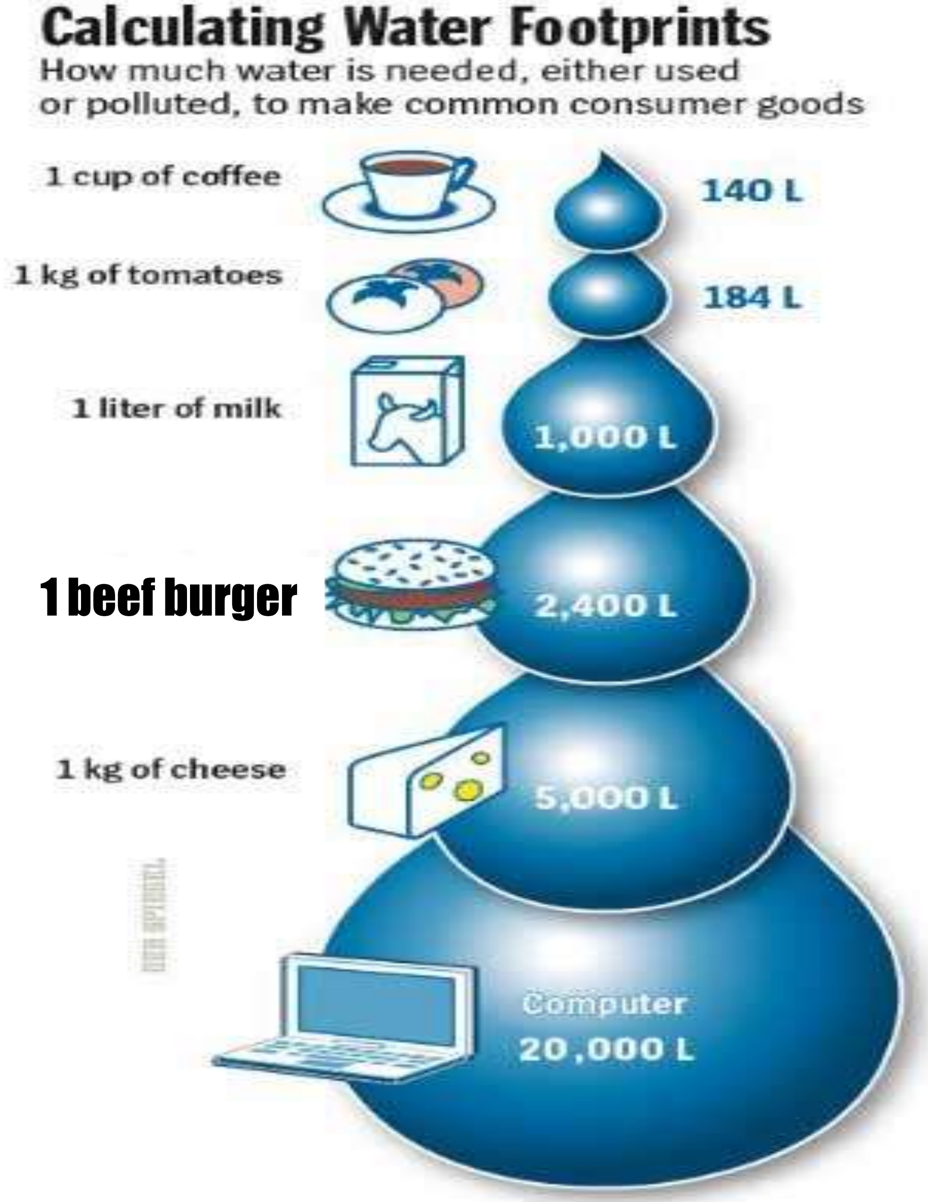
An economic good?

What value water in the UK?

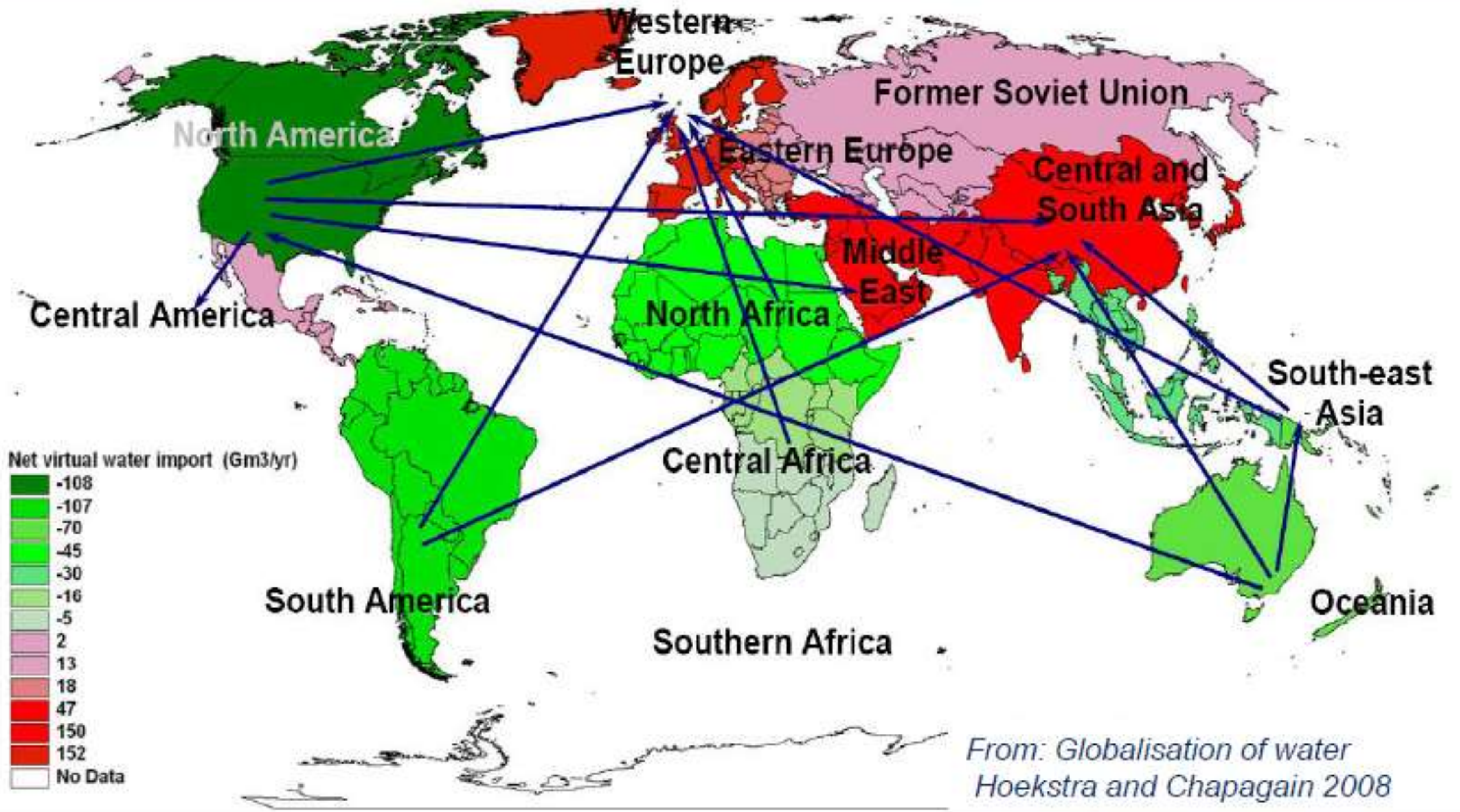


The emergence of virtual water....

