Belgian Institute for Sustainable IT asbl/vzw

Webinar on water footprint indicators facing the water cycle complexity with prof. Alain Dassargues from Liège University

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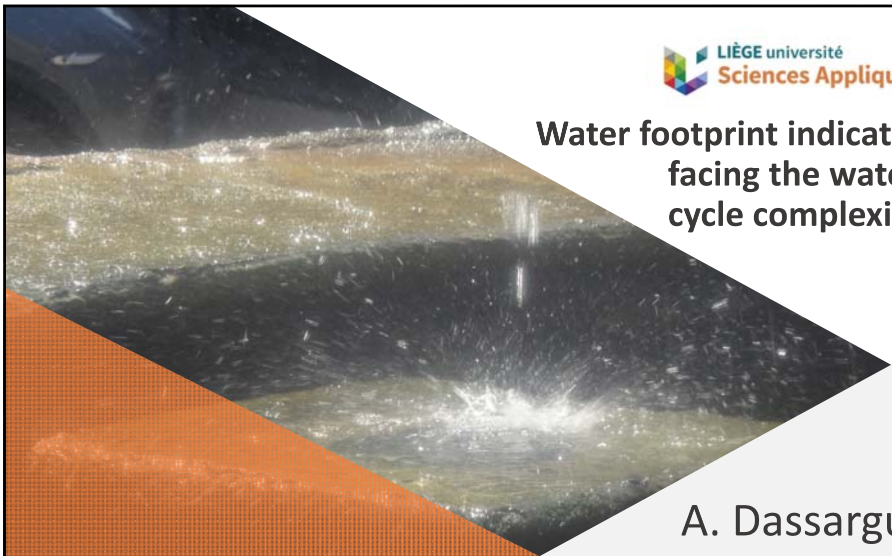


LIÈGE université
Sciences Appliquées

Water footprint indicators facing the water cycle complexity

A. Dassargues

Webinar, October 5, 2023

Hydrogeology
Environmental Geology

The global picture of water resources

Water on Earth (currently estimated) at
1,387 million km^3
100 %
- *-96.5 % seawaters*
- *-0.96 % other saline waters*

➡ *2.54 % freshwaters*
- *-1.75 % ice caps and glaciers*
- *-0.02 % vapor in the atmosphere, soil moisture and permafrost*

➡ *0.77 % 'available' freshwaters*
- *0.01 % lakes and rivers*
- *0.76 % groundwaters*

➡ ***ratio (lakes + rivers) / groundwater = 1/76 !!!***

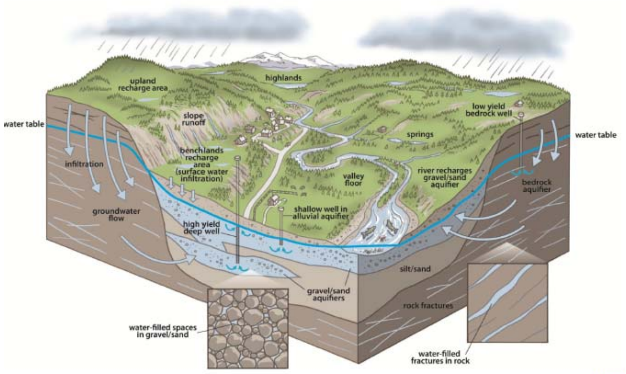
Freshwater: unevenly distributed or easily accessible
➡ *groundwater of critical importance (especially in arid zones)*

Renewability of groundwater ?
… in arid zones, water production from very old groundwater reserves
(i.e., 'fossil groundwater' not renewed for thousands of years),
sustainable development (?)

… hides huge regional differences 3

Groundwater resources

➡ ***not well understood***
➡ ***out of sight, out of mind***



(watershed-watch.org

aquifers = saturated geological formations with a 'useful' permeability

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'out of sight, out of mind'

quantity aspects

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Water and climate change

What kind of impacts ?

