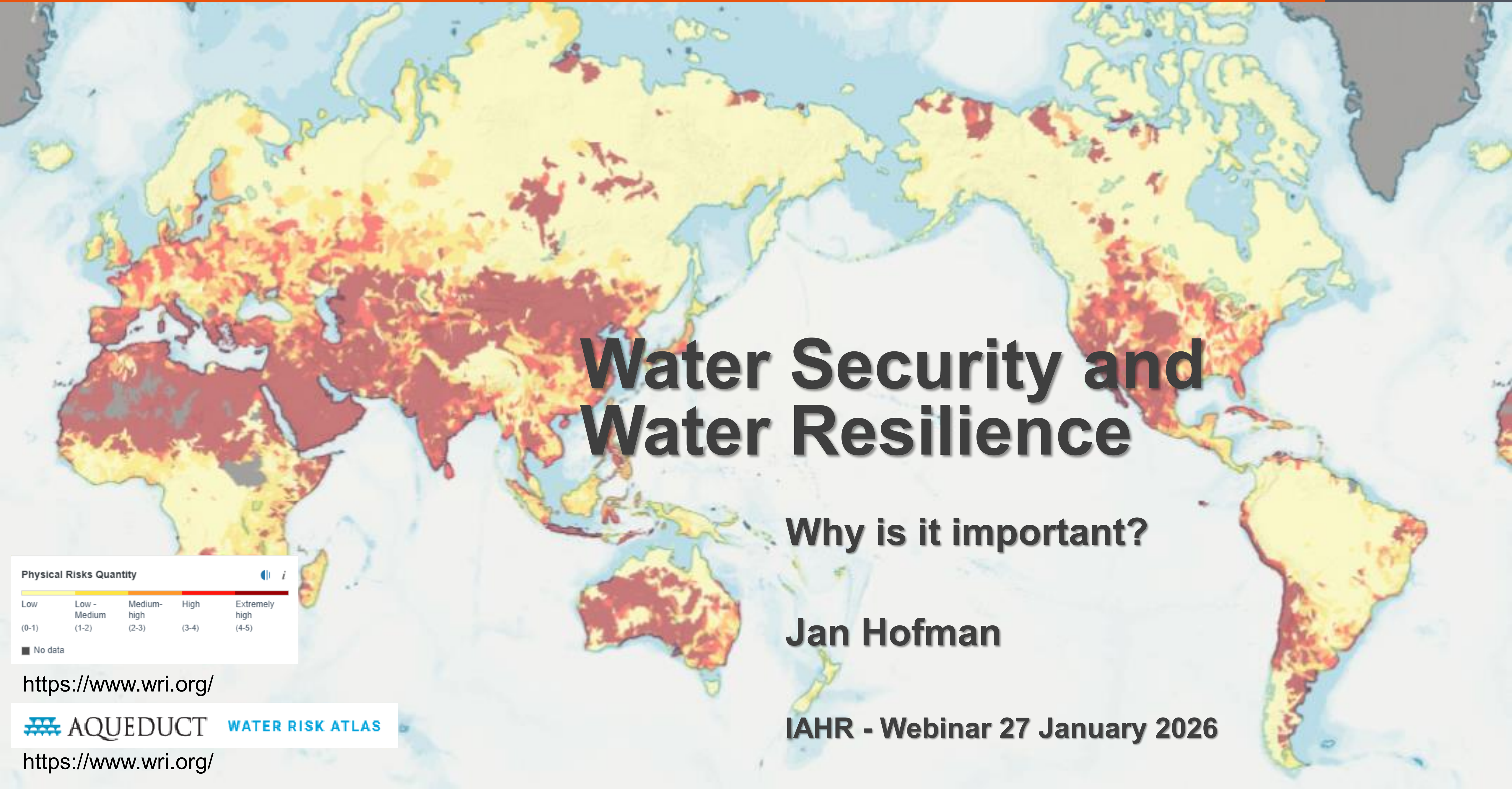
Water Security and Water Resilience

Why is it important?

Jan Hofman

IAHR - Webinar 27 January 2026



https://www.wri.org/

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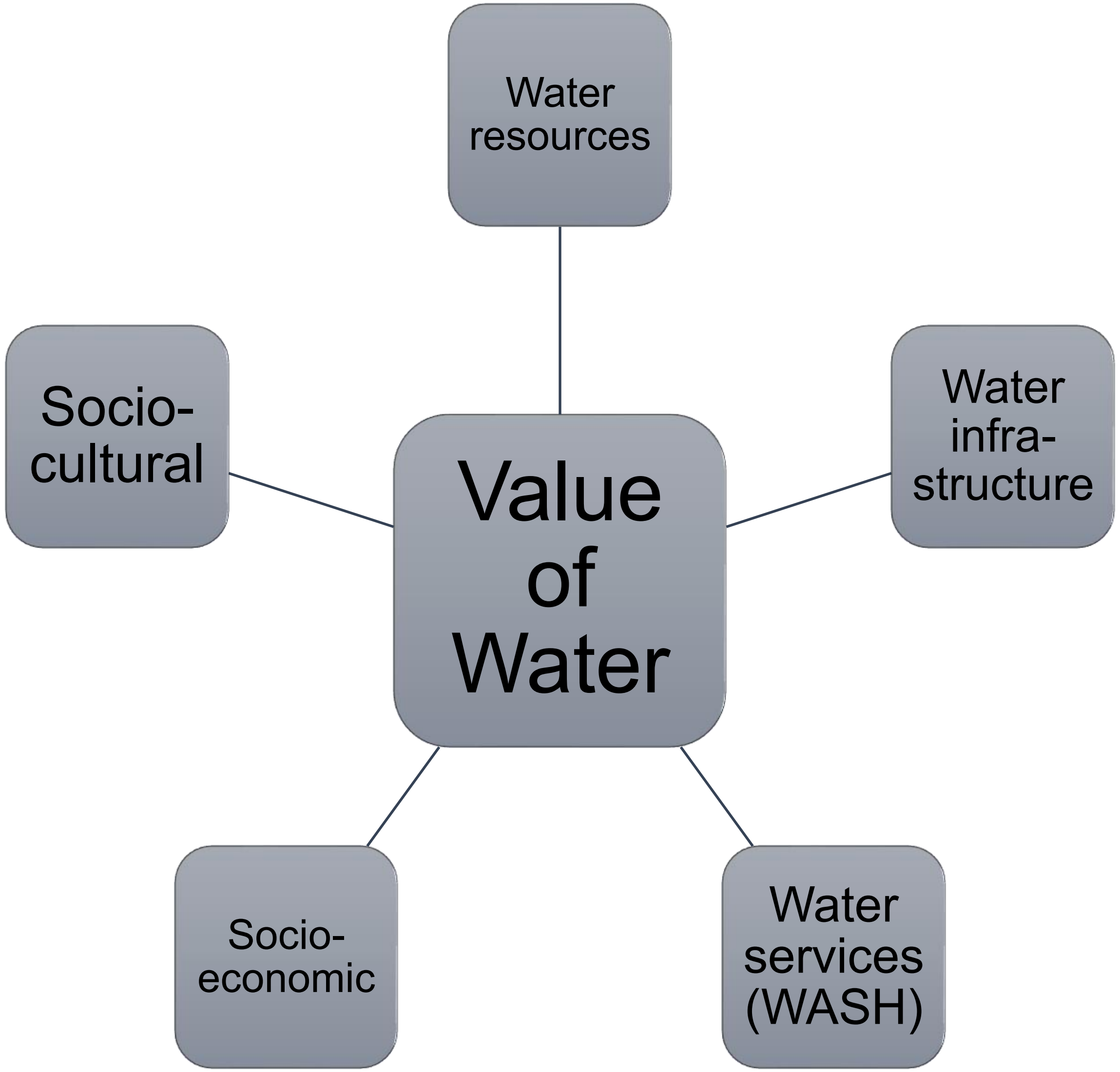
Value of water

- Water's worth is arguably infinite – without water live ceases to exist
- Sometimes the real value is neglected -> wastage, misuse
- Other times contention or conflicts rise from clashes in different value domains