- The term was first coined by John Allan in 1993 when he postulated that it could be considered a partial solution to water scarcity in the Middle East
- A definition:
    - The volume of water of water consumed or polluted in the making of a product, measured over the full supply chain
- It can be thought of as:
    - an import
    - an export
    - A flow between two locations

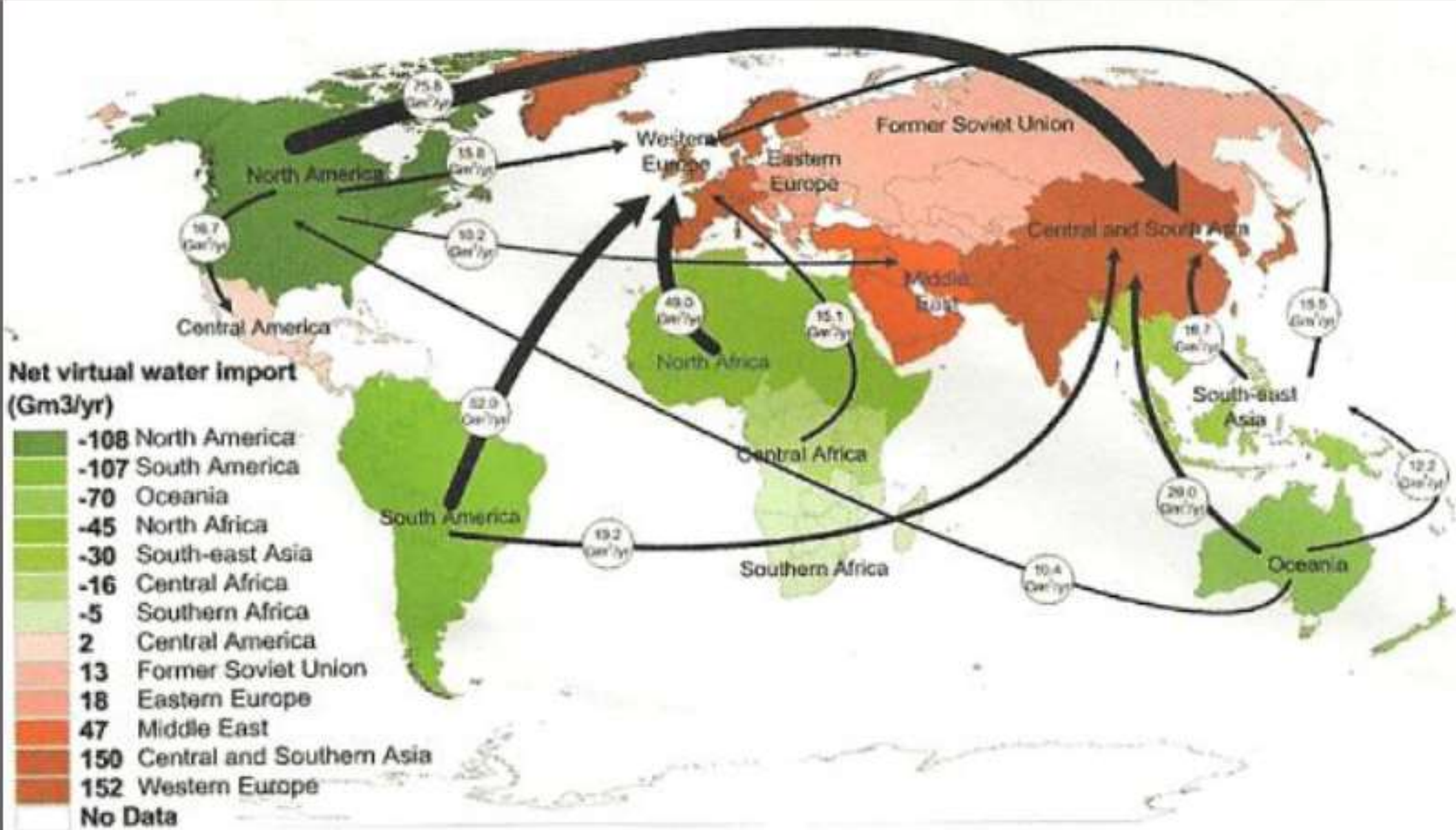

Calculating Water Footprints
How much water is needed, either used or polluted, to make common consumer goods
1 cup of coffee
140 L
1 kg of tomatoes
184 L
1 liter of milk
1,000 L
1 beef burger
2,400 L
1 kg of cheese
5,000 L
Computer
20,000 L

