Socio-economic scenarios incorporation into hydrological modeling

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CHR-Spring seminar
„Socio-economic influences on thje discharge of the River Rhine“
Bregenz, 27 March 2014

Center for Environmental Systems Research

Outline

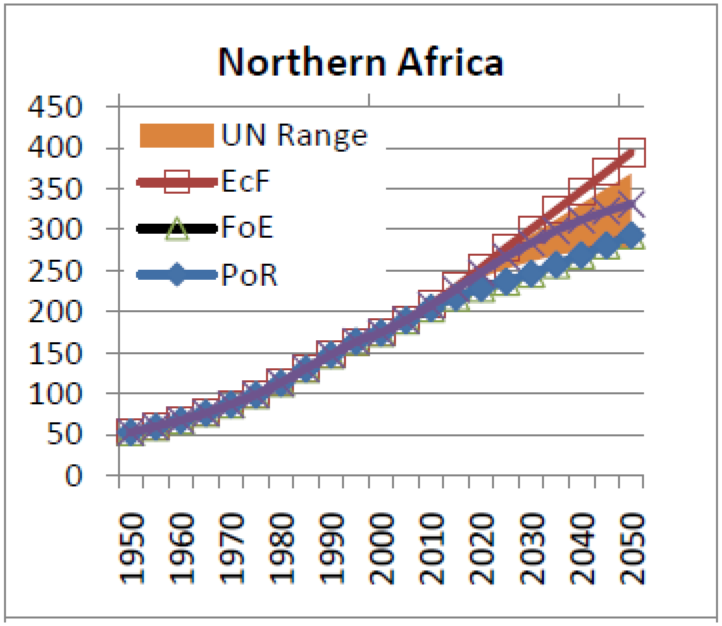
- What are socio-economic scenarios?
- Why do we need socio-economic scenarios?
- What is the role of socio-economic scenarios in hydrological modeling?

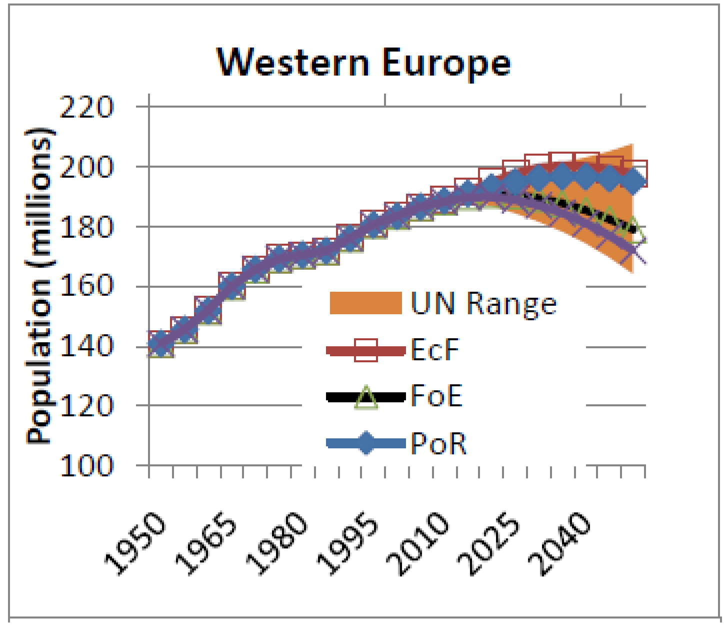
What are socio-economic scenarios?

The global social and economic situation in the future may be very different from the world in which we currently live.

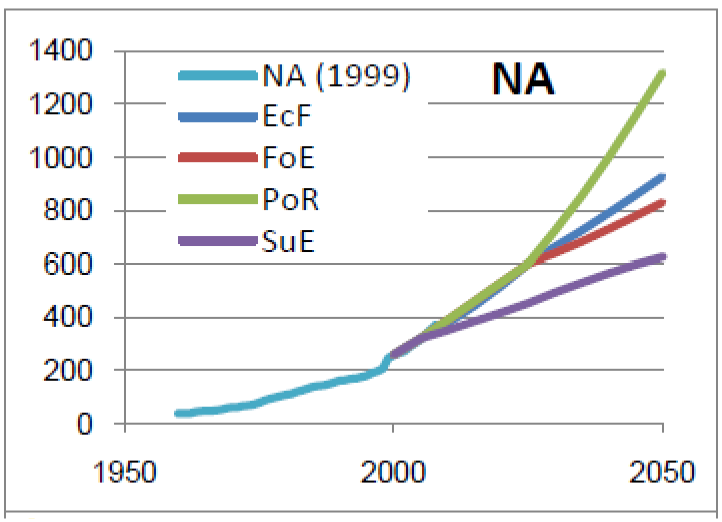
- Socio-economic scenarios are plausible (somethimes simplified) representations of possible futures of socio-economic parameters.
- Socio-economic scenarios are important tool for exploring the long-term consequences of anthropogenic climate change and available response options.

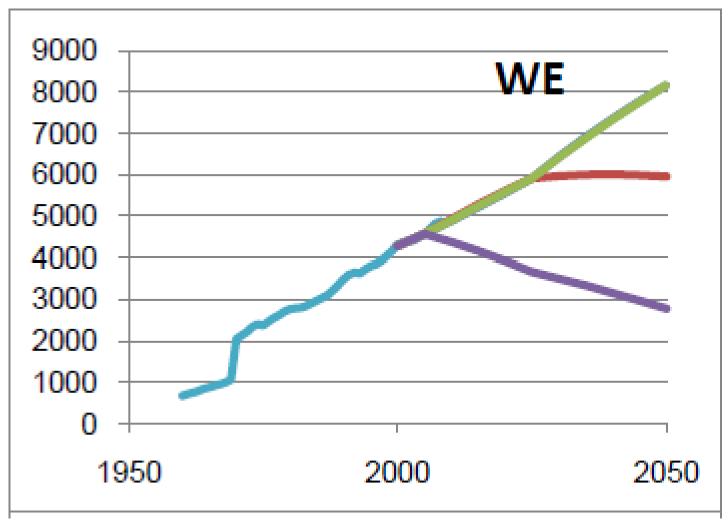
Population (SCENES)





GDP in const. 2000 USD (SCENES)





Why do we need socio-economic scenarios?

- Socio-economic scenarios underpin impact and adaptation studies.

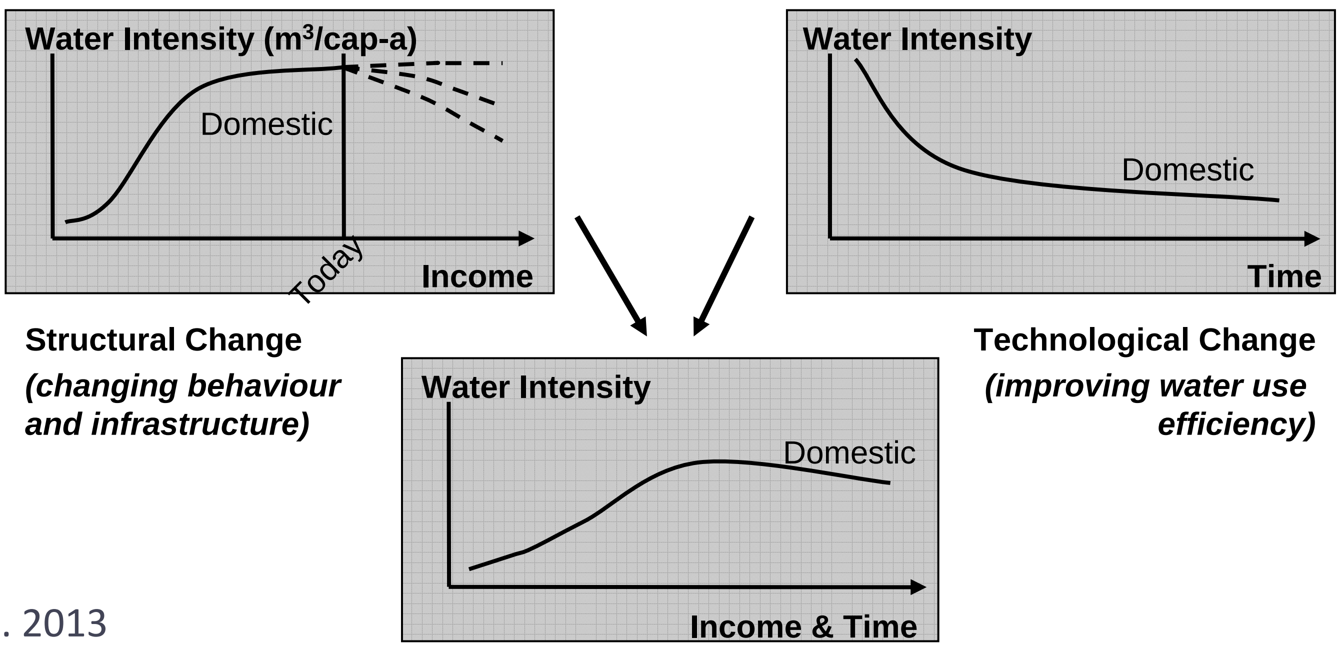
- Socio-economic scenarios project the major driving factors of change.
  - Change in emissions
  - Change in energy consumption
  - Change in land use
  - **Change in water abstraction and consumption**
  - …