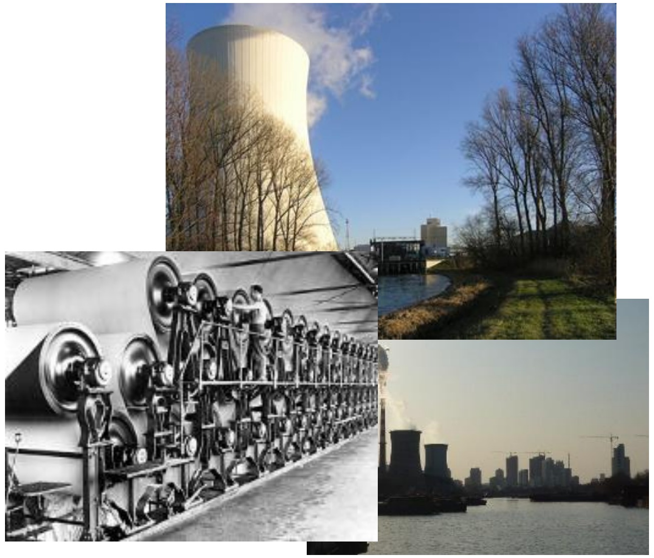
- Exchange value (= market price)
- Utility: the use value (≠ market price)
- Importance: appreciation or emotional value



Value of water

Public health

Ecosystems (services)



Business/manufacturing

Food production

But what about this?

Morning Mix

Manslaughter charges possible in Flint water crisis, says top investigator

A | 🖶 | 154 | Save for Later | Reading List

By Michael E. Miller February 10 Follow @MikeMillerDC

Flint water crisis

Flint mayor calls for immediate removal of corroded lead pipes

Other US mayors join call to 'get the lead out of Flint right now' after Michigan governor said replacing pipes amid water crisis was not on 'short-term' agenda

Alex Kellogg in Flint, Michigan

Tuesday 2 February 2016 23.28 GMT

Shares 1,086 Comments 21

Save for later

Flint mayor Karen Weaver: 'We are here to take a stand to get the lead out of Flint right now.' Photograph: Mandel Ngan/AFP/Getty Images

Joined by other former and current mayors, the mayor of Flint, Michigan, called for immediate action to remove corroded lead pipes from the city's contaminated water distribution system on Tuesday.

"We are here to take a stand to get the lead out of Flint right now," said Mayor Karen Weaver of the city's water crisis, which has exposed an untold number of children and adults to high levels of lead. "We want to make sure we identify every place that is high risk. This is where we want to start."

… or this ?

Libya
Sept 2023

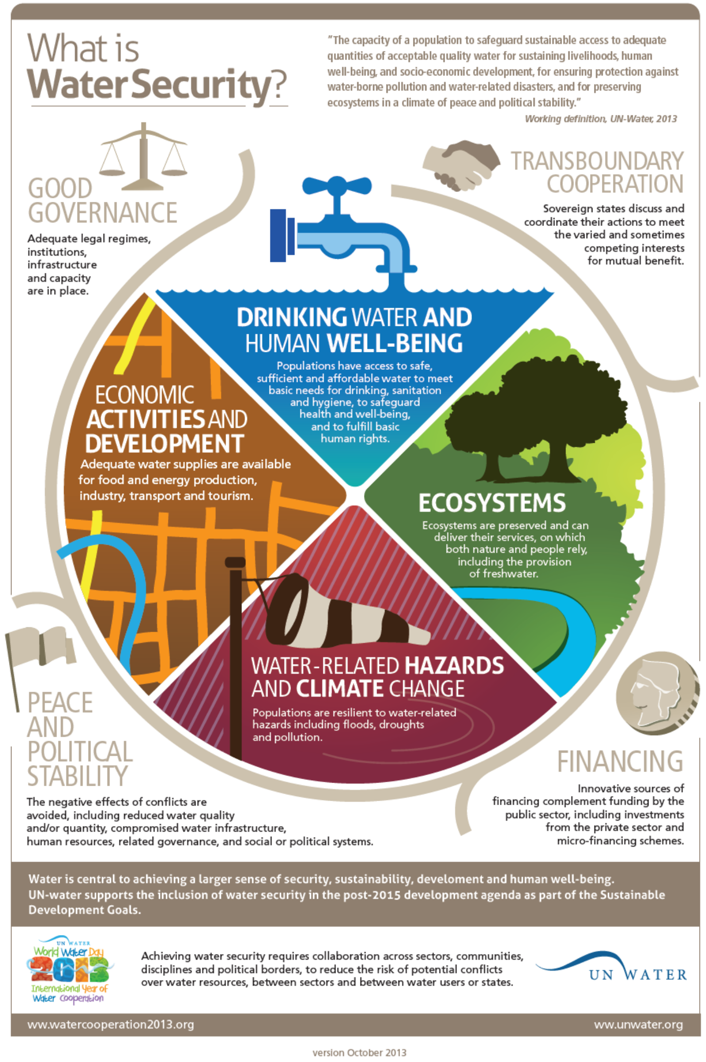
NL, BE, GE
July 2021

Storm Boris
Central Europe
2024

And droughts?

- Droughts risk, frequency and severity are increasing globally
- Climate change is the main driver, but significant impact from deforestation, urban expansion, unsustainable agriculture
- Disrupting freshwater availability with huge effects for ecosystems
- Economic costs of droughts are increasing at an annual rate of 3 - 7.5% globally
- Human toll and displacement

OECD (2025), Global Drought Outlook: Trends, Impacts and Policies to Adapt to a Drier World, OECD Publishing, Paris, https://doi.org/10.1787/d492583a-en.



- Safeguard sustainable access to water
- Ensure adequate quantities of water
- Provide acceptable quality water
- Sustain livelihoods and human well-being
- Support socio-economic development
- Protect against water-borne pollution and water-related disasters
- Preserve ecosystems

Key Elements of Water Security

Too much, too little, too polluted water

Definitions, scales, perspectives, approaches

Assessment

- Incentivizing to actions
- Setting priorities

Urban context

- **68%** of the world population by 2050[1]
- **Complexity :** high population density, climate change, demand pressures and the co-existence of intricate infrastructure systems
- **Heterogeneous** conditions: inequality and diversity
- One score or average for an urban area: **overlooking realities?**
- Different perspective could provide new information for decision makers

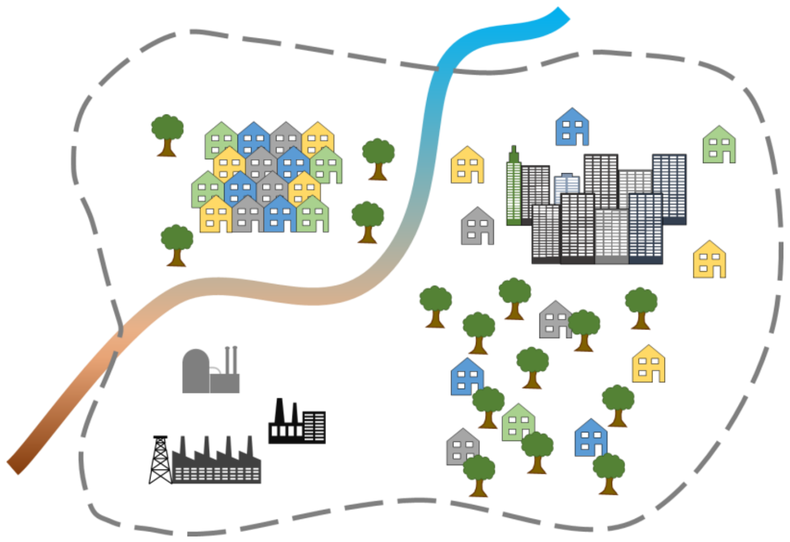
Water security for whom... [2]


(C_Fernandes/Getty Images)