Global flows of virtual water

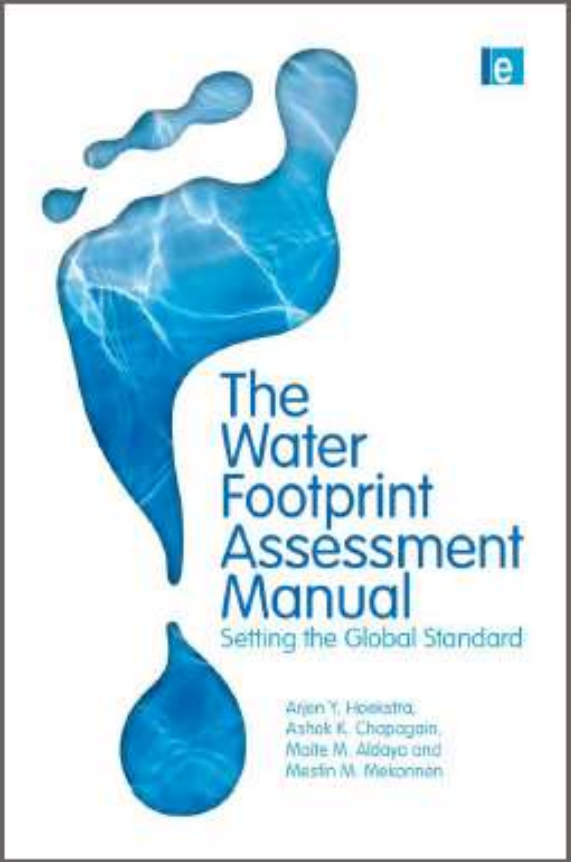


From: Globalisation of water Hoekstra and Chapagain 2008

Major inter-regional flows

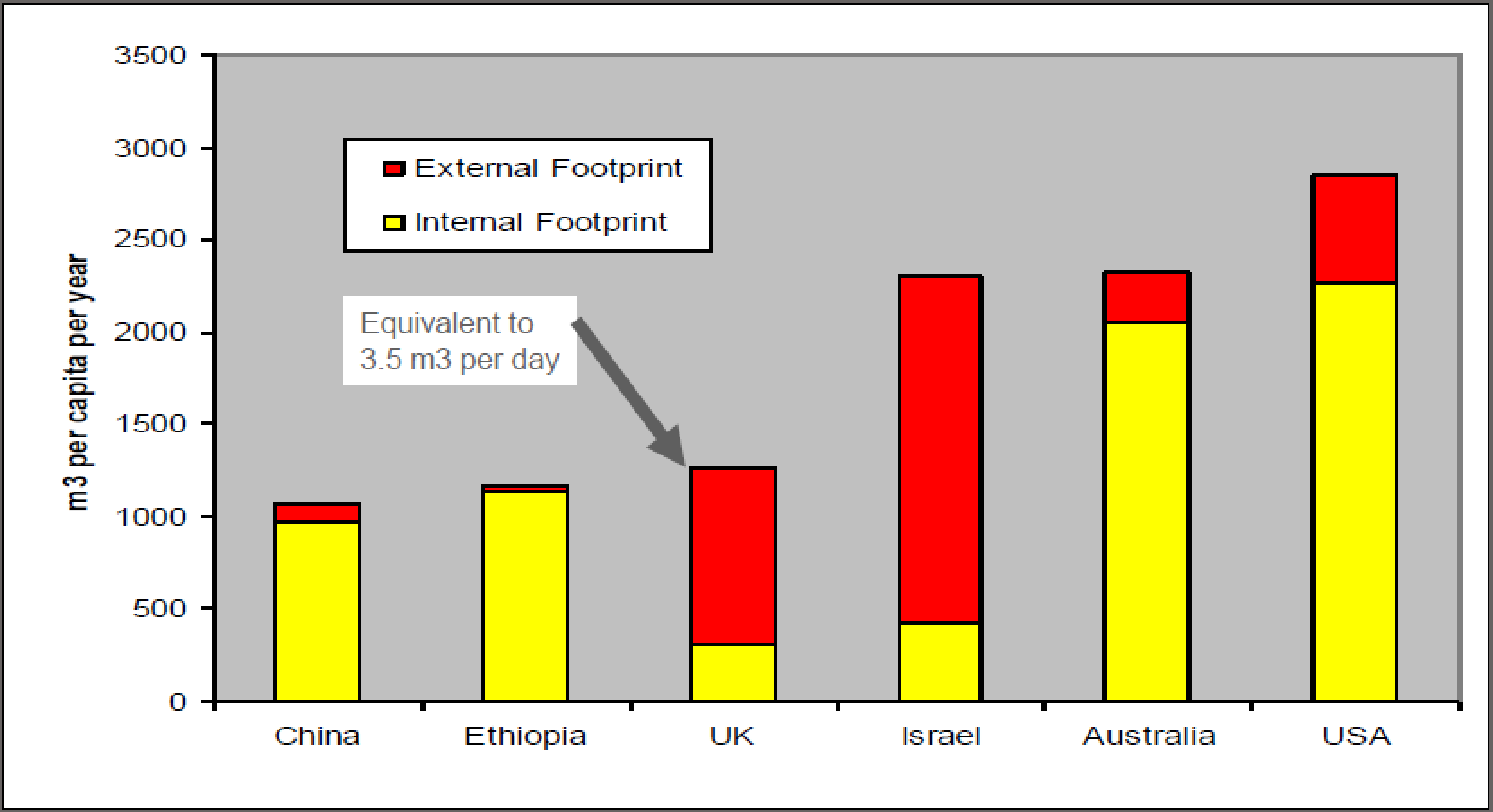


Water Footprint

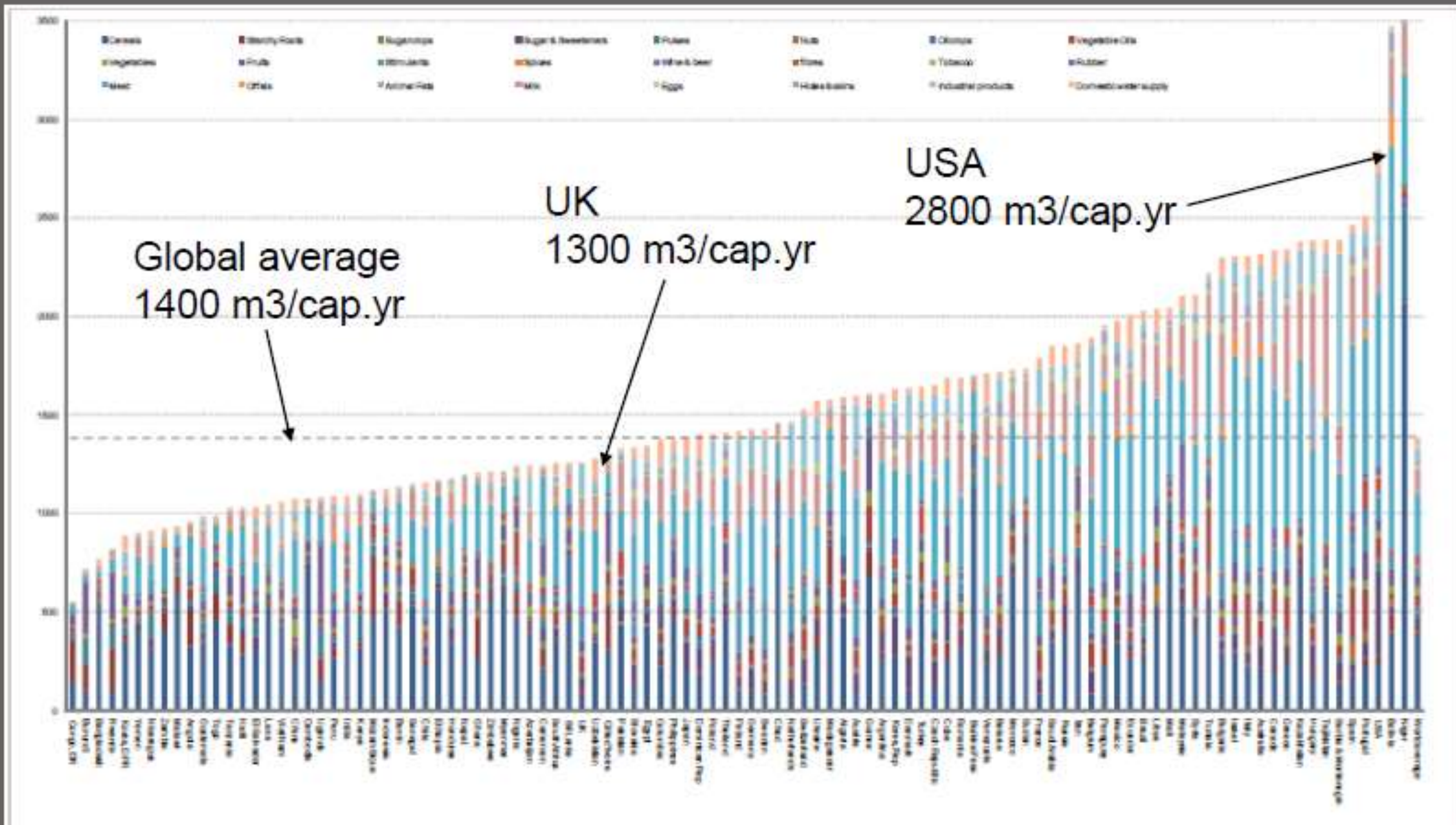


- The total volume of freshwater that is used to make a product or suite of products, expressed in terms of green, blue and grey water, and in terms of location.
- Water Footprint can be expressed for nation, state, river basin, business, community, citizen, product or commodity.
- Water footprint tells us much more than a volume of Virtual Water:
  - Origin: green, blue of grey
  - Location of that water