1. **How are (inter)national socio-economic developments translated into developments in water use per sector?**

- The large-scale perspective:

Domestic water withdrawals

Water use intensity	X	Technological change	X	Number of people	=	Water withdrawals
[m³/cap-a]						[M m³/a]



Structural Change
(changing behaviour and infrastructure)

Technological Change
(improving water use efficiency)

Structural & Technological Change

Flörke et al. 2013

Manufacturing water withdrawals

Water use intensity [m³/GVA] X Technological change X National manufacturing output [GVA] = Water withdrawals [M m³/a]

Water use intensity: Decreasing due to structural change

= f (GDP)

Technological change: Decreasing due to improvements in efficiency

= f (time)

National manufacturing output: Share of GDP

GVA = Gross Value Added (const. USD)

Flörke et al. 2013

Thermoelectric water withdrawals

Water use intensity [m^3/MWh] X Technological change X National therm. electricity production [MWh/a] = Water withdrawals [M m^3/a]

= f (cooling system, type of fuel)

Decreasing due to improvements in efficiency

= f (time)

Flörke et al. 2013

Irrigation water use

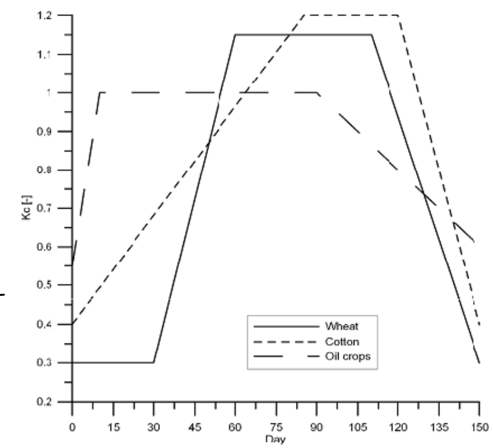
aus der Beek et al. (2011), Schaldach et al. (2012)

climate

Irrigated area

allocation of irrigated crops

Cropping coefficient (Kc)



Crop-specific water requirements for each 5‘ grid cell

Irrigation efficiency

Crop-specific water withdrawals for each 5‘ grid cell

Resolve a problem

- Socio-economic scenarios are not sufficient to estimate sectoral water use
- Additional information is required, e.g. technology, elec. production, etc.
- Not all information can be gathered from stakeholders
  - Expert judgement and assumptions
- Qualitative information needs to be translated into numerical values