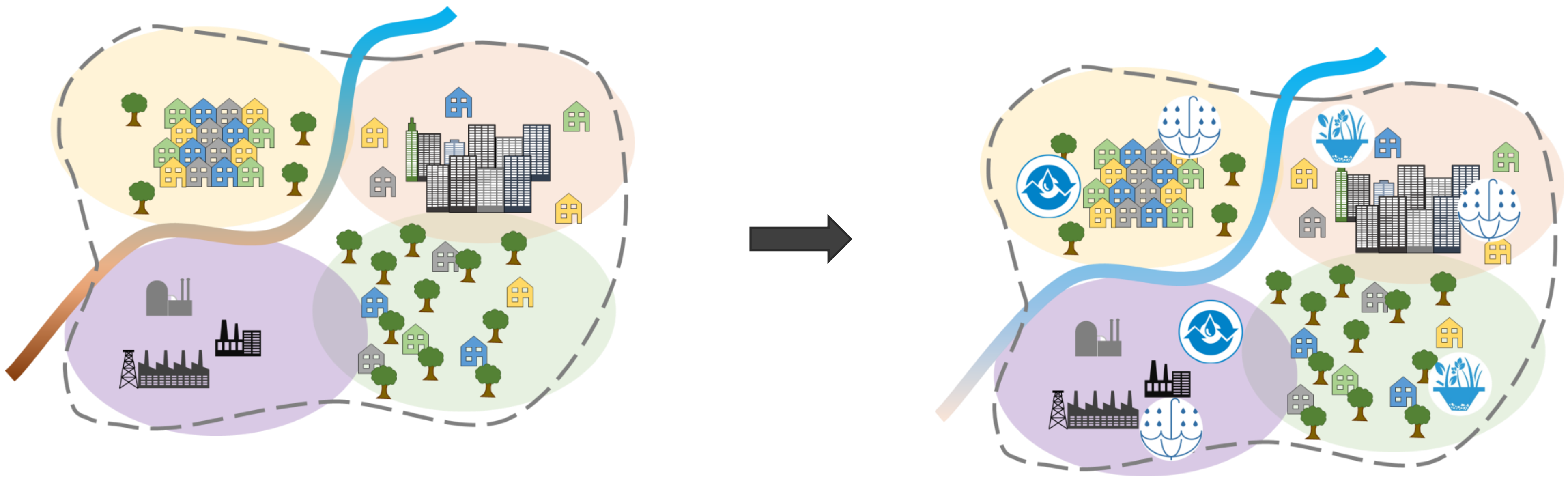
[1] Water, U. N. (2018). Sustainable Development Goal 6 synthesis report on water and sanitation. Published by the United Nations New York, New York, 10017.

[2] A. Y. Hoekstra, J. Buurman, and K. C. Van Ginkel. Urban water security: A review. Environmental Research Letters, 13(5), 2018.

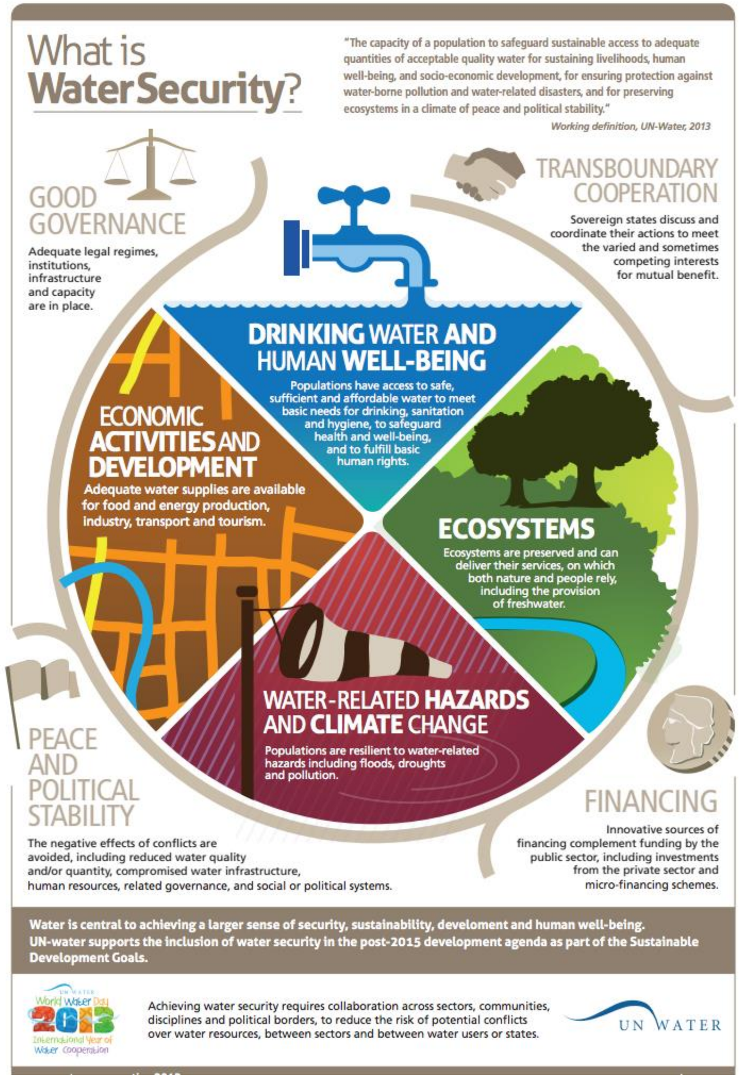
Multi-level assessment approach



- Downscaling the assessment
  - Sectors in the city **- spatial distribution** of water security
- Specific realities and needs
- Guidance for decentralized actions (rainwater harvesting, SUDS, wastewater treatment, etc.)



Downscaling urban water security assessment



- Considering the definition from UN-WATER
- Framework based on 4 dimensions - indicators

Economic Activities and Development
Water for economic development
Governance, stakeholders engagement, investments
Socio-economic aspects

Water-related hazards and climate change
Hazards and vulnerability, affected area
Prevention, preparedness and response
Pollution incidents

Drinking water and human well-being
Water quantity and quality
Access to water services and infrastructure reliability
Water recycling/reuse
Hygiene, public health and wellbeing

Ecosystems
Water resources and river health
Pollutants discharge, quality and quantity of effluents
Vegetation cover and biodiversity
Sustainability