- ***globally: more water evaporated in the atmosphere, less iced-water***
- ***locally : depending on the local changes of climatic conditions***
- ***in Belgium: probably more or less the same amount of precipitation***
  (except if the Gulf Stream is decreased, then less P and low T°)

but: ***- more evaporation (increase of T°)***
- change in frequence and intensity of the rain events
- less recharge of the aquifers
and: ***- increase of irrigation***
- many changes in use of water

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‘out of sight, out of mind’

quality issues

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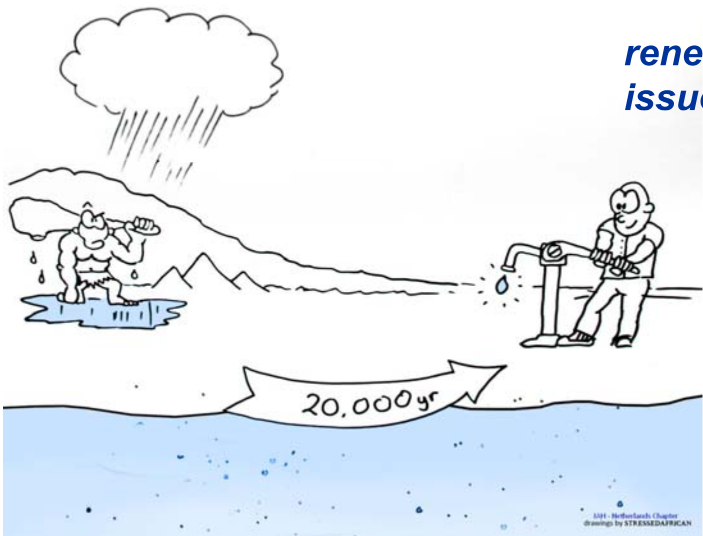
in some places, groundwater pathway is long



renewability issues

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Terminology

Simmons 2015 : *'confusion exists between used water, consumed water and produced water or withdrawn water'*

Used water:

➡ *water can be used many times, ensuring different successive functions or services:*
- *recycled water (with water treatment)*
- *reused water (without treatment)*

Consumed water:

➡ *water that is not (at least locally) recycled or reused (i.e., evaporated, transpired or transformed into food)*

Produced water:

➡ *withdrawn water, extracted from a source: a part can actually be reinjected (recycled) or reused, while the other part is consumed*

Main problem: when water ends in the atmosphere

➡ ***irrigation: the water is mostly evapotranspirated and leaves the local scale basin***

➡ ***quantity + quality problem***

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Terminology (2)

Water 'footprint' *(i.e., from a NGO called Water Footprint Network WFN)*

➡ *the total volume of freshwater **used** to produce the goods and services consumed by the individual or community or produced by the business*

LCA of water *(i.e. Life Cycle assessment from the general LCA community)*

➡ *metric(s) that quantifies the potential environmental impacts related to water (not the volume of water used or consumed but the caused potential impacts)*

(Pfister et al. 2017)

➡ ***LCA based water footprint ≠ Water footprint (WFN)***

but
both assessment methods are complementary

Main points to be considered
- ***local vs. global perspective***
- ***'green' water vs 'blue' water and 'gray' water***

➡ ***+ various physical interpretations of 'water stress index' or other similar empirical factors***

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Terminology (3)

(based on Pfister et al. 2017)

Green water vs Blue water and Gray water

Green water = water used for plant growth from naturally available precipitation

Blue water = water withdrawn from aquifers and rivers

Gray water = locally recycled water but with a quality impairment

Example

- *agriculture in Belgium (until recently) is mainly rain-fed agriculture using the natural soil moisture and reducing use of blue water: green water*

  water footprint assessments consider the total green water as used and consumed (no distinction is made)

  but without agriculture in Belgium natural vegetation would have consumed also green water (even more, see later)

- ***pure volume water footprint assessments are robust but often misleading indicators***

Terminology (4)

Local vs. global perspective

- *the shortage of water is always a local problem ('use' ≠ 'consumption')* (Pfister et al. 2017)
- *e.g., groundwater pumped for domestic use will be in a big part recycled (or reused) in the same catchment*
- *this is taken into account in LCA assessment but not in Water Footprint assessments (main goal of WFN approach is to account for global water use)*

- *in WFN assessments, water is treated as any other goods (and traded virtually via products between water abundant and water scarce regions), the robustness of the argumentation for worrying about global water quantity is questionable*