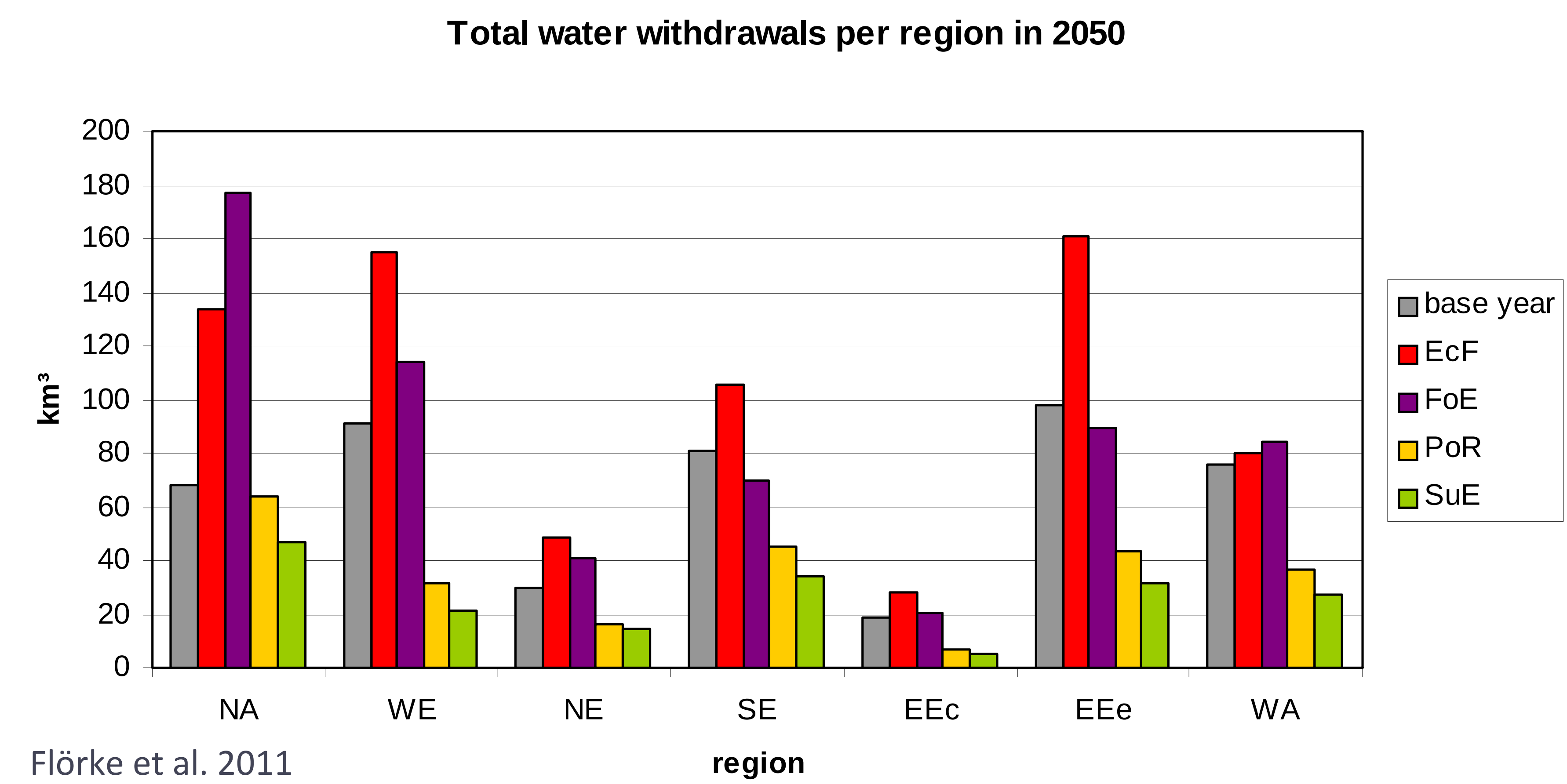
➢ Water-related scenarios

2. How does the sector anticipate on future changes in water availability and requirements from the sector?

- Experiences from the SCENES project

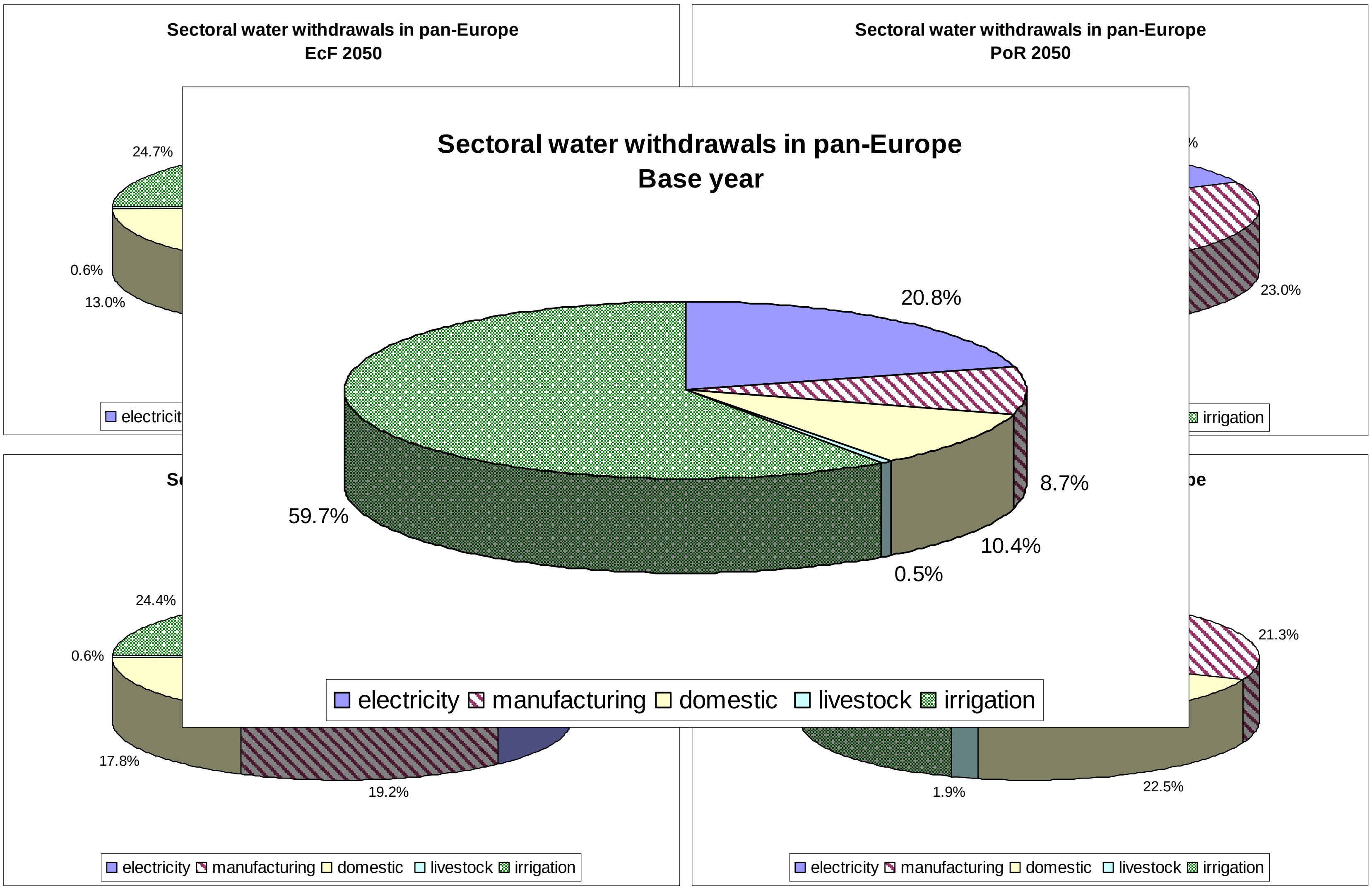
Future water withdrawals

Water uses are expected to increase or decrease
…depending on the region.



Flörke et al. 2011

Sectoral shares

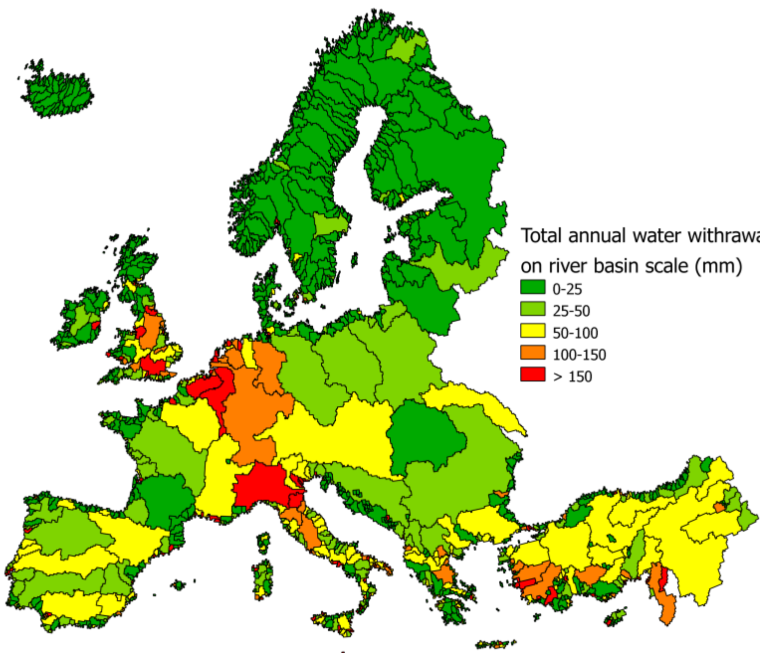


3. On what time horizon does the sector prepare for future changes in water availability?

- 2030 better 2050 to account for climate effects

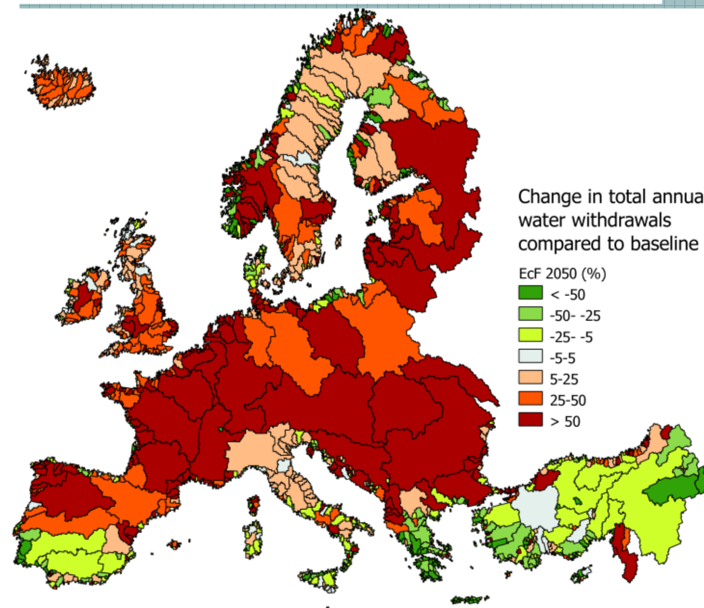
Water withdrawals

Year 2005

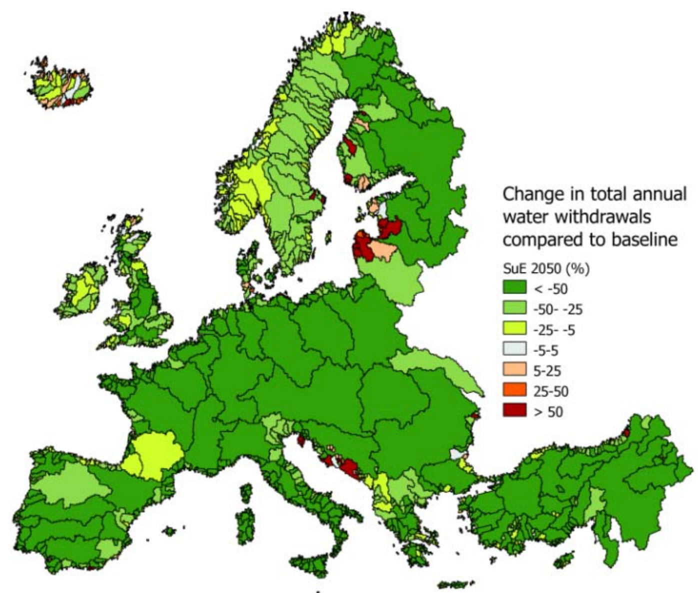


Future?

EcF (2050)



SuE (2050)