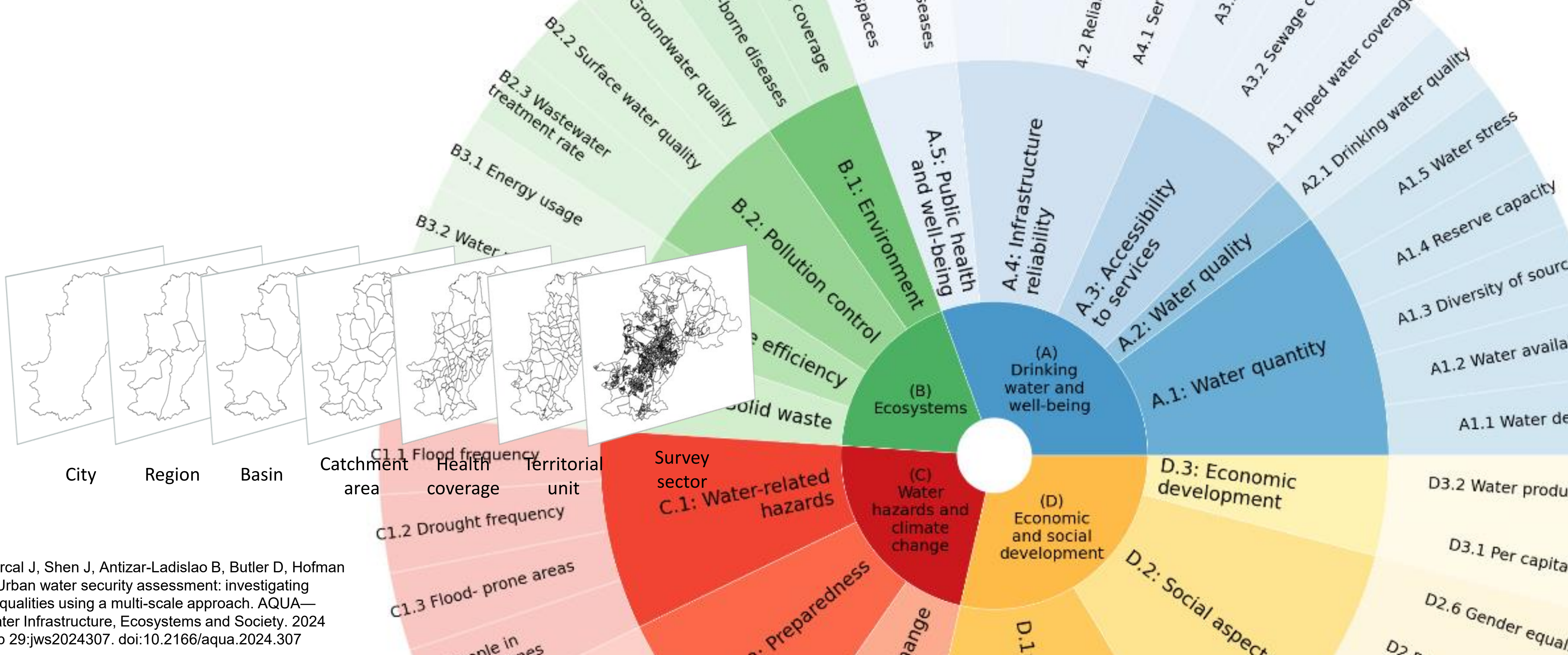
Case study: Campinas - Brazil

- Population - 1,213,792 (2020) [3].
- Territory - 794,571 km^2 [3].

(a) Country: Brazil (b) State: São Paulo (c) City: Campinas

[3] IBGE - Instituto Brasileiro de Geograa e Estatistica. IBGE - cidades e estados.

Urban Water Security Assessment Framework



Marcal J, Shen J, Antizar-Ladislao B, Butler D, Hofman J. Urban water security assessment: investigating inequalities using a multi-scale approach. AQUA—Water Infrastructure, Ecosystems and Society. 2024 Feb 29:jws2024307. doi:10.2166/aqua.2024.307

Ecosystems

ENVIRONMENT
B1.1 - Green areas
B1.2 - Environmental safety

POLLUTION CONTROL
B2.1 - Groundwater quality
B2.2 - Surface water quality
B2.3 - Wastewater treatment rate

USAGE EFFICIENCY
B3.1 - Wastewater treatment efficiency
B3.2 - Wastewater reuse rate

SOLID WASTE
B4.1 - Solid waste collection
B4.2 - Solid waste recycling

Water related hazards and climate change

WATER-RELATED DISASTERS
C1.1 - Flood frequency
C1.2 - Drought frequency
C1.3 - Flood-prone areas
C1.4 - People leaving in hazardous zones

PREPAREDNESS
C2.1 - Risk management
C2.2 - Flood protection infrastructure (storm drain)
C2.3 - Flood protection infrastructure (pavement)
C2.4 - Investment in drainage

CLIMATE CHANGE
C3.1 - CO2 emissions
C3.2 - Temperature
C3.3 - Extreme events of precipitation

Drinking water and well-being

WATER QUANTITY
A1.1 - Water demand
A1.2 - Water availability
A1.3 - Diversity of sources
A1.4 - Storage capacity
A1.5 - Water stress

WATER QUALITY
A2.1 - Drinking water quality

ACCESSIBILITY TO SERVICES
A3.1 - Access to piped drinking water
A3.2 - Access to wastewater collection
A3.3 - Affordability

INFRASTRUCTURE RELIABILITY
A4.1 - Service discontinuity
A4.2 - Service reliability
A4.3 - Metering level
A4.4 - Water loss

PUBLIC HEALTH AND WELL-BEING
A5.1 - Water diseases
A5.2 - Recreational opportunities

Economic and social development

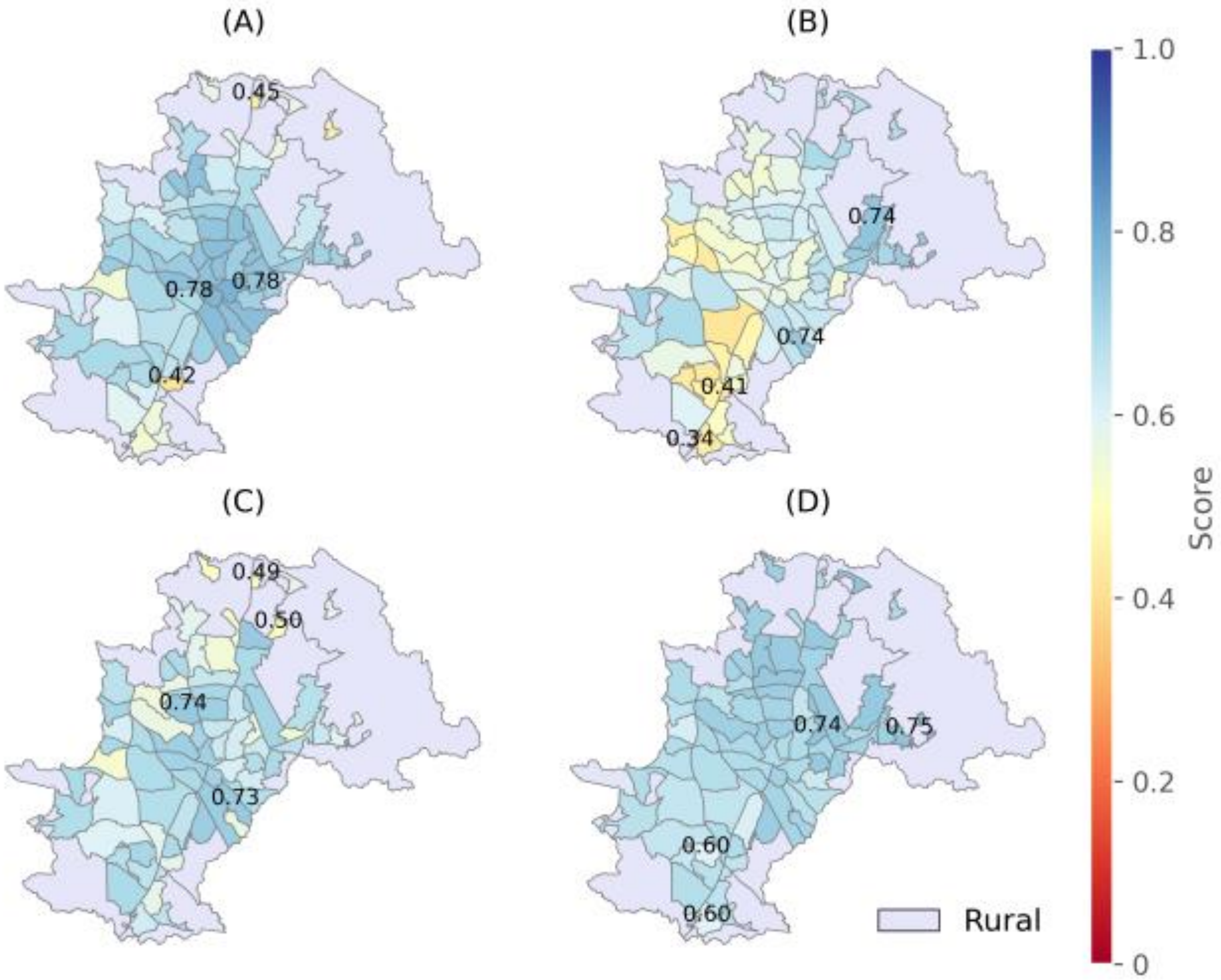
GOVERNANCE
D1.1 - Communication and access
D1.2 - Public participation
D1.3 - Equality and non-discrimination
D1.4 - Infrastructure investment
D1.5 - Water self-sufficiency
D1.6 - Regulation and institutional framework

SOCIAL ASPECTS
D2.1 - Literacy
D2.2 - Population density
D2.3 - Inequality coefficient
D2.4 - Income
D2.5 - Informal dwellings
D2.6 - Gender equality