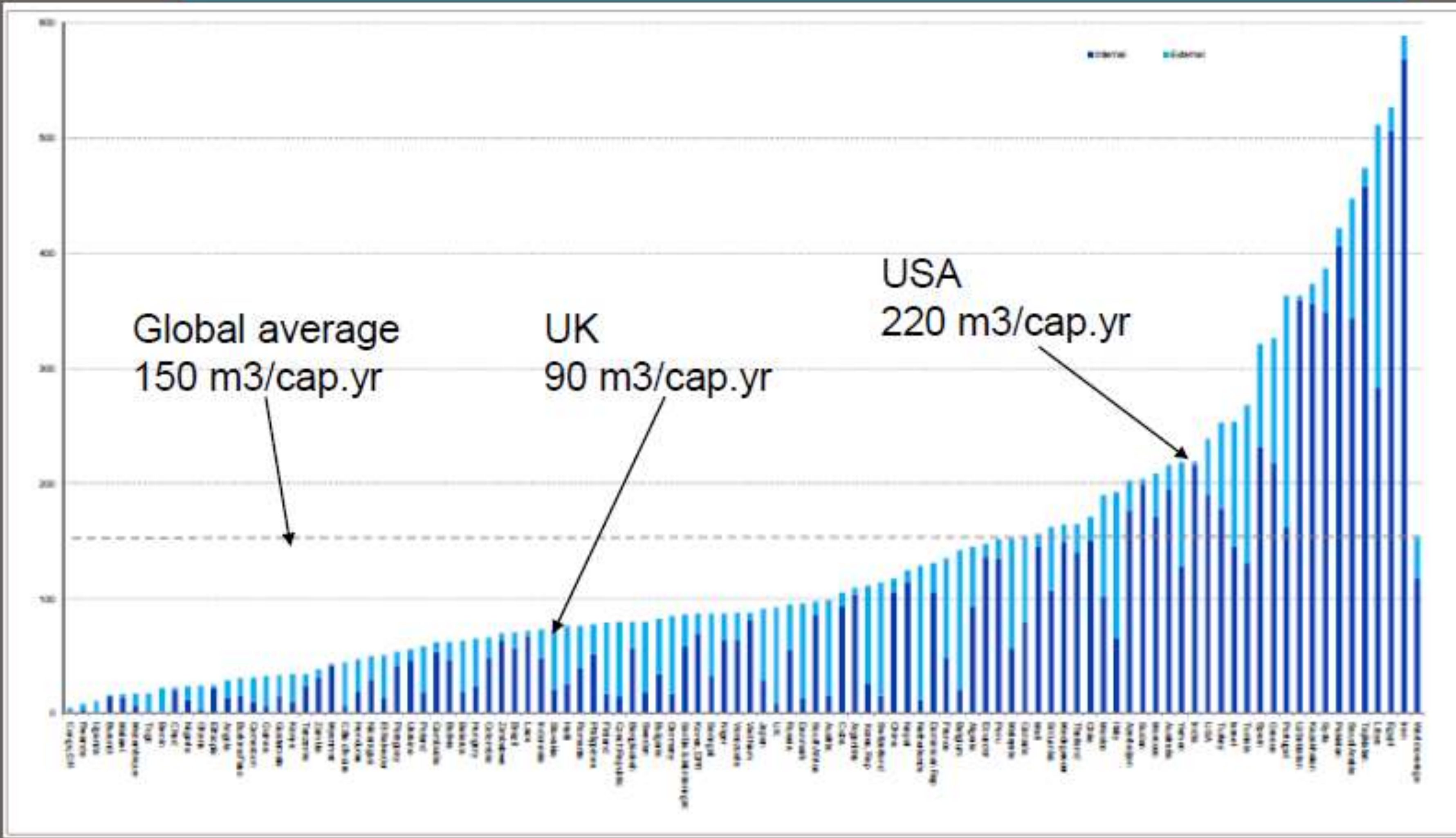
The water footprint of some nations



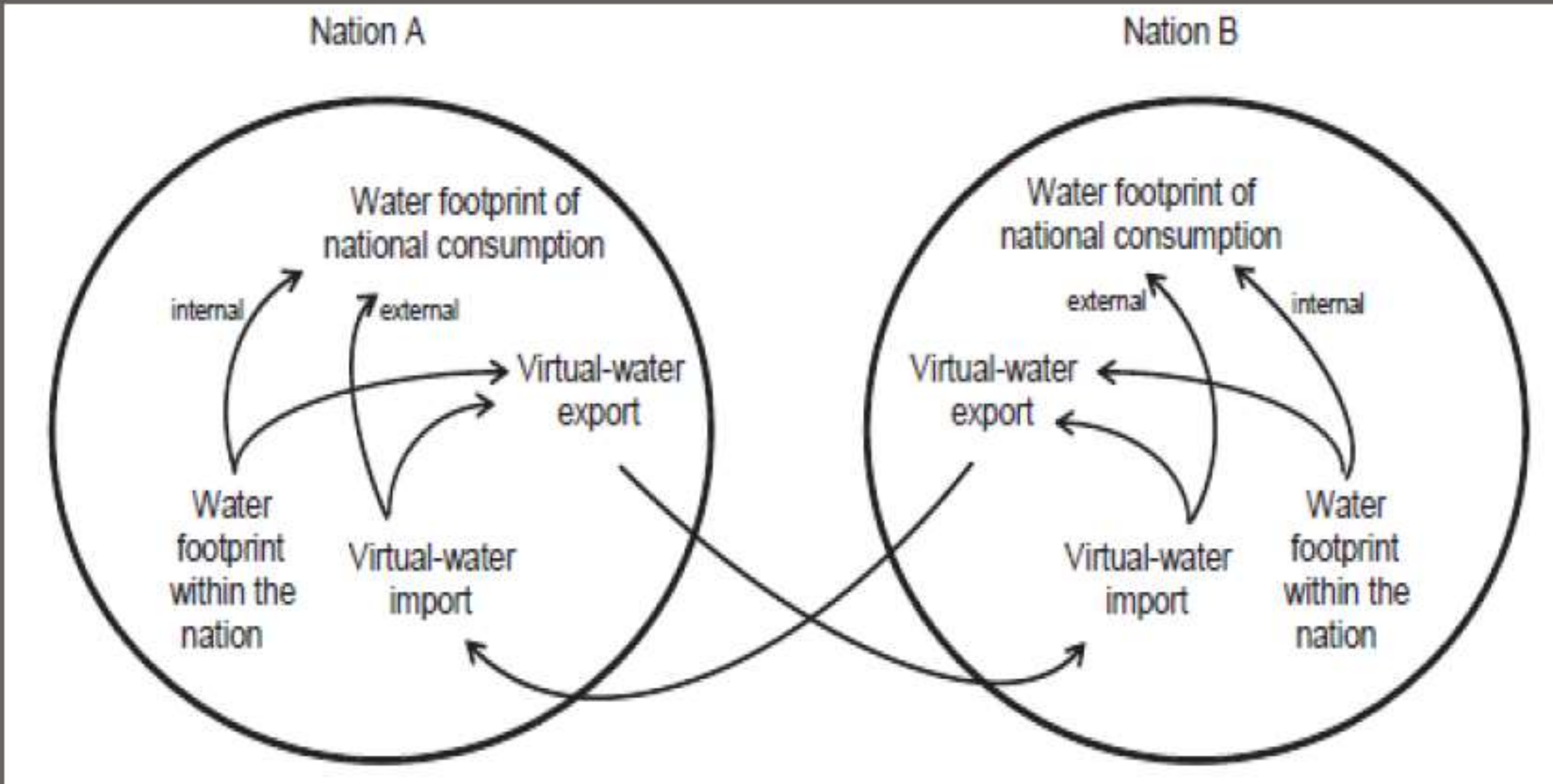
National Water Footprint of consumption



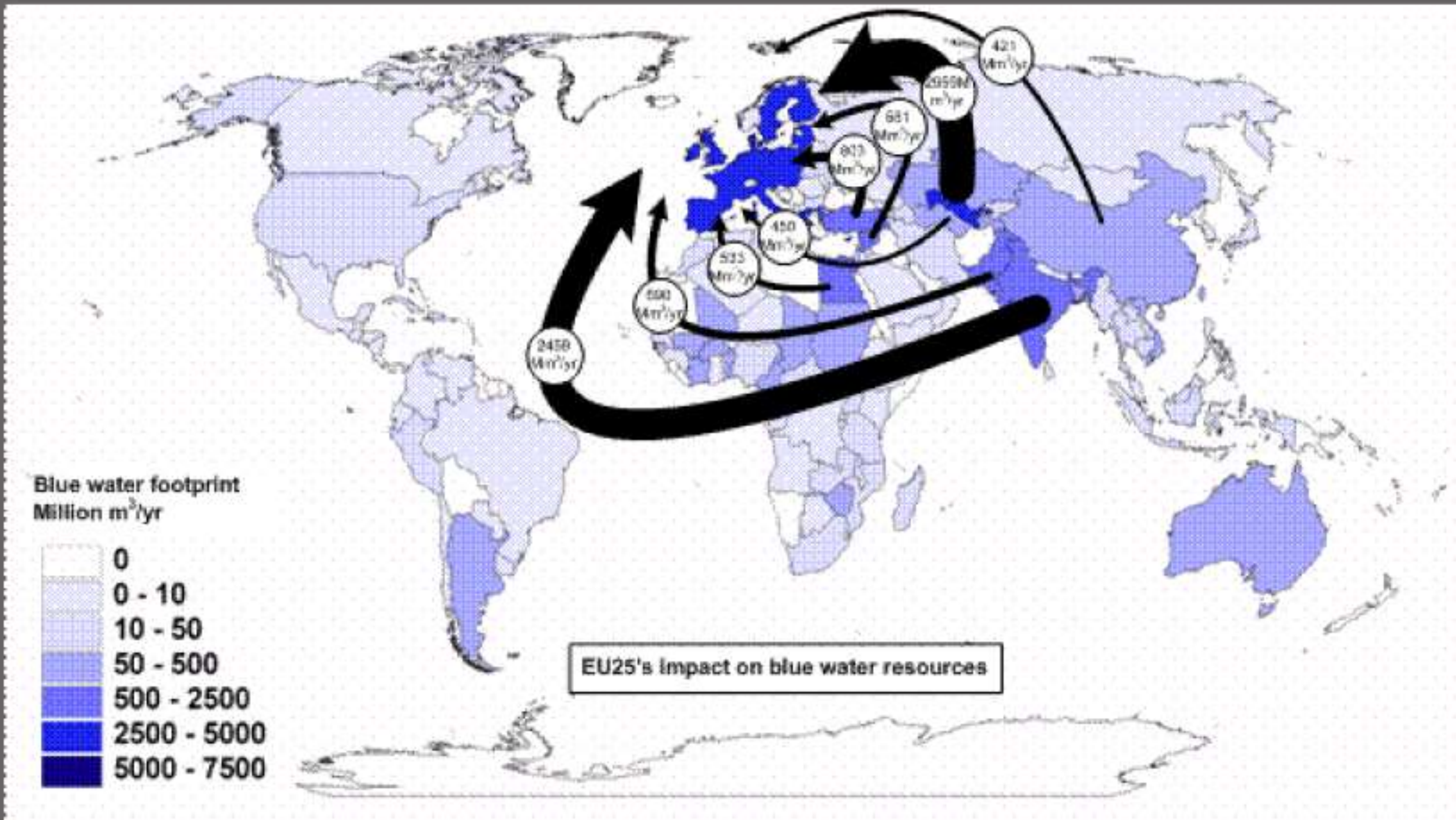
Blue water footprint of consumption