Flörke et al. 2011

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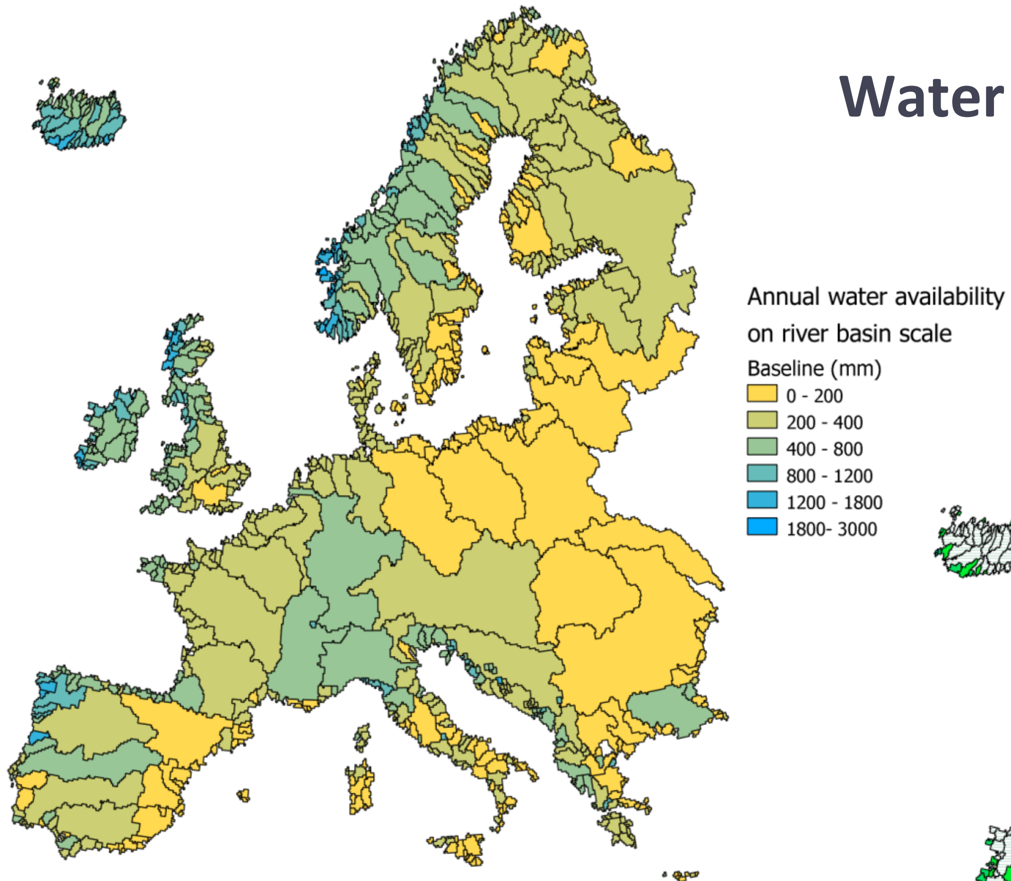
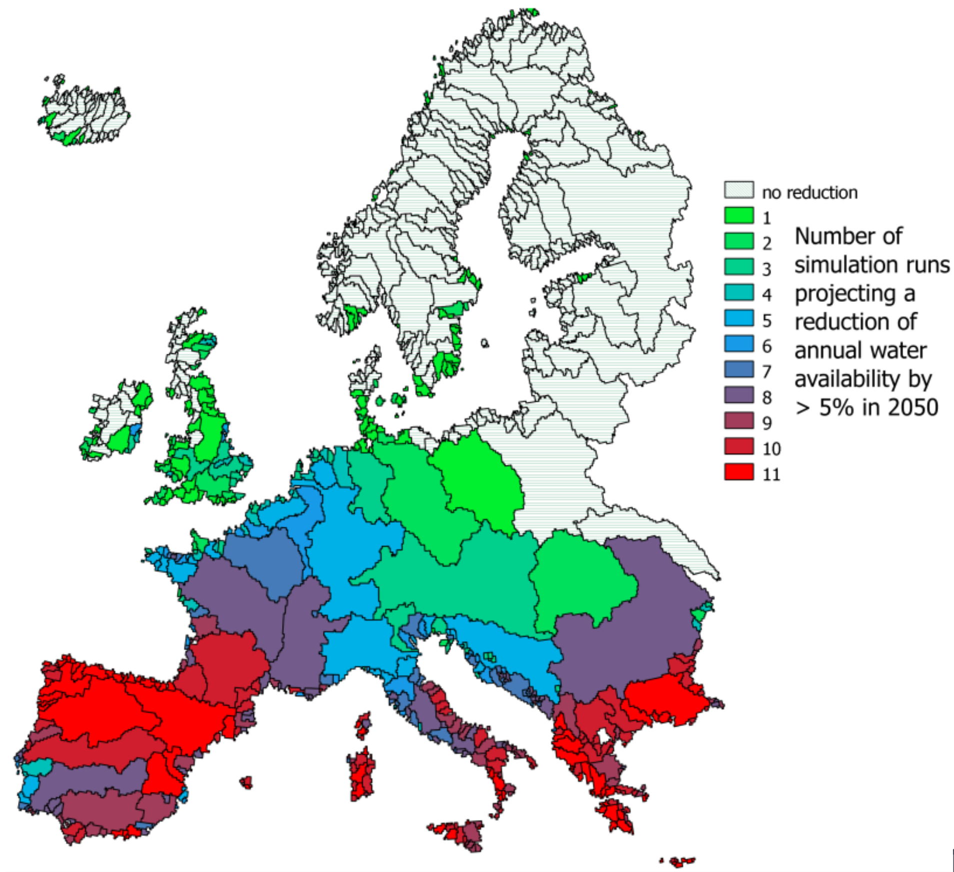
Water availability



Baseline (1961-90)

2050s (2041-2070)
ENSEMBLES, 11 GCM-RCM



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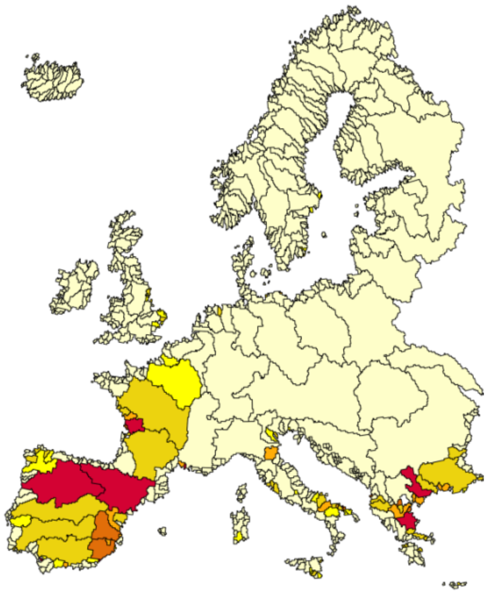
4. Is there a temporal/spatial differentiation in the water use sector?

- Indicator assessment

Water scarcity (sectors)

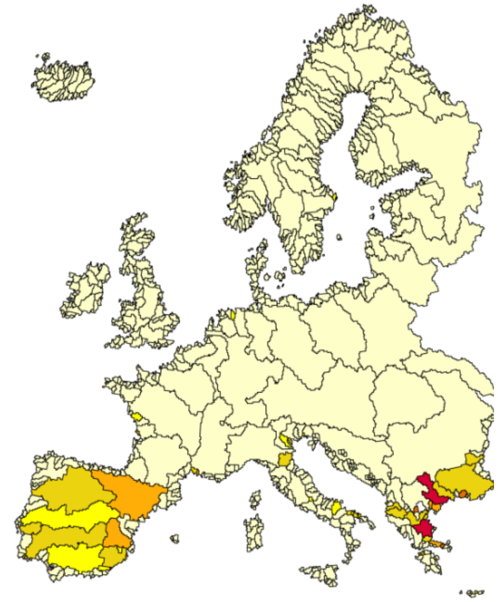
EcF



agriculture

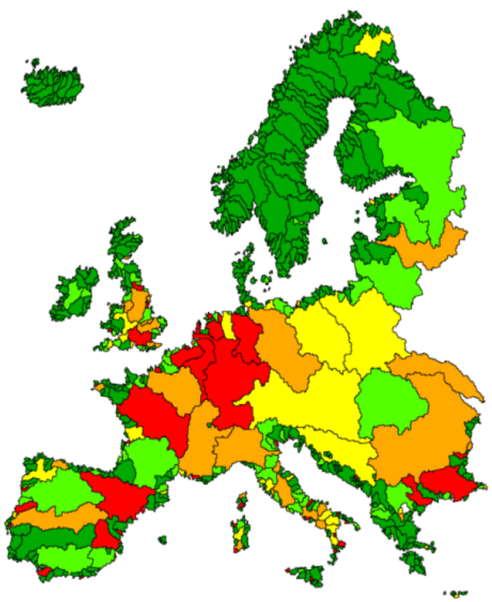
Ratio of irrigation water consumption to water availability

EcF 2050, summer
- < 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1.- 1.5
- 1.5- 2
- > 2