ECONOMIC DEVELOPMENT
D3.1 - Per capita GDP
D3.2 - Water productivity

Mean score
1.0
0.8
0.6
0.4
0.2
A:City
A:Region
A:Sector
B:City
B:Region
B:Sector
C:City
C:Region
C:Sector
D:City
D:Region
D:Sector
Dimension: Scale
Population
1M
100k
50k
20k
1k

Spatial distribution of Water Security



Aggregated results for Campinas:

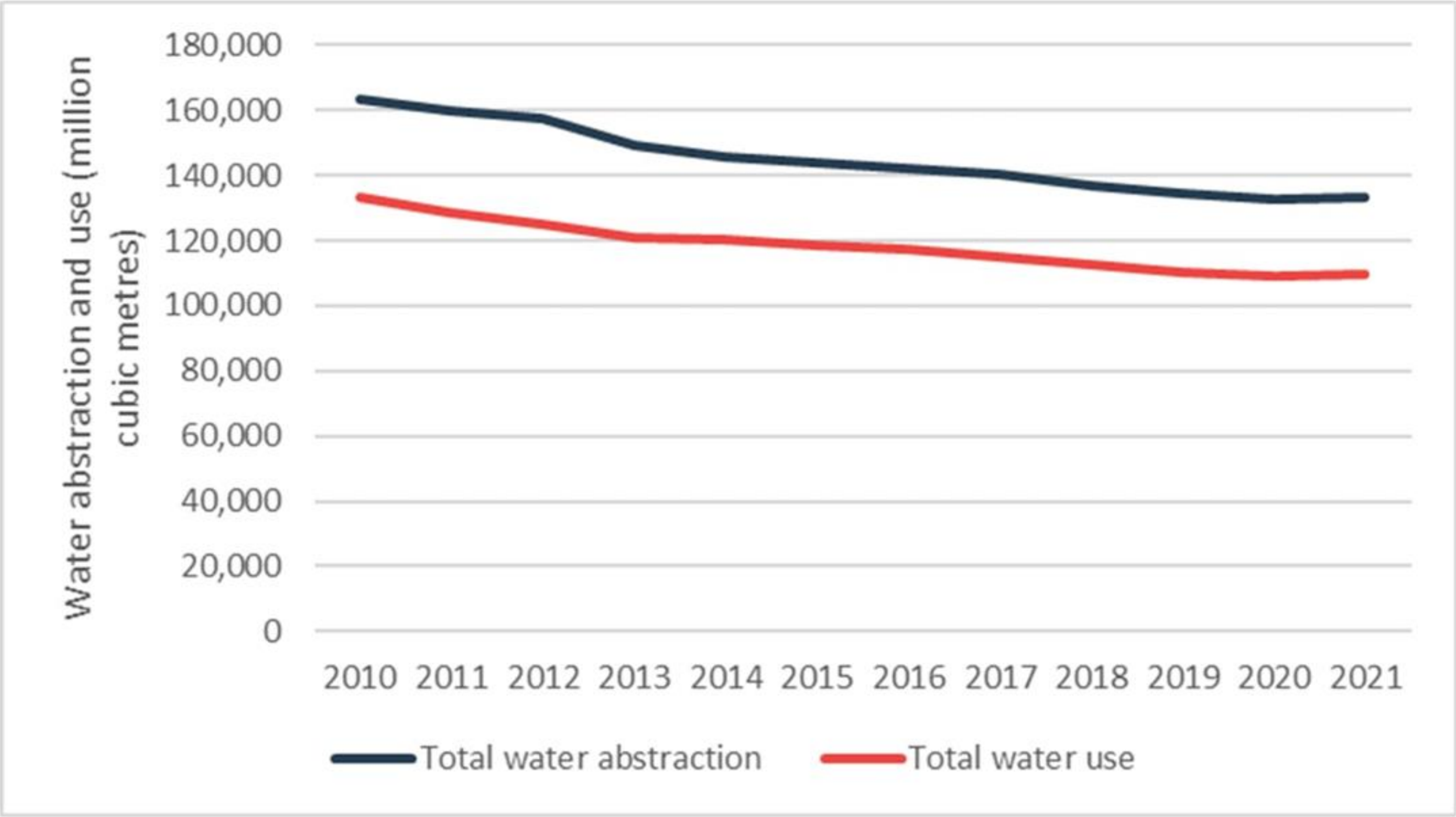
(A): Drinking water and human well-being

(B): Ecosystems

(C): Water-related hazards and climate change

(D): Economic and social development.

Water consumption and abstraction EU



Considering growth of population and GDP:

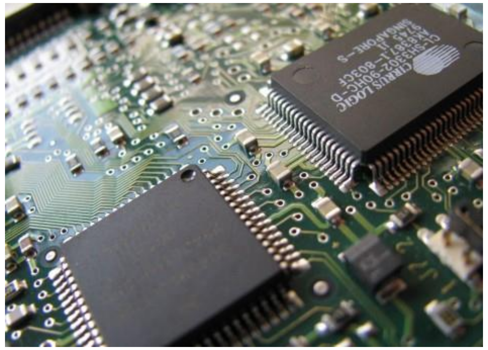
- Water efficiency improved
- Economic growth decoupled from water abstraction

Gross Value Added (EU-27) grew by 25%

Yet increasing pressure on Water Scarcity

Water Europe/WSP 2024, Socio-economic study on the value of the EU investing in water, https://watereurope.eu/wp-content/uploads/2024/10/Water-Europe-Socio-Economic-Study-1.pdf

Strategic sectors



Semiconductors
- Driver for digital transformation
- High water demand
- Use of hazardous chemicals, including PFAS

Data management/Data centres
- High cooling water demand

Renewable energy technologies
- Hydrogen electrolysis
- Supply chains materials
- Potential 30% increase in water demand energy sector

Sustainable food production
- Crop yields
- Pollution (nutrients, pestides pharmaceuticals)

Water and energy demand AI

Creating a 100-word email with the assistance of an AI chatbot powered by ChatGPT-4.

Scenario	Water demand	Energy demand
Once	0.52 L	0.14 kWh
Once per week for a year	27 L	7.5 kWh
Once weekly for 1 out of 10 employees	220,000 L Drinking water for 1400 persons per day	22,500 MWh Electricity consumption of 6,800 UK households

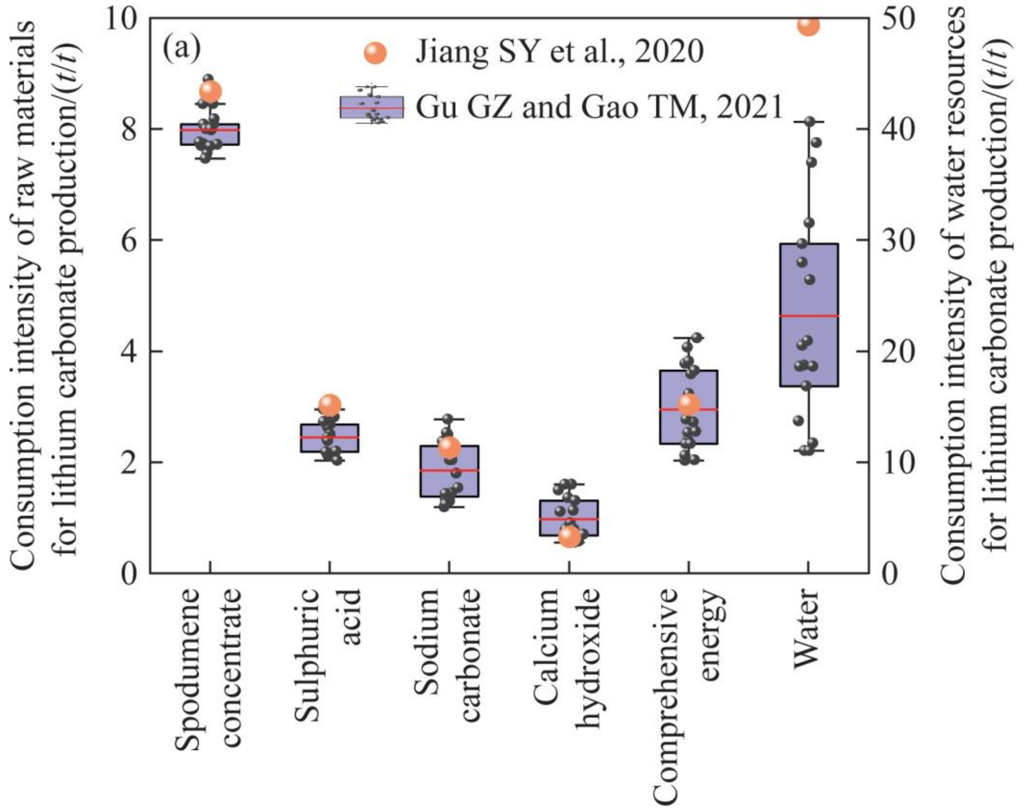
Data:

- The Washington Post/University of California, 2024
  https://www.washingtonpost.com/technology/2024/09/18/energy-ai-use-electricity-water-data-centers/
- Payrolled employees: 30 million in UK, ONS, 2024
  https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/earningsandemploymentfrompayasyouearnrealtimeinformationuk/latest

Materials and supply chains

- Lithium
- Cobalt
- Copper
- Rare earths

- Average 24 tons of water to produce 1 ton Li carbonate using sulphuric acid process



Tian-ming Gao, Na Fan, Wu Chen, Tao Dai (2023), Lithium extraction from hard rock lithium ores (spodumene, lepidolite, zinnwaldite, petalite): Technology, resources, environment and cost, China Geology, https://doi.org/10.31035/cg2022088.

Green Hydrogen

- Water treatment – Electrolysis – storage – fuel cell – overall efficiency
- 1 kWh electricity produced from hydrogen uses 500-1000 L water
- What to do with the O_2? Here are opportunities!

Example UK:

Total energy demand UK in 2023 (industry, transport, domestic, services): 125 million tons oil equivalent [1)]

1 MTOE = 11630 kWh

If 30% is based on green H_2, this would use **600-1200 MLD water**

Current water supply UK 15300 MLD [2)]

1) Energy Consumption in the UK 2024, Department for Energy Security & Net Zero
2) Water supply | Water UK , 2025.

What is water resilience?

Ability of water and wastewater utilities to withstand and quickly recover from natural and human-made disasters.

USEPA: Basics of Water Resilience | US EPA

Creating security and crisis preparedness, strengthening business and competitiveness, protect health, and food production.

- Restoring and protecting the water cycle
- Building a water-smart economy
- Secure clean and affordable water and sanitation