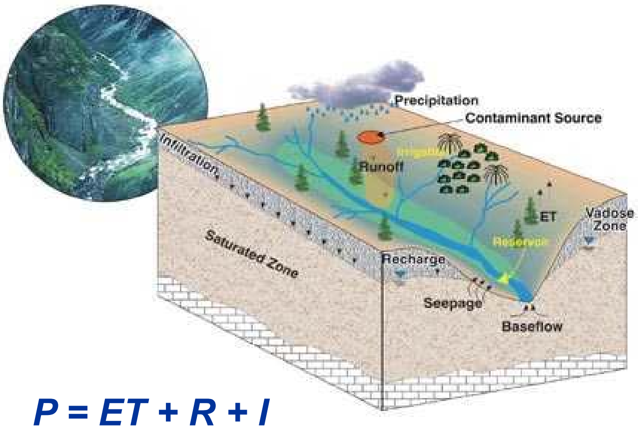
Example

- ***use of 500 mm/y of soil moisture for vegetable production in Belgium over a 1km² region (= 500,000 m³) and then… is it wrong? No, if green water***

- ***worse than groundwater pumping (blue water) of 250,000 m³ in Mauritania (?) this is not really consistent in terms of environmental impact***

The reasoning should be clearly different than for the other products !

Hydrological cycle



balance on a basin

- precipitations
- storages
- runoff
- evaporation

⚠ + impact of climatic changes

$$P = ET + R + I$$

$$P = ET + R + Q_{gw} + \Delta Storage + Q_{pumped}$$

Q measured at the basin outlet

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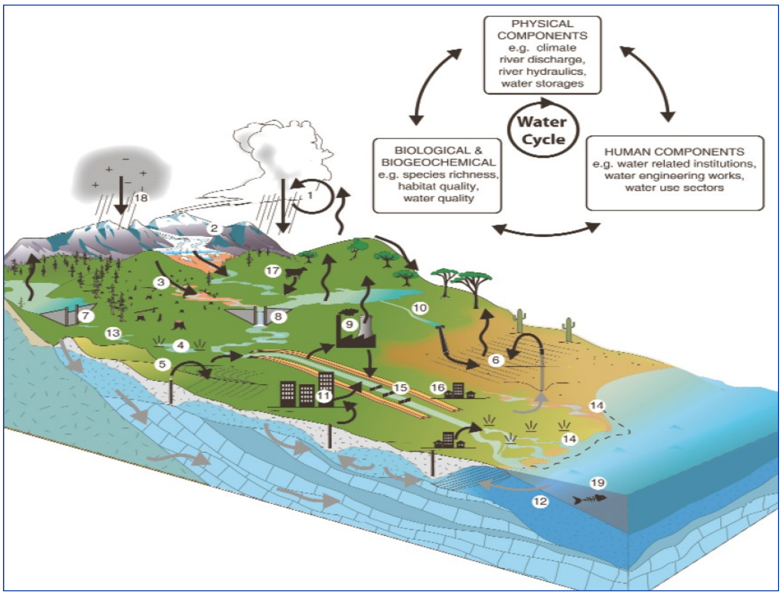
Hydrological cycle : complex network of fluxes and storage … more an more influenced by human activities !



Scale issue when dealing with exchanges between basins !

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Thinking about water availability

de Marsily 2009: *'This is not so much a global problem as it is a regional problem of availability to satisfy our needs for improving human health, food security, biodiverse natural ecosystems and effective energy production.'*

Scanlon *et al.* 2017, Cai *et al.* 2018 :

multiple feedback effects, interconnections and couplings among these four main domains dependent on water resources

➡ *the 'water – energy – food nexus'*

… natural resources may limit the development of our well-being and of our growing human communities

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Examples

- '1kg of beef needs 15,000 L of water' (WF assessment)

what is not said: if the beef is raised on rain-fed non-irrigated grasslands, the impact can be even positive on the local water balance)

➡ ***in our regions, most of this amount is green water***

- '1kg of tomatoes needs 214 L of water' (WF assessment)

what is not said: here most often it needs irrigation with blue surface water and groundwater in greenhouses or in semi-arid regions

➡ ***most of this amount is blue water (in some places, grey water)***

- 'data center of St Ghislain (Google) consumes for cooling 1.44 million m³/year … as much as 10,700 households' (Le Soir 25/7/23)

(a) 70% would be evaporated: about 1 million m³/year is consumed
(b) for domestic use of water in households we need quality of drinking water (blue water) while St Ghislain uses/consumes water from a canal (mostly grey water)

➡ ***the local specificities could be huge in the local availability of grey and blue waters during meteorological dry periods***

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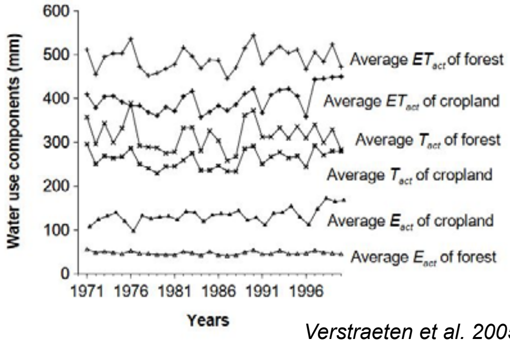
Irrigation is the most negative process as it increases evapotranspiration !