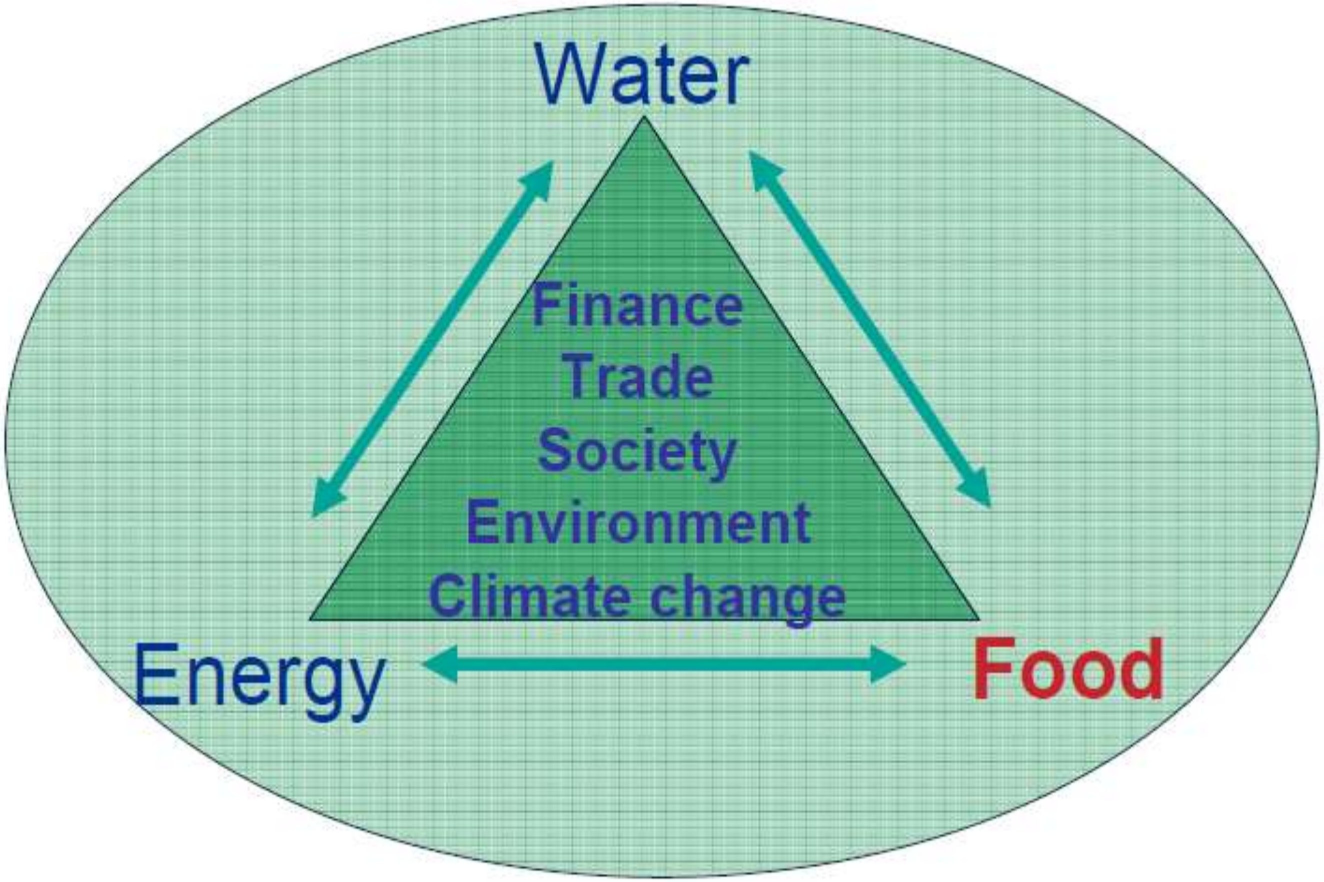
If the world was only two countries....



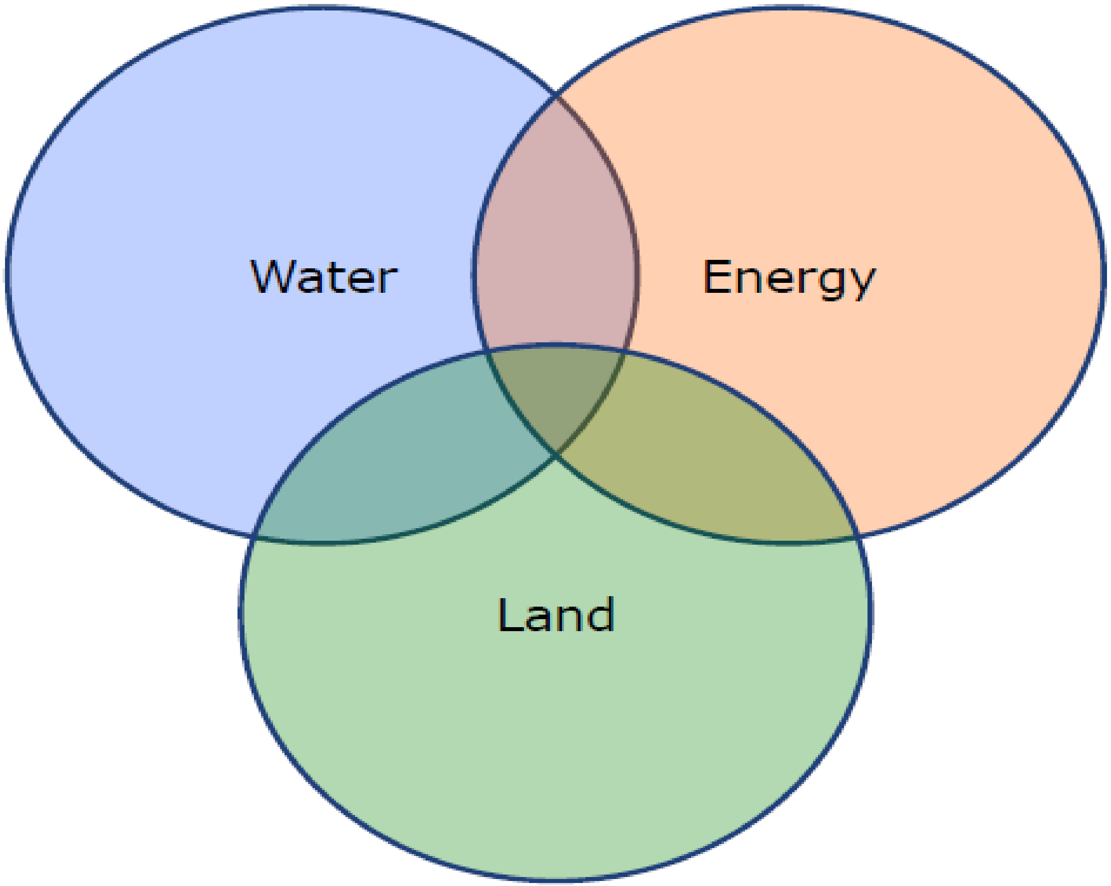
Global blue water impact of EU25



A Water-Food-Energy nexus



WEL Nexus



Water abstraction and the link with food...