European Union: EUR-Lex - 52025DC0280 - EN - EUR-Lex

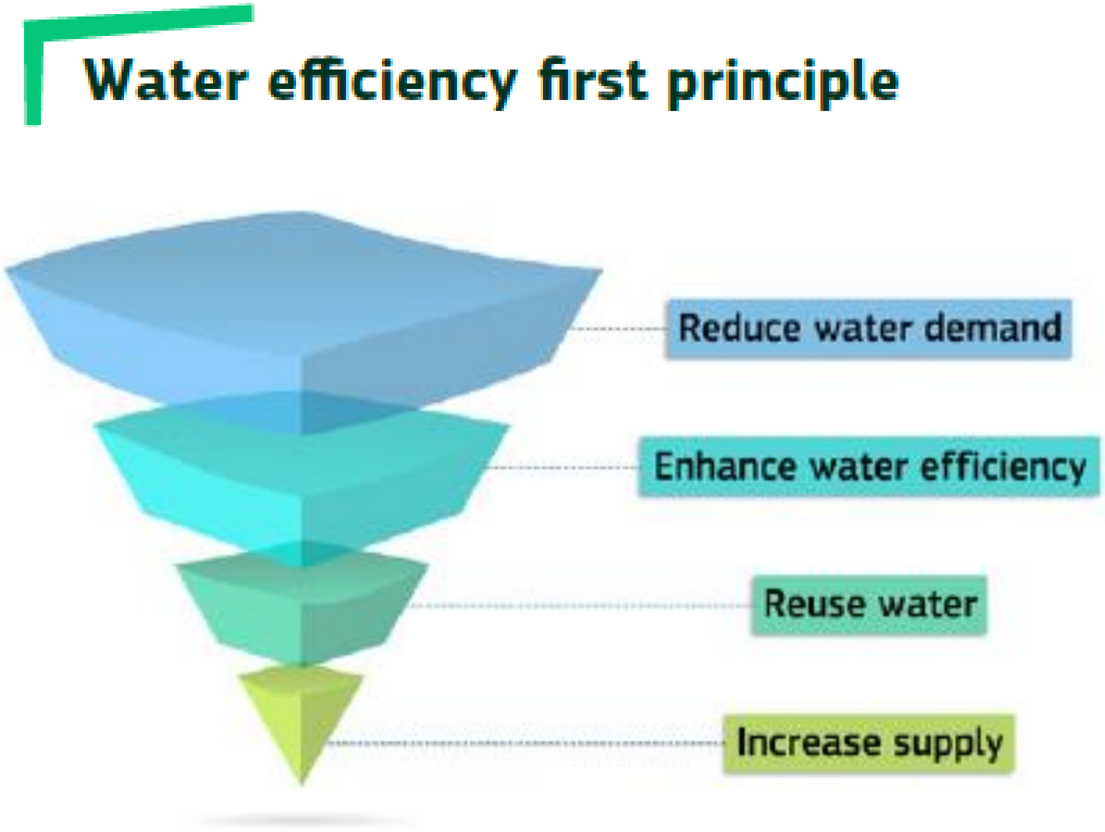
Water resilience strategy EU

Unique holistic approach based on first principle

Competitiveness and independence

Call for action / actions identified

Investment fund

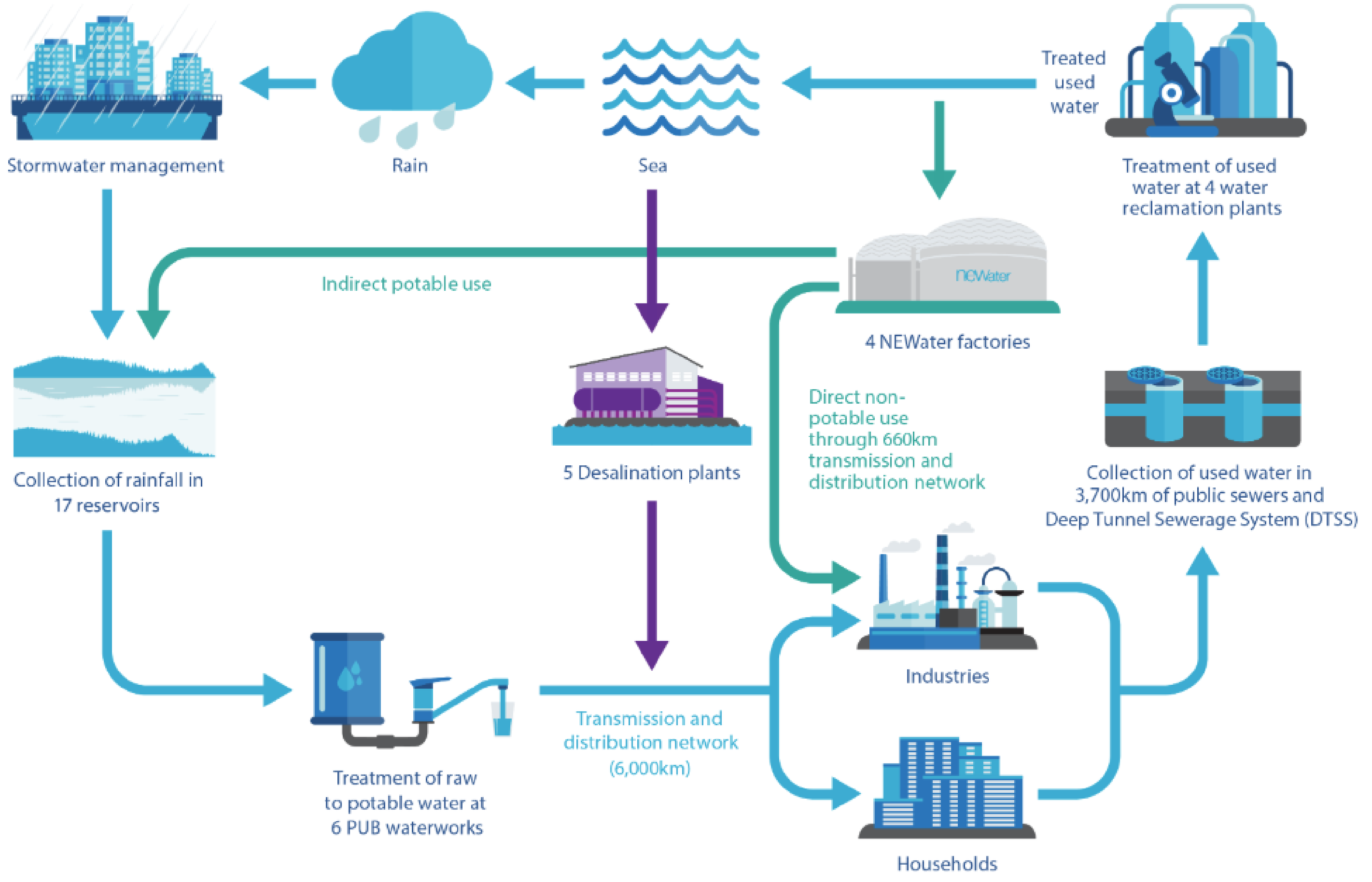


Singapore's Water Loop

As demand for water continues to increase as our population and economy grows, we take a holistic approach to water management by creating a robust integrated system that allows us to continuously:

- Collect every drop of water
- Reuse water endlessly
- Desalinate seawater

Click **here** to learn more about our water loop.

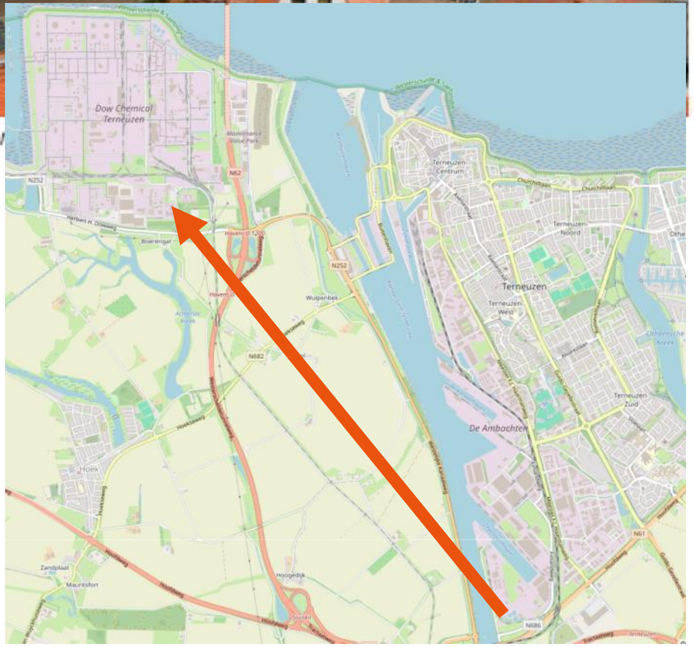


PUB SINGAPORE'S NATIONAL WATER AGENCY

Industrial water reuse

- Freshwater scarcity in the area; secure local water supply
- Turning effluent into high-value industrial application
- Water used three times:
  Drinking water → manufacturing → cooling towers
- 96% lower energy demand compared to desalination
- Lower maintenance costs, 50% reduction OPEX
- 2.5 million m^3/y wastewater reused

The city of Terneuzen



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NextGen's Main Results
– and Key Messages

nextGen
Circular Water Solutions

NextGen has challenged embedded thinking and practices in the water sector by embracing circular economy principles and technological innovation

NextGen went beyond current approaches that target incremental improvements in water, resource, and energy efficiency. It provided the whole value chain with a Circular Economy approach demonstrated at large scale.

10 demo cases
across 8 countries

Reducing water, energy and material consumption.

Prevention of pollution to water ecosystems

Providing added value of recovered resources to be used in other sectors

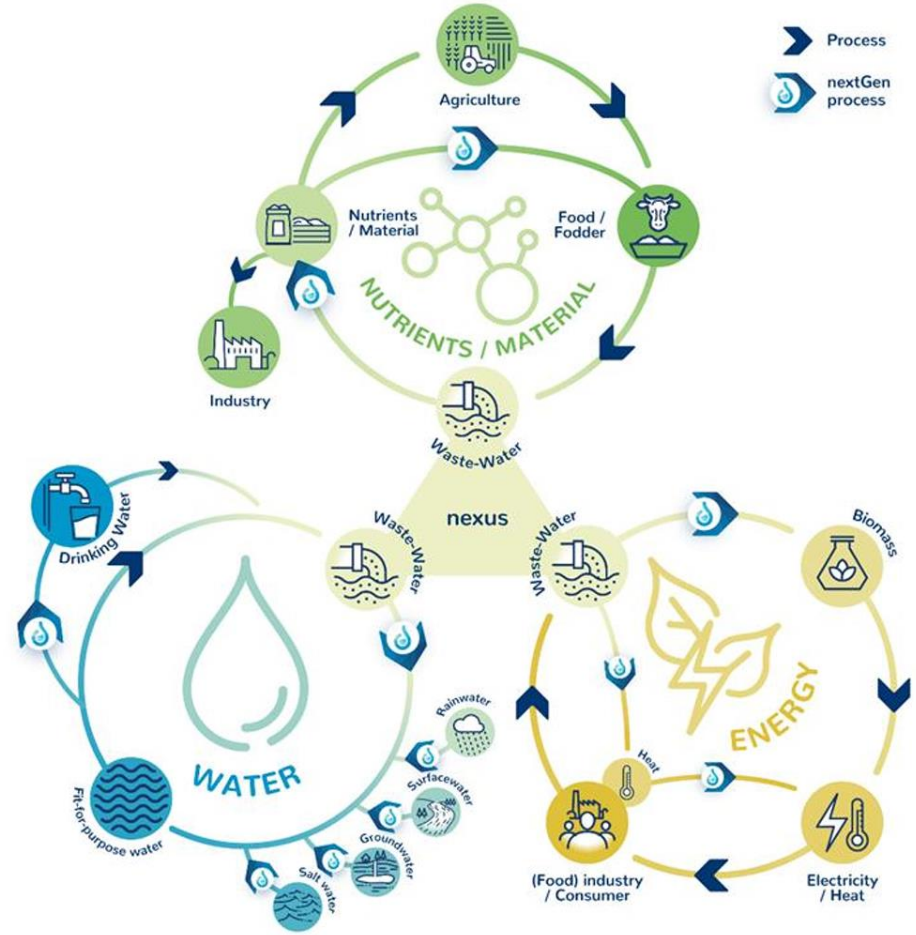
NextGen's
10

demo cases provided evidence-based knowledge on the conditions for the transition to a circular economy in the water sector

Framework conditions:
1. Sustainable circular water technologies at system level
2. Circular value chains and business models
3. Societal acceptability and stakeholders engagement
4. Supportive policy and regulations

@NextGenWaterEU
@NextGenWaterEU
nextgenwater.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541



NextGen's Main Results
– and Key Messages

nextGen
Circular Water Solutions

NextGen created a platform that supports the market uptake of circular water solutions.

NextGen has launched the Water Europe online match-making marketplace for products and services, that showcases circular water technologies, environmental and economic assessment tools, and best practices to implement circular economy solutions.

Policy recommendations
From NextGen

Include the water sector in energy efficiency and renewable energy.

Adopt the water fit-for-purpose principle.

Create simpler and less costly routes to market for recovered resources.