The impact of any agricultural production could be assessed depending on many factors

➡ *fundamental to distinguish between* *- rain-fed agriculture* *- irrigated agriculture*

In our regions, agriculture consumes less water than the natural land use (i.e. forest)



Verstraeten et al. 2005

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… and gray water ? *(locally recycled water but with a quality impairment)*

not taken into account in WFN Water Footprint assessments
indeed gray water is dependent on the local development and organization

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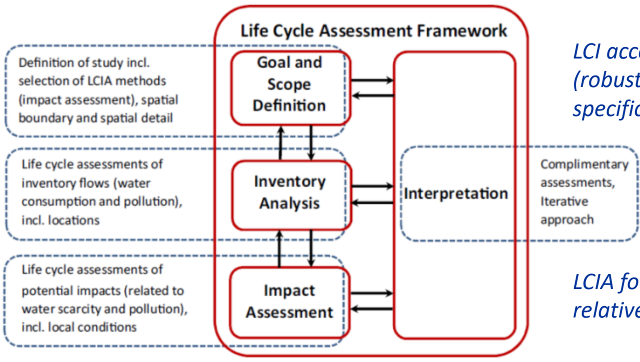
LCA water assessments
include LCI (LC Inventory) and LCIA (LC Impact Assessment)



*LCI accounts for **local** scale state (robust analysis of region specific databases)*

*LCIA focuses on the **local** relative 'water scarcity'*

➡ *often considered as less 'robust' because more complex and thus subjective than water footprint assessments*

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'Water stress index' (?)

...let's be curious, cautious and rigorous

Many examples from organizations using
definition of the local 'water scarcity index' or 'vulnerability to water shortage'
with an obvious sense of goodwill

➡ *losing any real physical consistency*

➡ *leading to the use of empirical and subjective index*

but who ultimately harm the cause they wish to defend

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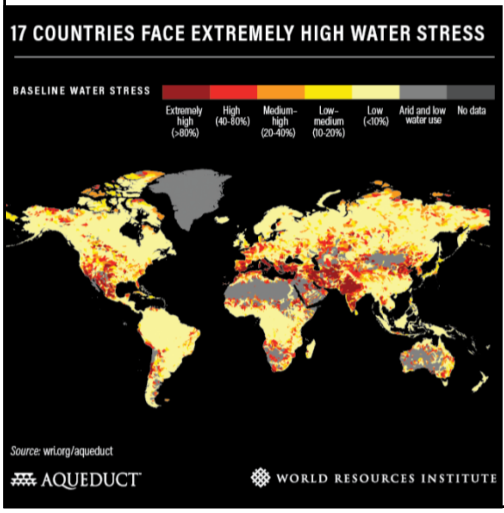
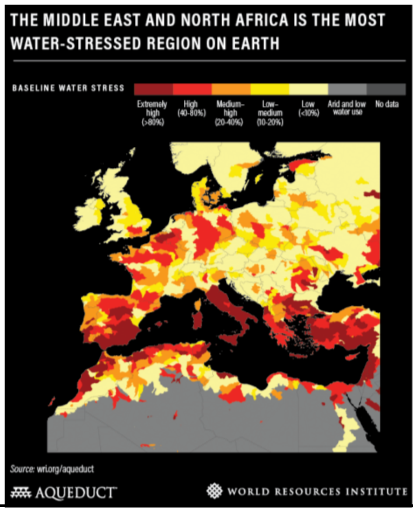
An example: World Resource Institute

… making regularly the headlines in the media

publishing/advertising their 'water stress country rankings'
with regards to 'water-quantity related risks' (2013, 2015, 2019, …)





***WRI** (2013, 2015, 2019)*

WORLD RESOURCES INSTITUTE

National Water Stress Rankings

EXTREMELY HIGH BASELINE WATER STRESS

1. Qatar
2. Israel
3. Lebanon
4. Iran
5. Jordan
6. Libya
7. Kuwait
8. Saudi Arabia
9. Eritrea
10. United Arab Emirates
11. San Marino
12. Bahrain
13. India
14. Pakistan
15. Turkmenistan
16. Oman
17. Botswana