SuE

EcF

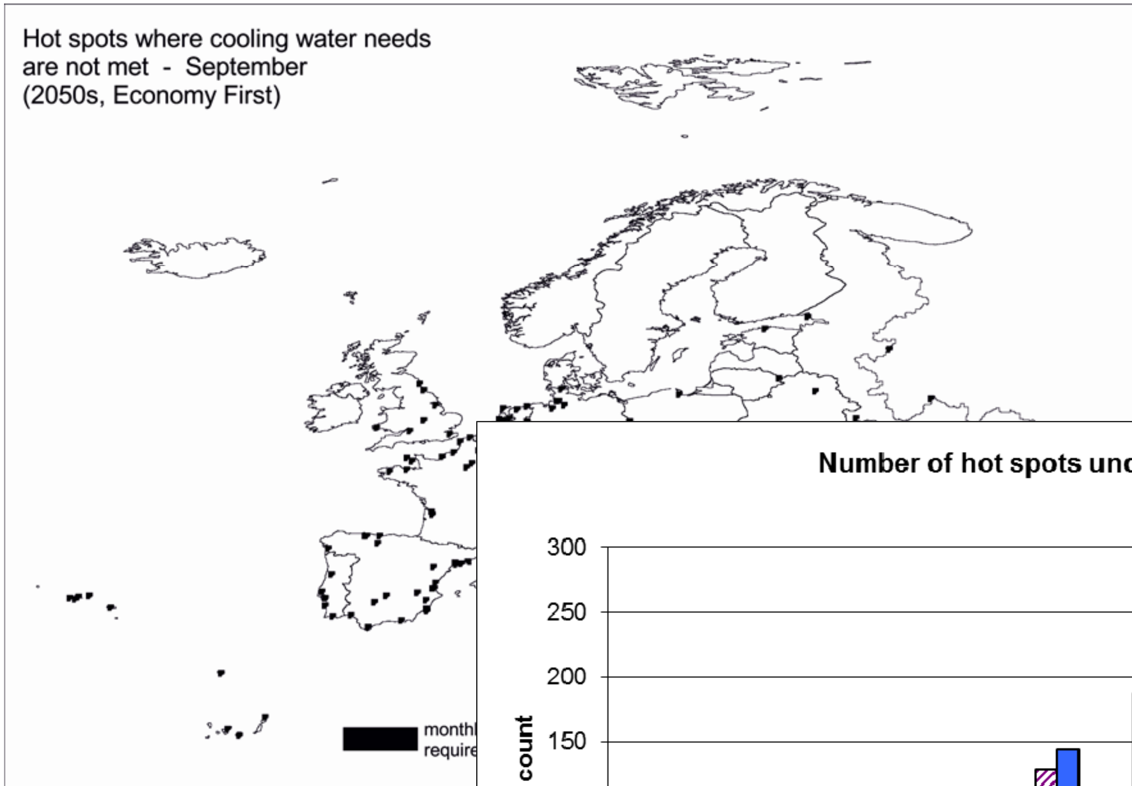


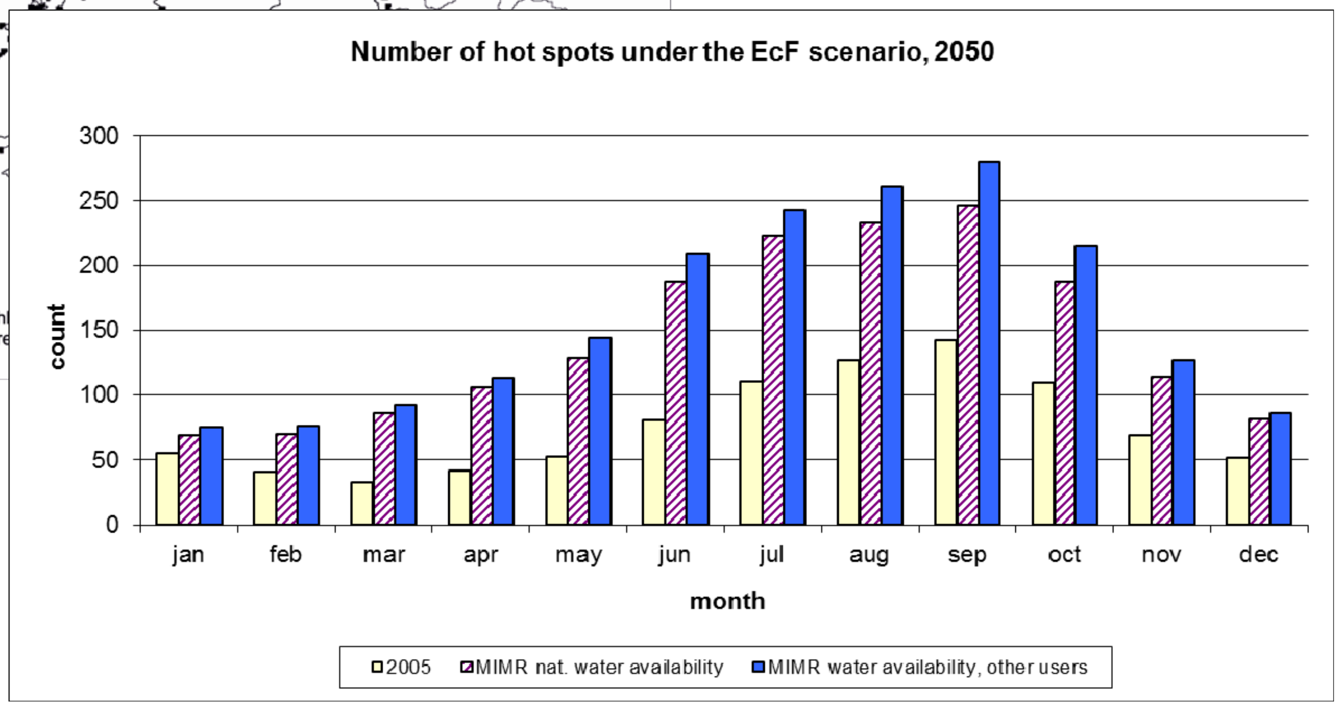
energy

Ratio of cooling water abstractions to Q90 based on ensemble median and EcF for 2050
- < 0.05
- 0.05 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

SuE

cooling water hotspots

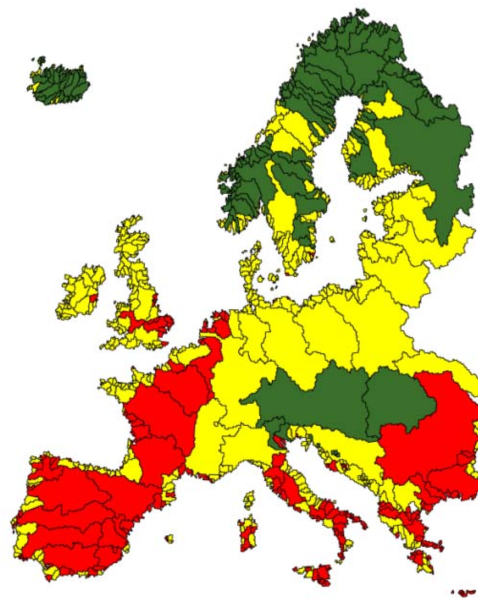




Flörke et al. 2011

Water scarcity (nature)

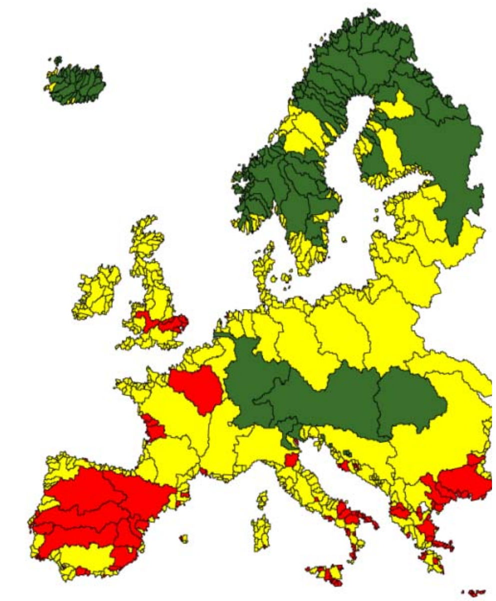
EcF



Minimum flow (Q95)

Maintainance of env-ironmental minimum flows during summer

EcF 2050
- Env. flows depleted
- Env. flows at risk
- Env. flows maintained

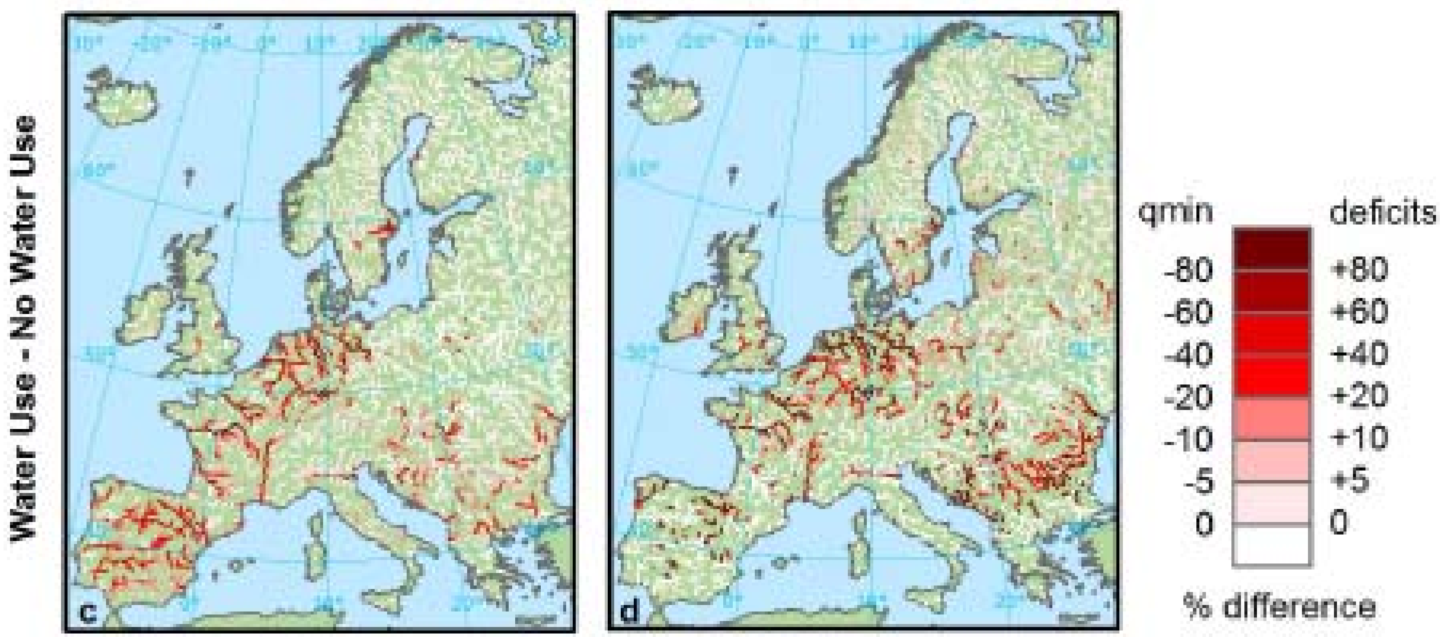


SuE

Env. flows depleted: residual flow equals 0-100% of baseline Q95
Env. flow at risk: residual flow is 2-4 times larger than baseline Q95
Env. flow maintained: residual flow is more than four times larger than baseline Q95