		Africa	Asia	Europe	**Global**
• Domestic		7%	6%	13%	**8%**
• Industry		5%	8%	54%	**23%**
• Agriculture		88%	84%	33%	**69%**

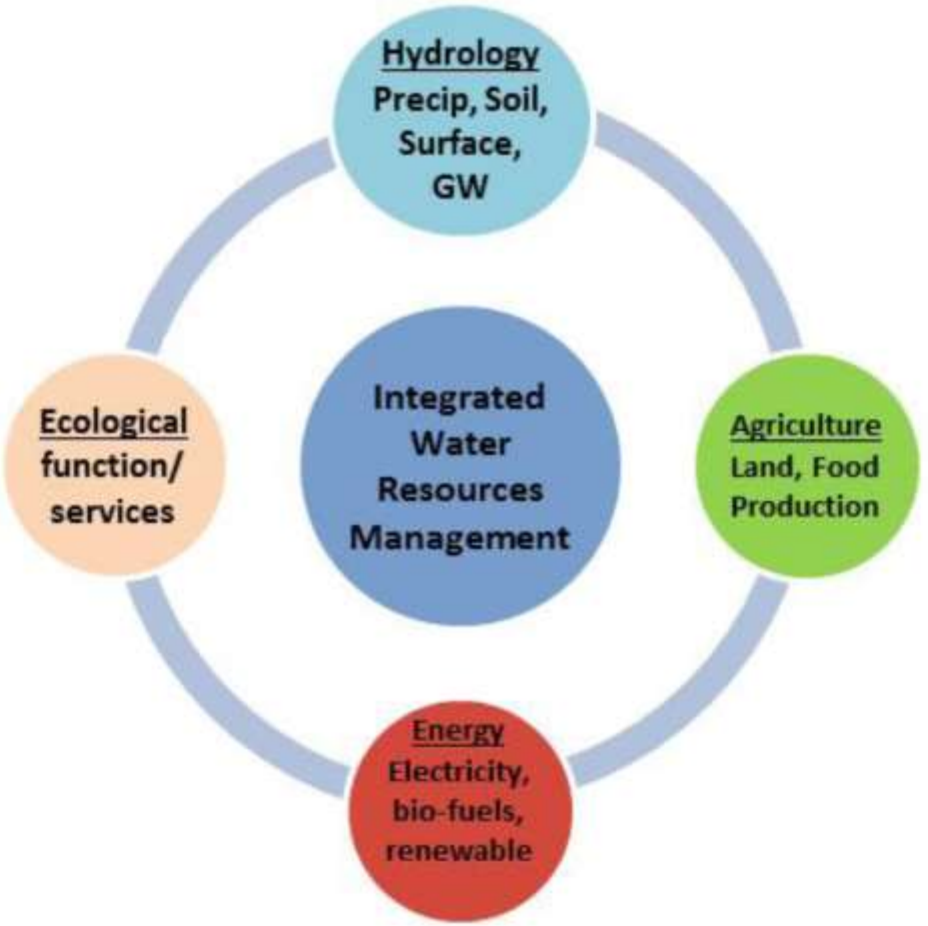
The **water, energy and food security nexus** means that the three sectors — water security, energy security and food security — are inextricably linked and that actions in one area more often than not have impacts in one or both of the others.

These linkages have always been present, but as the world population hurtles towards 8 billion with increasing demands for basic services and growing desires for higher living standards, the need for more conscious stewardship of the vital resources required to achieve those services and desires has become both more obvious and urgent.

Energy for water for food

Overview

- Why is this of interest?
- How significant are GHG emissions from water use?
- Energy usage is currently under recognised.



What is energy required for?

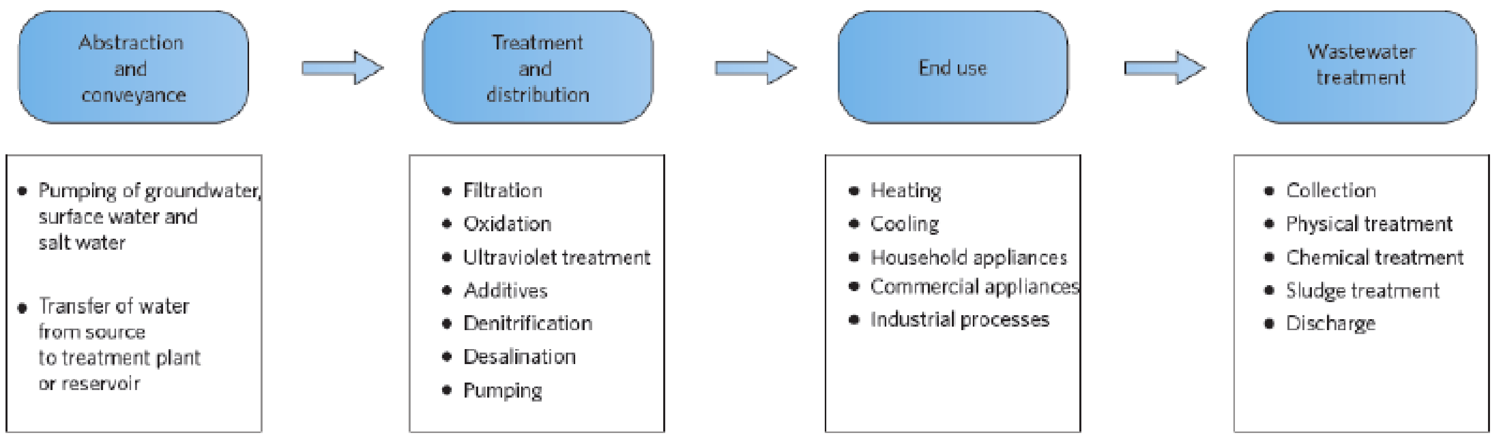


Figure 1 | **A conceptual model of water-sector processes involving energy use.**

Energy use is high……

- UK roughly 3% of electricity used by water industry.
- Water-related energy use in the US accounts for nearly 5% of total GHG emissions.
- Proportion is even higher in the UK mostly associated with end uses of water, such as heating.
- In countries with extensive irrigation energy use for abstraction and conveyance can be high:
  - Estimates for India suggest emissions from lifting water for irrigation as much as 6% of total national emissions.
- In the US, agriculture is the largest business consumer of electricity, annual cost of almost US$1.2 billion

Energy for water for food

- Irrigation and energy use
- Globally, irrigation accounts for around 20% of the arable land area, but contributes 40% of the global harvest

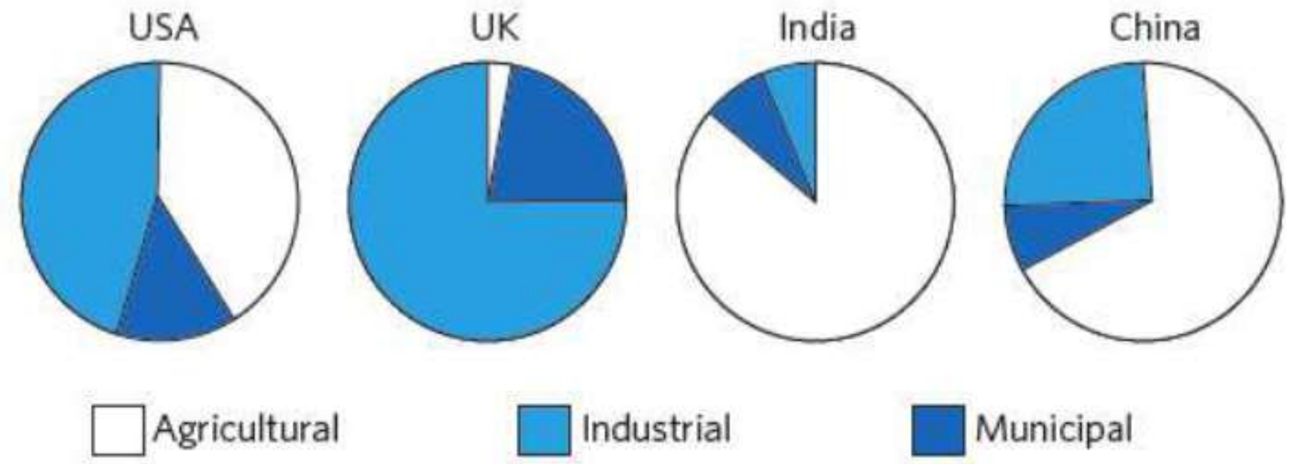


Figure 4 | Freshwater withdrawals by sector in 2000 (%). Data from ref. 41.