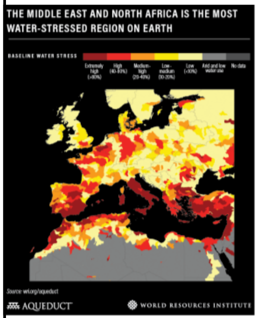
HIGH BASELINE WATER STRESS

18. Chile
19. Cyprus
20. Yemen
21. Andorra
22. Morocco
23. Belgium
24. Mexico
25. Uzbekistan
26. Greece
27. Afghanistan
28. Spain
29. Algeria
30. Tunisia
31. Syria
32. Turkey
33. Albania
34. Armenia
35. Burkina Faso
36. Djibouti
37. Namibia
38. Kyrgyzstan
39. Niger
40. Nepal
41. Portugal
42. Iraq
43. Egypt
44. Italy

'Les chiffres affolants de la consommation en eau en Belgique' (Télémoustique)
'La Belgique parmi les régions les plus menacées par une pénurie en eau' (LLB et Le Soir))
'Watertekort in Belgïe…' (De Morgen, De Standaard, …)

47. Sudan
53. South Korea
59. France
65. Indonesia

An example: World Resource Institute



The World Resource Institute = American Private Foundation funded by American donors including the Democratic Party, Coca Cola, and many others

Their work is not peer-reviewed.

The index is in fact a ratio
annual water use / annual renewable water availability
per country or region

➡ *this index may seem logical to the general public,*
in fact it, in no way, measures the actual water stress prevailing (or which will prevail in a few years' time) in a region or a country

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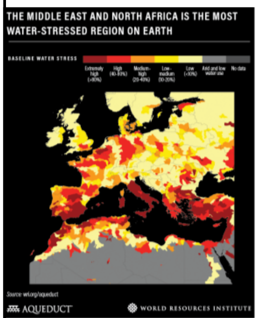
WRI *(2013, 2015, 2019, …)*



Why is there a problem ?

- ***water use is assimilated here to water consumption****,*
  these are two different things, since volumes of use are always greater than those of actual consumption
  much of the water uses is recycled locally

- ***the index itself is biased***
  water use / renewable availability of water

  In arid countries, the availability of renewable water is very limited, so ***water use has been forced to be greatly reduced*** *as each region has had to adapt to its local hydrological/climatic situation.*

  Indeed, in the reality, countries like Niger or Mali are much more 'water-stressed' than Belgium (to take just one example), even though this is not reflected in the ratio, since the numerator decreases just as much as the denominator.

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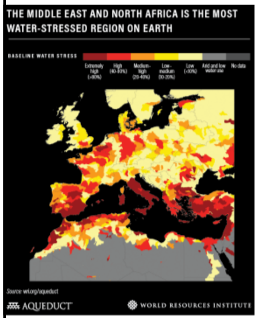
***WRI** (2013, 2015, 2019, …)*



- *also, take a look at the data:*
  - *estimates of countries' night-time water consumption on the basis of satellite images quantifying night-time lighting (!?)*
  - *cooling water from nuclear power plants located in estuaries (e.g. the Scheldt) is totally taken into account, even though this in no way affects the local freshwater cycle*
  - *other large approximation in withdrawal assessments*
  - *large approximation in available water (e.g., gray water not accounted for)*

but the most biasing factor: the indicator itself

➡ *other indicators should be developed (i.e., involving a sensitivity analysis of available renewable water if the withdrawal are changed, …)*

Messages to take home

- *renewability of freshwater can only be assessed at a local (regional) scale*
- *water 'consumption' = evapotranspiration **not to be confused with***
  'use', 'production', 'withdrawals'
  (e.g. high withdrawals do not automatically imply high consumption)
- *in terms of 'Water Footprint' and Water LCA ?*
  … very important to distinguish blue, green and gray waters
- *important to think 'local water balance'*
- *water issues are not only a quantity problem, but also a quality problem*
- *water shortages are due to the uneven spatial and temporal distributions of freshwaters and inadequate management*
- *considerable impacts of climate and other changes on the water cycle, including in Western European countries*
- *many things to be done, to maintain the quantity and quality of our fresh groundwater and surface water resources*
- *first priority: a clear, rigorous communication*

Thanks !

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