River drought

2080s + EcF scenario



Forzieri et al. 2014

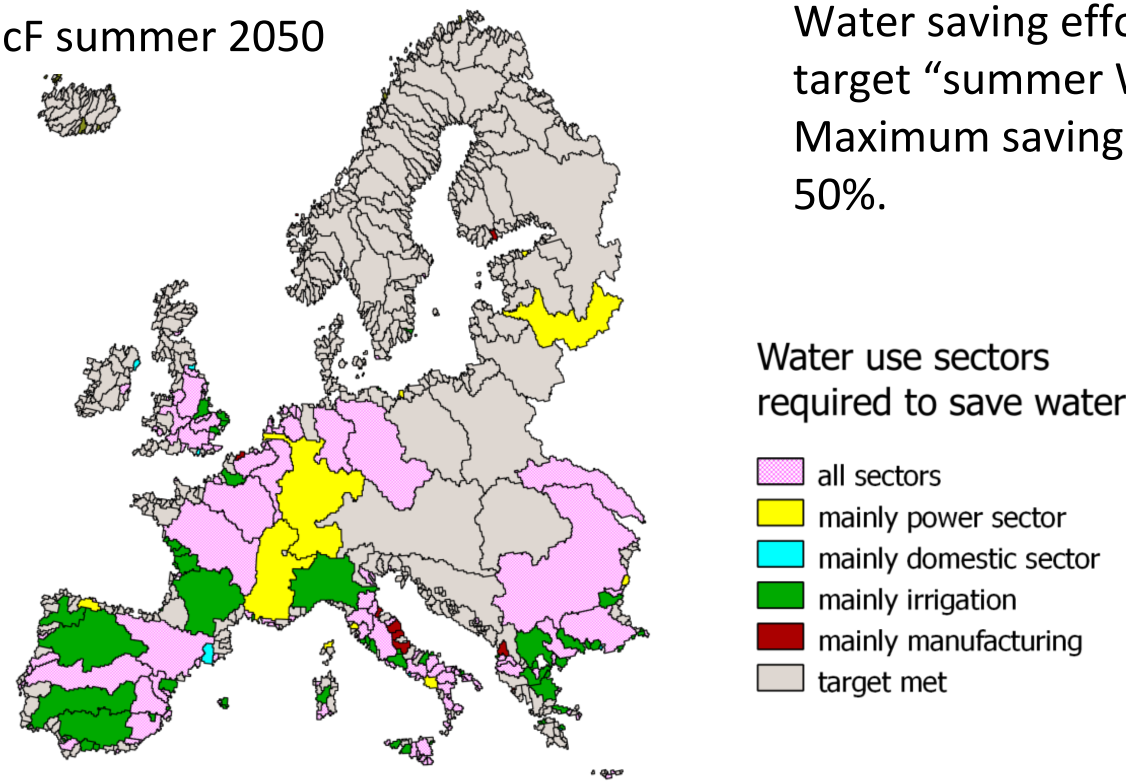
- Intensive water consumption will aggravate streamflow drought (+10-30%)
- Negatively affecting both minimum flows (20yr recurrence) and deficit volumes

Key messages

- Socio-economic scenarios dominate the dynamics of water scarcity
- Decreasing water availability exacerbates water scarcity
- Environmental flows are threatened by climate change impacts and socio-economic developments
- Vulnerability assessments should consider cross-sectoral aspects
- Many of the transboundary river basins are expected to be in the severe water scarcity class in 2050.
- Competition for scarce water resources could be an on-going source of tension between sectors and nations.

Reducing risk to water scarcty

EcF summer 2050



Water saving efforts needed to achieve the target “summer WEI ≤ 0.4”.
Maximum saving per sector is assumed to be 50%.

- Most water saving obligations are related to irrigation and thermoelectric power production.
- An integrated multi-sectoral approach is needed in half of the vulnerable river basins to reduce water stress (EcF).

Flörke et al. 2012

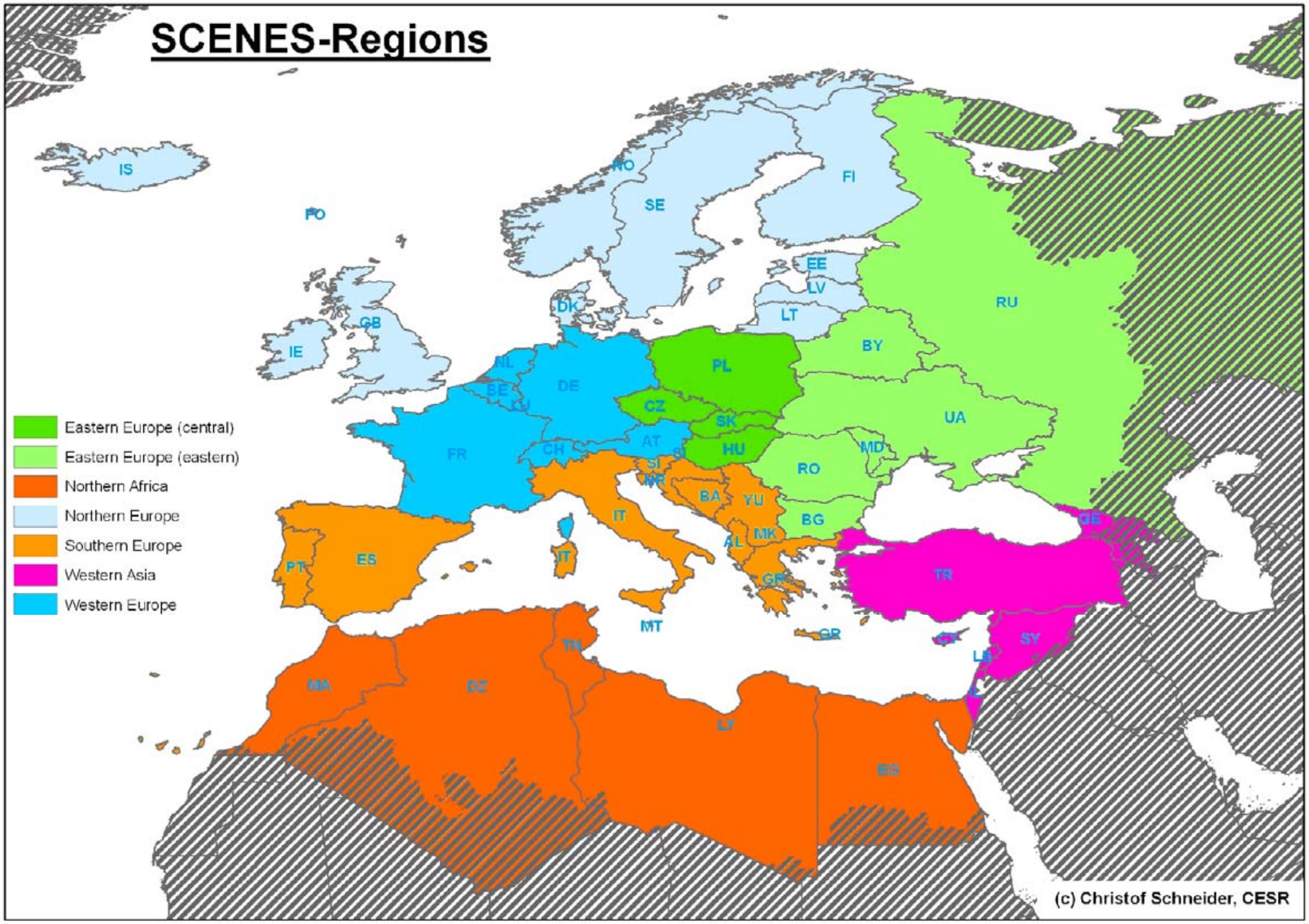
The SCENES project

SCENES – “Water Scenarios for Europe and for Neighbouring States”