Other Policy recommendations:
- Introduce reporting requirements for recovered products.
- Extensive application of digital solutions to increase reporting
- Support financial incentives targeted to circular water technologies.
- Improve alignment between directives and incentivise circularity.

@NextGenWaterEU
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nextgenwater.eu/

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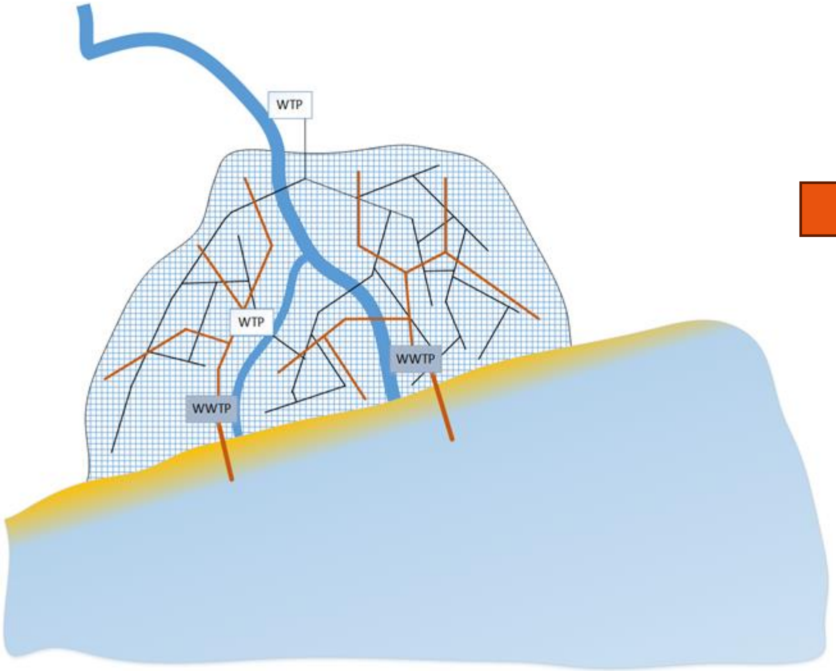
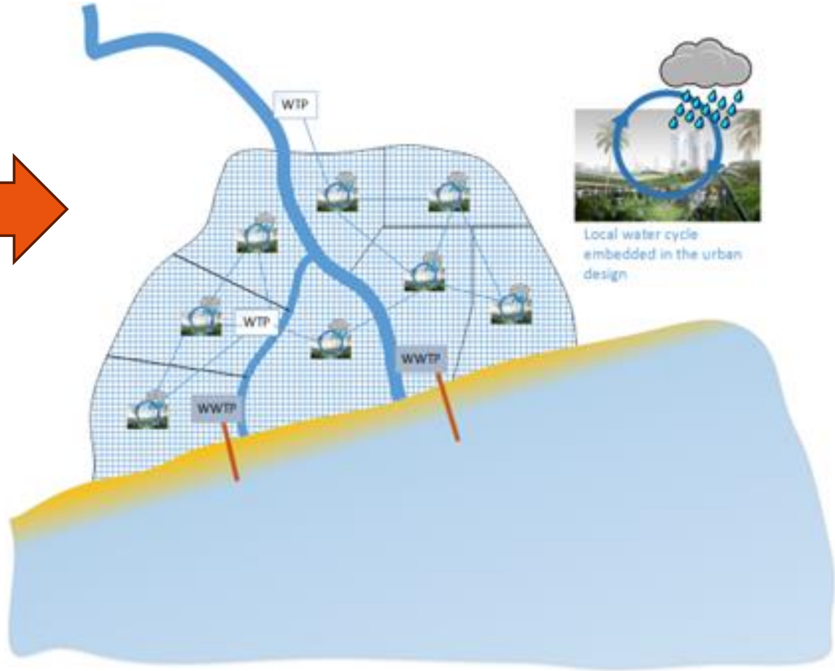




- Water resources mostly outside city in the peri-urban areas
- Water resources competing with agriculture
- Clean water transport over long distances
- Mixed wastewater and storm water collection and centralised wastewater treatment

Energy intensive, High capital, High maintenance cost

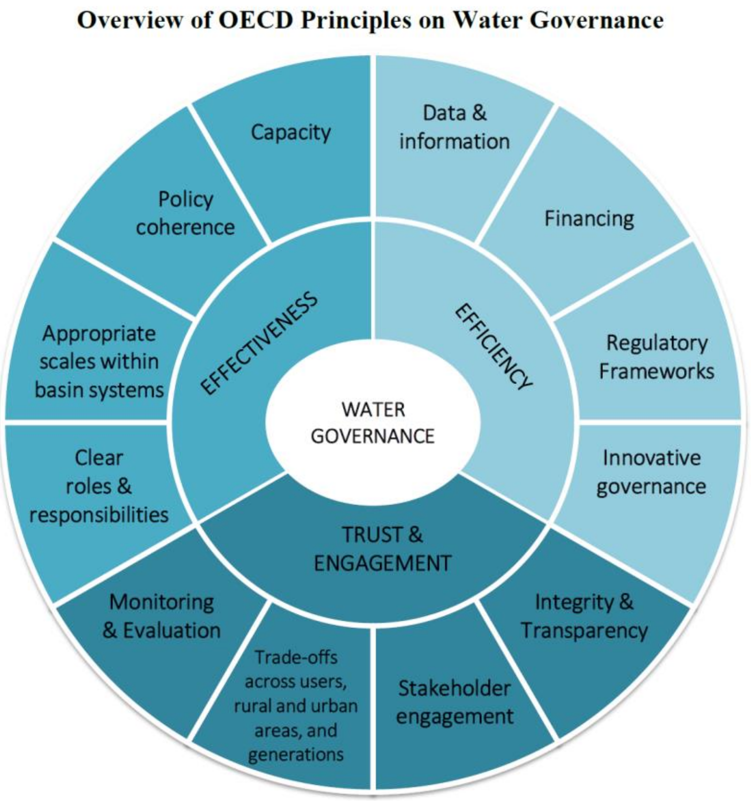
Global investment needs are estimated for water supply and sanitation are
USD 6.7 trillion by 2030 to USD 22.6 trillion by 2050 (OECD)

- Further diversification of water sources
- Local closure of the water cycle, embedded in the urban design
- Using 'grey' and 'green' infrastructure
- Interconnected network to create resilience
- Reduced pumping distances
- Existing infrastructure can partly be re-used
- Multi-disciplinary and multi-stakeholder approaches

OECD Water Governance Principles

Three dimensions:

1. Effectiveness: Have and implement clear sustainable water policy goals at all levels of government
2. Efficiency: Maximise the benefits of sustainable water management and welfare for the least cost to society
3. Trust and engagement: Building public confidence and ensuring inclusiveness of stakeholders through democratic legitimacy and fairness for society at large



Advancing investment in water resilience

Addressing investment needs

- **Comprehensive, multi-stakeholder approach**
- **Aligning regulatory frameworks**
- Targeted financial instruments
- Funding technological innovation
- Cross-sectoral collaboration

Public-Private collaboration

- **Take away regulatory uncertainty**
- **De-risking mechanisms**
- Standard investment frameworks
- Predictable returns
- Robust performance metrics
- Cross-border investments

Unlocking financing for new-technology upscaling

- Dedicated R&D
- Innovation finance
- Integrated market mechanisms
- Demand-side regulatory incentives/obligations
- Prioritise public infrastructure as early adopters

Water Europe White Paper (2025), Advancing investment in Water Resilience: A strategic pathway towards a Water-Smart Society and Economy
https://watereurope.eu/wp-content/uploads/2025/06/Advancing-investment-in-water-resilience_online.pdf

In conclusion

- Value of water is infinite – we cannot live, work, create without it
- Water Security and Water Resilience are, or should be, key strategic objectives on all levels: global, national, regional
- It is THE foundation for society, economic growth, and needs close public-private collaboration across sectors and stakeholders
- Governance and finance are key enablers and require increasing attention for trust, confidence and de-risking
- We need comprehensive and robust performance indicators for monitoring progress
- Long-term goals with policy-politics decoupling