Key points

- Important to link food-water-energy
- Energy use is under-recognised
  – System boundaries, lack of data
  – Disparate communities: water resources/climate research water industry/practionners
- Energy use is high……
  – Water is heavy, and has high specific heat capacity
- Energy for water for food
  – Irrigation and energy use
  – Food production policy targets: integrate adaptation and energy use

Factors affecting energy use for groundwater irrigation

Abstraction of water

- Total dynamic head
- Pump/motor type
- Efficiency
- Water purity
- Power source
- T and D losses

Application of water

- Transport
- T and D losses
- Irrigation system
- Pipe system
- Power source
- Efficiency

Water-use intensity

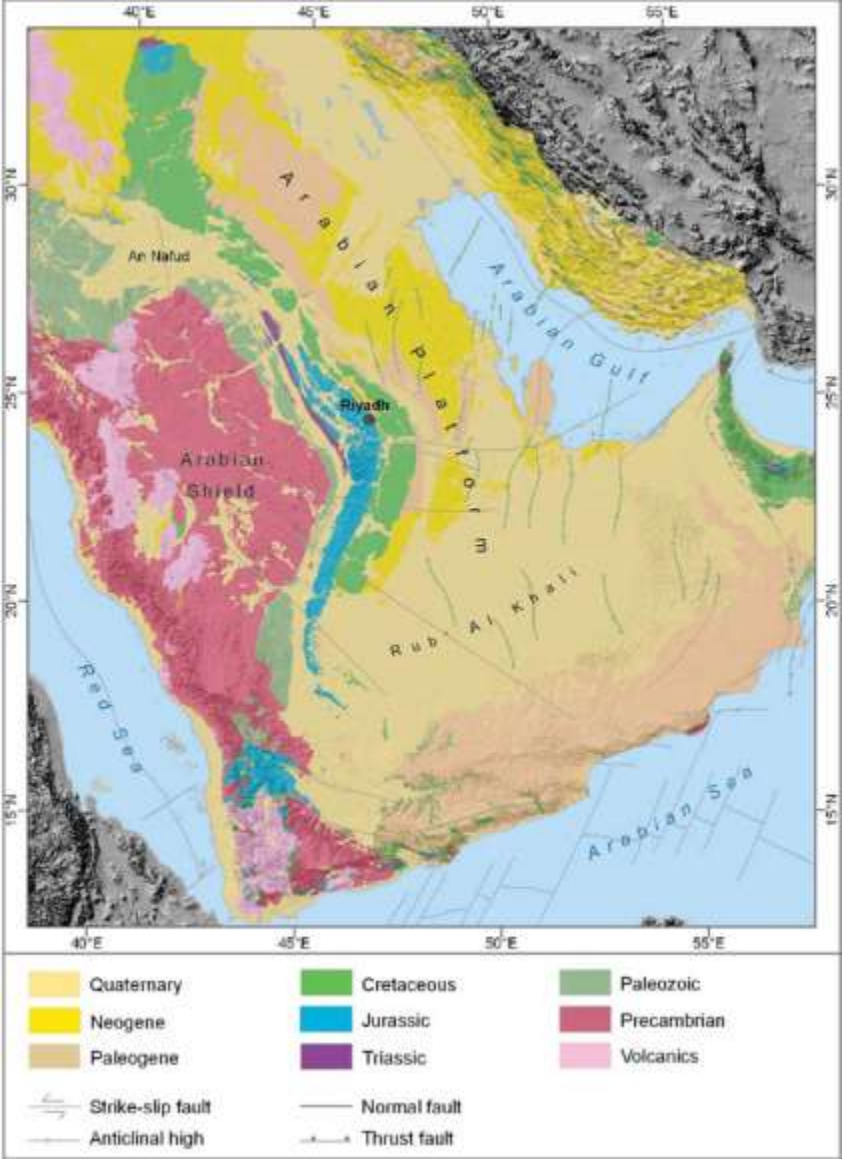
- Climate
- Topography
- Soil
- Crop type
- Agricultural management

Groundwater management in an arid environment

In arid and semi-arid regions groundwater is often the only natural resource for water supply. Therefore, stakeholders face great challenges in managing this resource in a responsible way.

The problem is further amplified by population growth, increase in agricultural, industrial and municipal water consumption, and the threat of climate change.

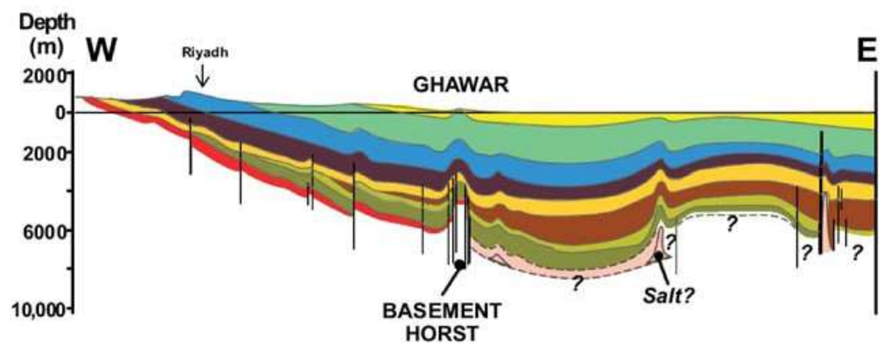
Therefore, an optimal use and management of the scarce groundwater resources is imperative. A precondition for this is a sound understanding of the particularities of the hydrogeology of arid and semi-arid regions as well as a proper knowledge of the water budget, water resources in storage, and water quality.



Case studies

Integrated Groundwater Management in the Kingdom of Saudi Arabia

(Mohammed Al-Saud, et al, *International Journal of Water Resources and Arid Environments* Vol1 Issue 1: 65-70, 2011)



Case study 1

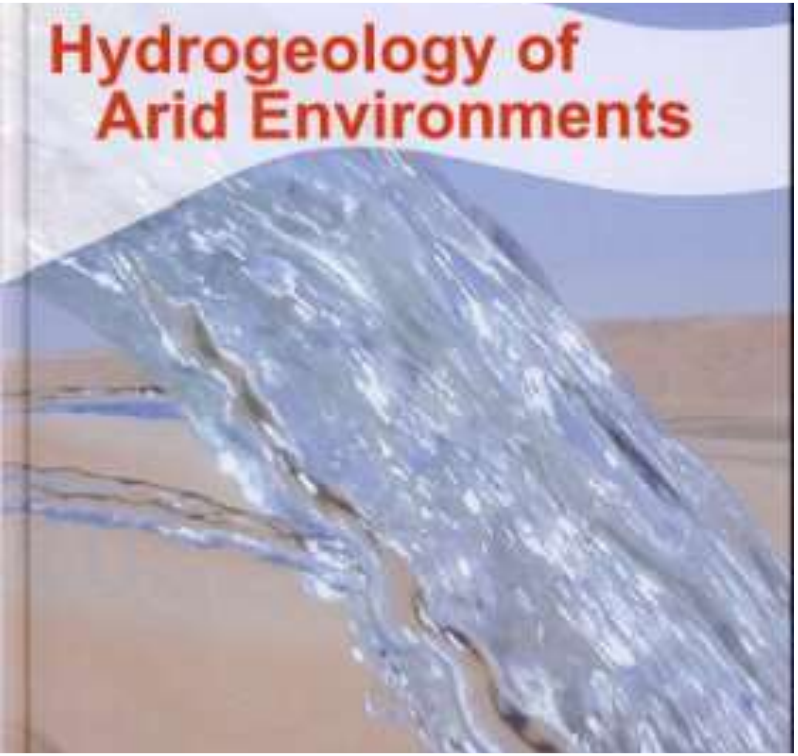
- **Saudi Arabia currently relies on** relies on three types of water resources – renewable water resources, non-renewable groundwater resources and desalinated seawater.

- **Groundwater Recharge:** For groundwater resources management, the rate of aquifer replenishment due to groundwater recharge is one of the most important factors and unfortunately also one of the most difficult to derive with sufficient accuracy.

- **Large-Scale Groundwater Modelling and Smart Groundwater Mining: I**n-depth understanding of the water balance, hydrochemical evolution and the fundamental characteristics of large, regional aquifer system covering thousands of square kilometres.


Case study 2

AMEC Aquifer Storage and Recovery (ASR) Project in Qatar



- ASR is a process where water is added to aquifers via injection wells or surface water storages, and then extracted when required.