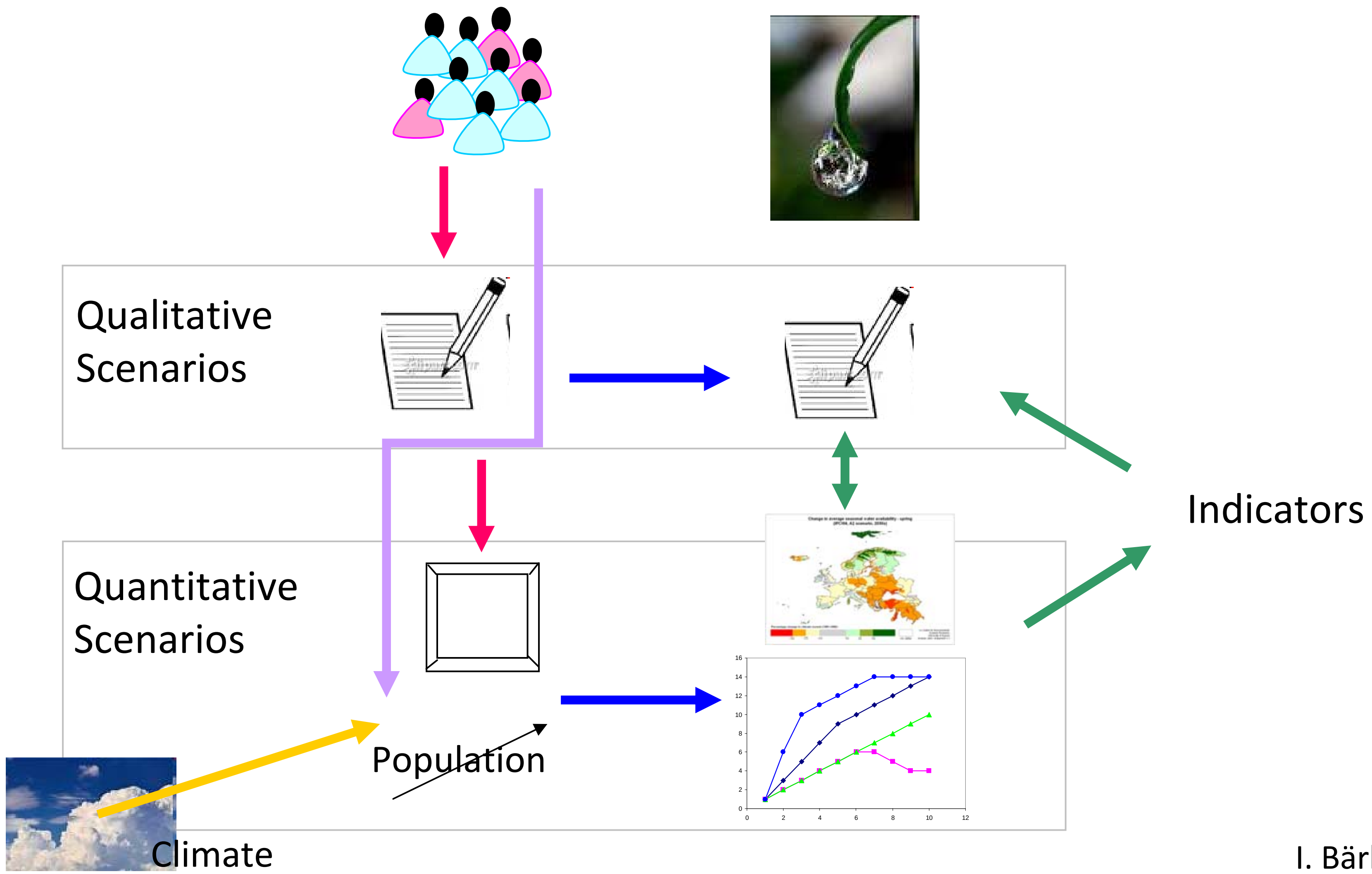
- Two objectives
  - To develop and analyze a set of scenarios of Europe’s freshwater futures up to 2025 and 2050
  - Environmental consequences of key socio-economic and political development as well as climate change

- Development of qualitative and quantitative scenarios
- Stakeholder participation