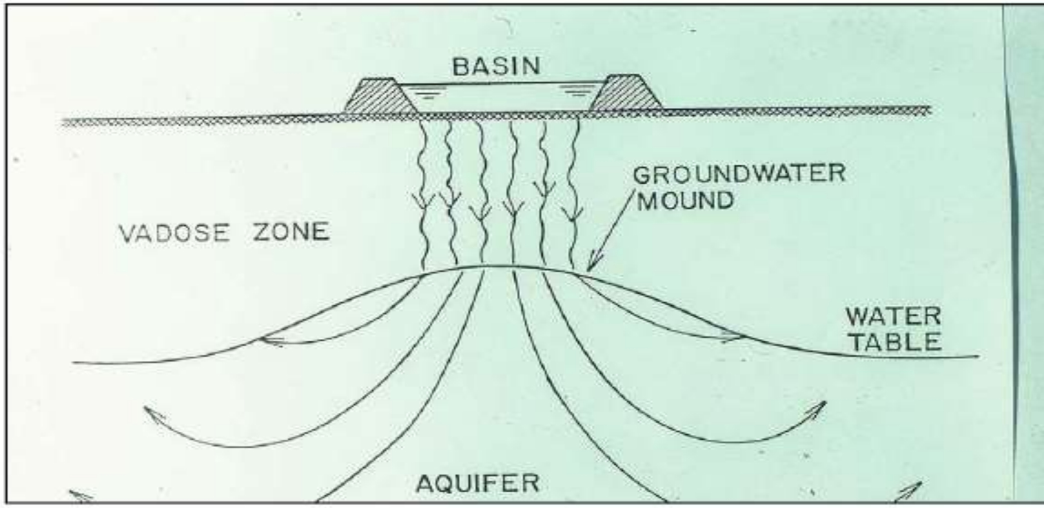
Project specifics:

- ASR as a way of preventing salt water incursion from coastal areas;
- as a way of recharging ground waters during infrequent periodic precipitation events;
- and also the use of treated wastewaters to allow this recharge to occur.

AQUIFER STORAGE RECOVERY

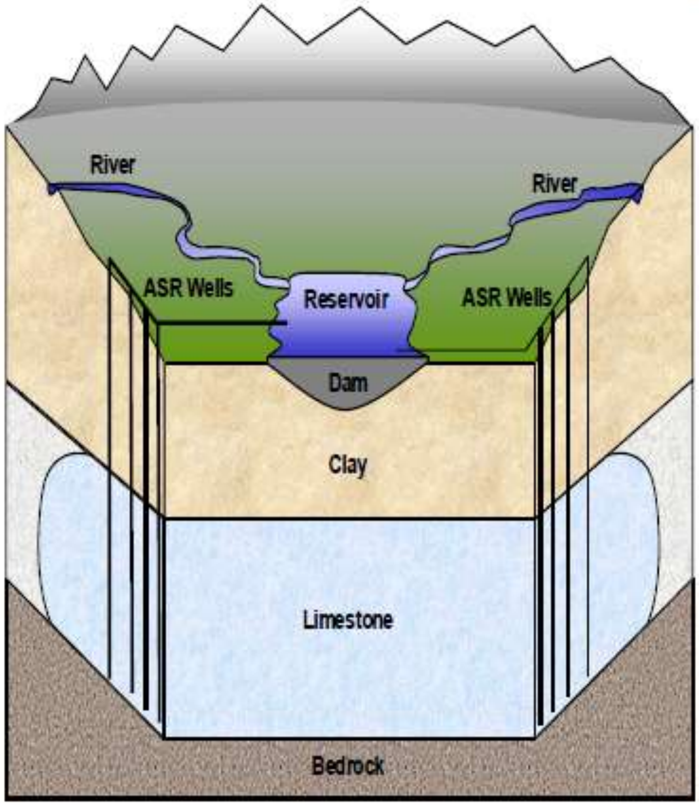
Water storage underground offers many advantages compared to storage above ground in surface reservoirs

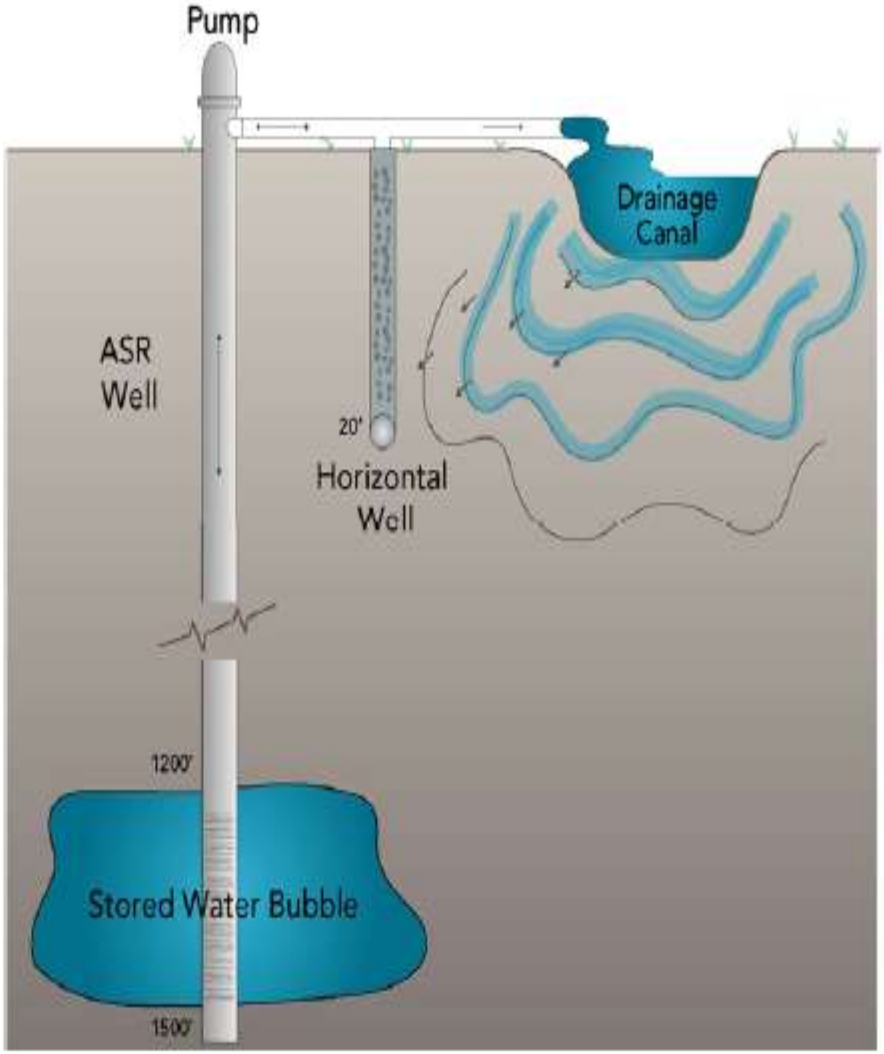
- Less environmental impact
- Lower cost
- Greater water storage volumes
- Recharge Alternatives
  - Basins, channels
  - Vadose zone wells
  - Injection wells
  - ASR wells
  - ASTR wells



A combination of ASR wells and surface reservoirs is very beneficial for providing water storage

- Surface reservoirs capture water quickly, but…
  - are expensive
  - often have evapotranspiration and seepage losses
  - garner environmental opposition
- Where feasible, ASR wells can store much larger volumes of water
  - occupy little land
  - can be built in increments
  - have few or no losses, but can only recharge and recover water slowly





All land has beneath the surface one or more water tables which can be separated by aquacludes.

The water tables constitute aquifers and act as reservoirs from which water may be withdrawn. Aquifers are replenished naturally through rainfall, but can also be recharged by ASR methods that inject water beneath the surface through wells or percolation beds.

Numerous North American communities practise ASR:

This process involves injecting water into aquifers during the winter, when supply is higher and demand is lower, and withdrawing it in the summer. This could be both recycled ‘greywater’ (water from sources such as laundry and showers) and ‘blackwater’ (the contaminated wastewater that passes down toilets).

The main drivers for ASR…

- Environmental benefits
  - Small footprint
  - Insignificant adverse impacts upon terrestrial and freshwater ecosystems
  - Reduced adverse impacts upon estuarine ecosystems
- Economic benefits
  - Low cost relative to other water supply and water storage options (10 to 50%)
  - Can be built incrementally
- Proven performance
  - about 400 operating ASR wells nationwide
  - very few failures

ASR Well, Cocoa, FL

Summary

- **Intensify debate** around the fundamental role of water
- **Understood better** the levers which will close the supply-demand gap
- Government, private sector and communities must **harmonise their aspirations**
- **Correlate countries** hydrologically best suite to grow food for 9bn people by addressing **trade barriers**, price supports and other subsidies

- **Water professionals stand up** and be counted … get out of the box!

Acknowledgements

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Water Security Research Centre

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