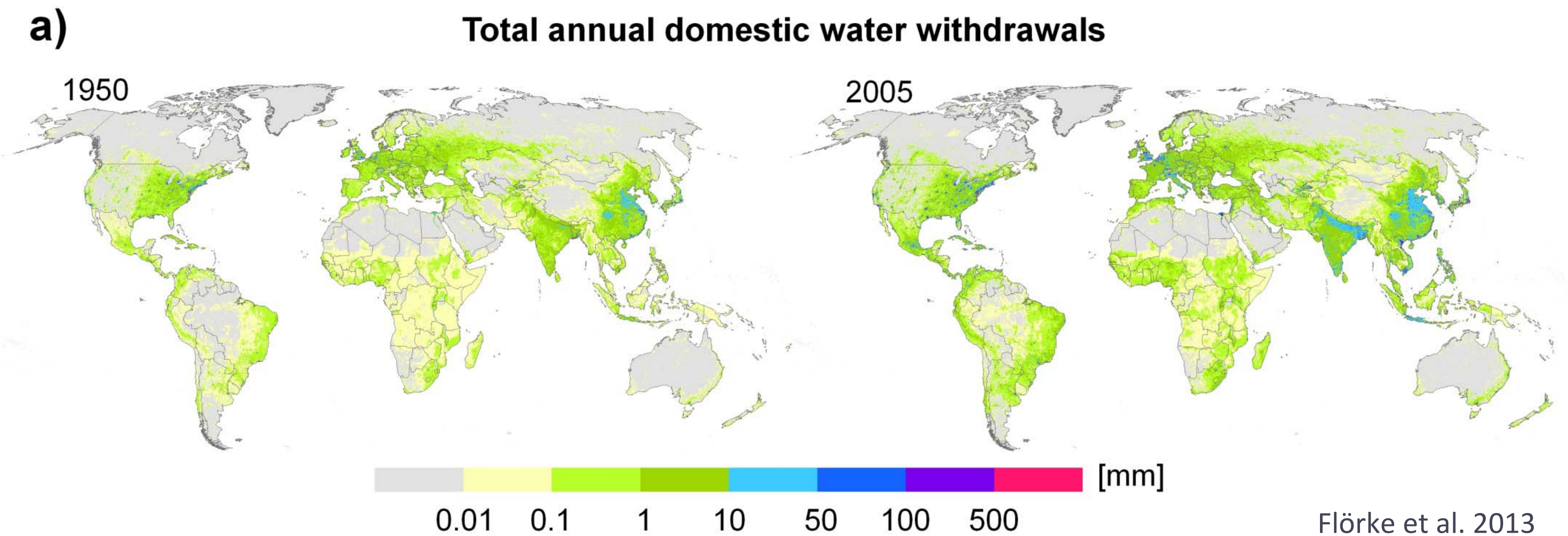
Geographical extension



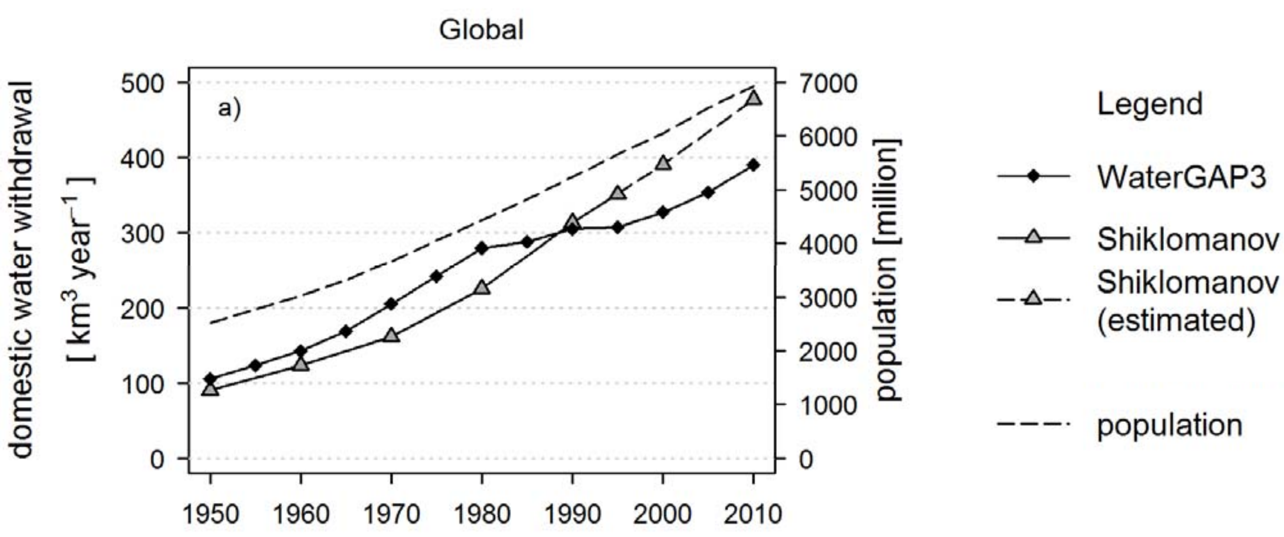
Scenario process

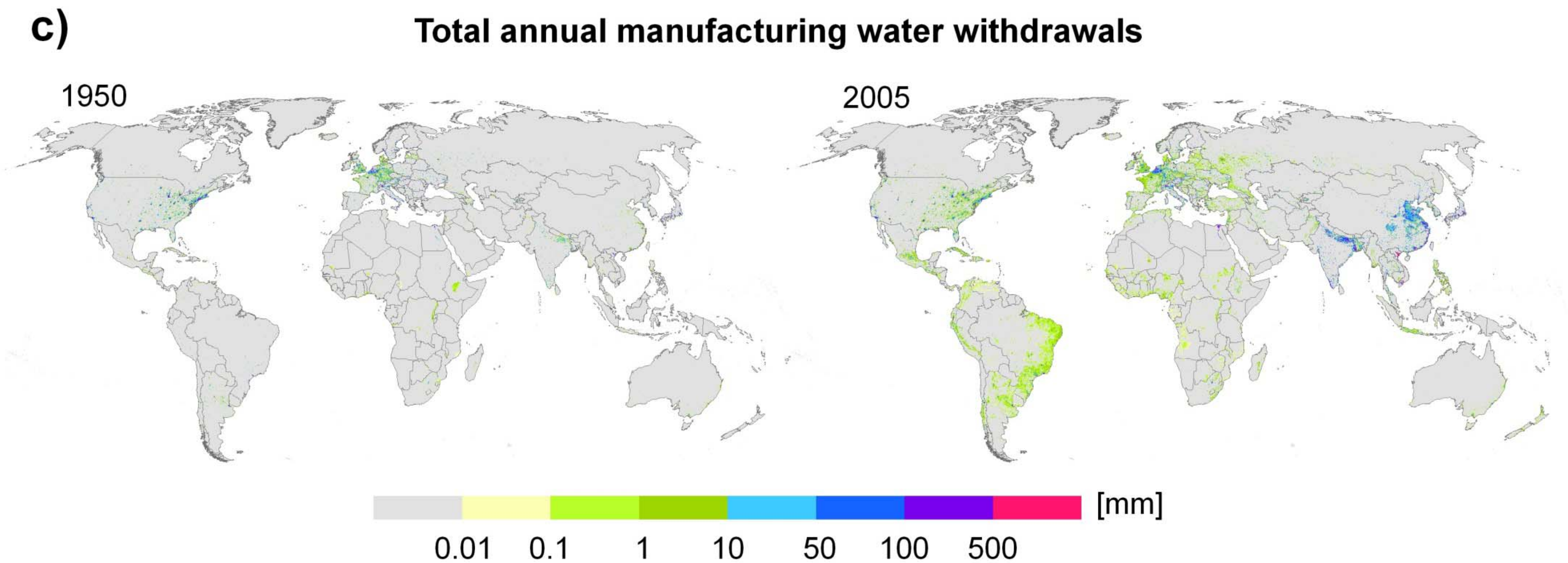


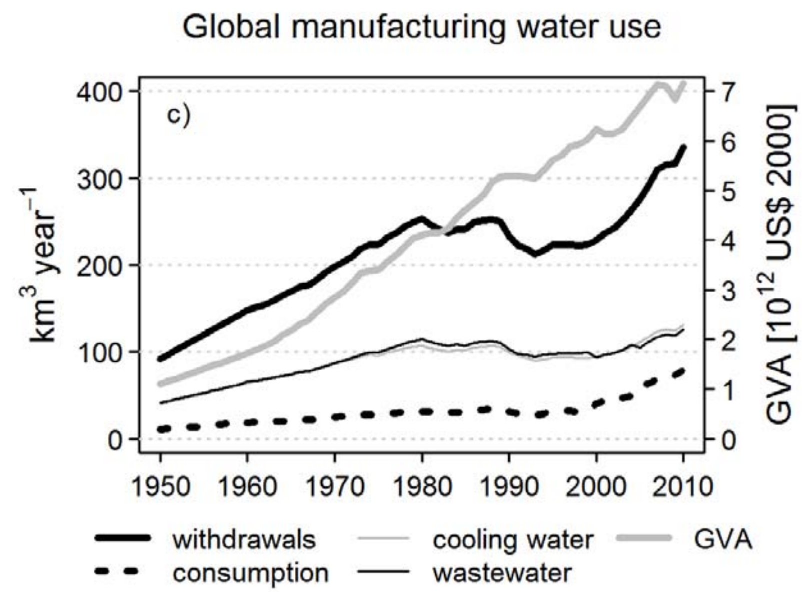
I. Bärlund



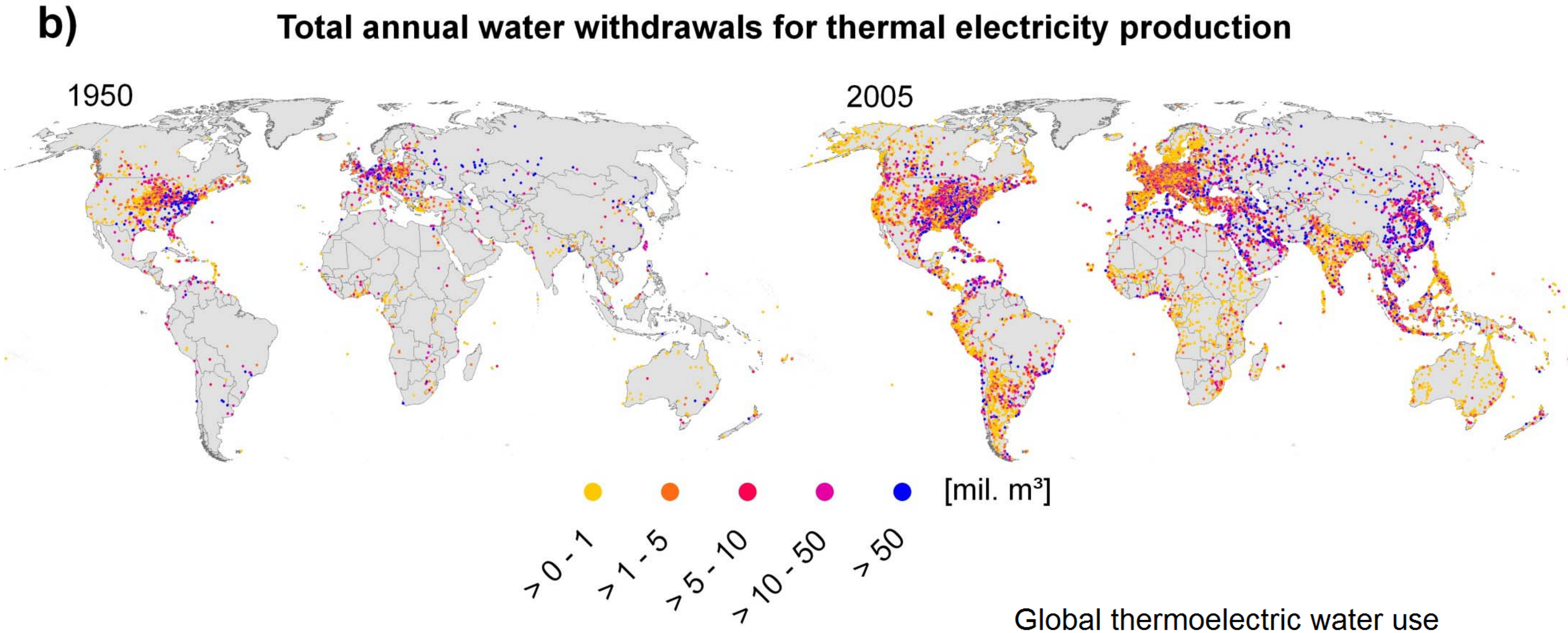
Flörke et al. 2013

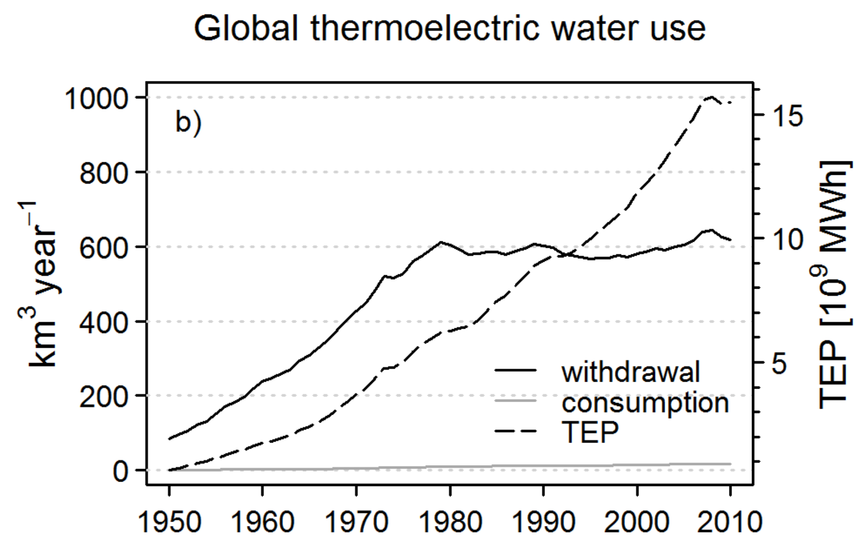






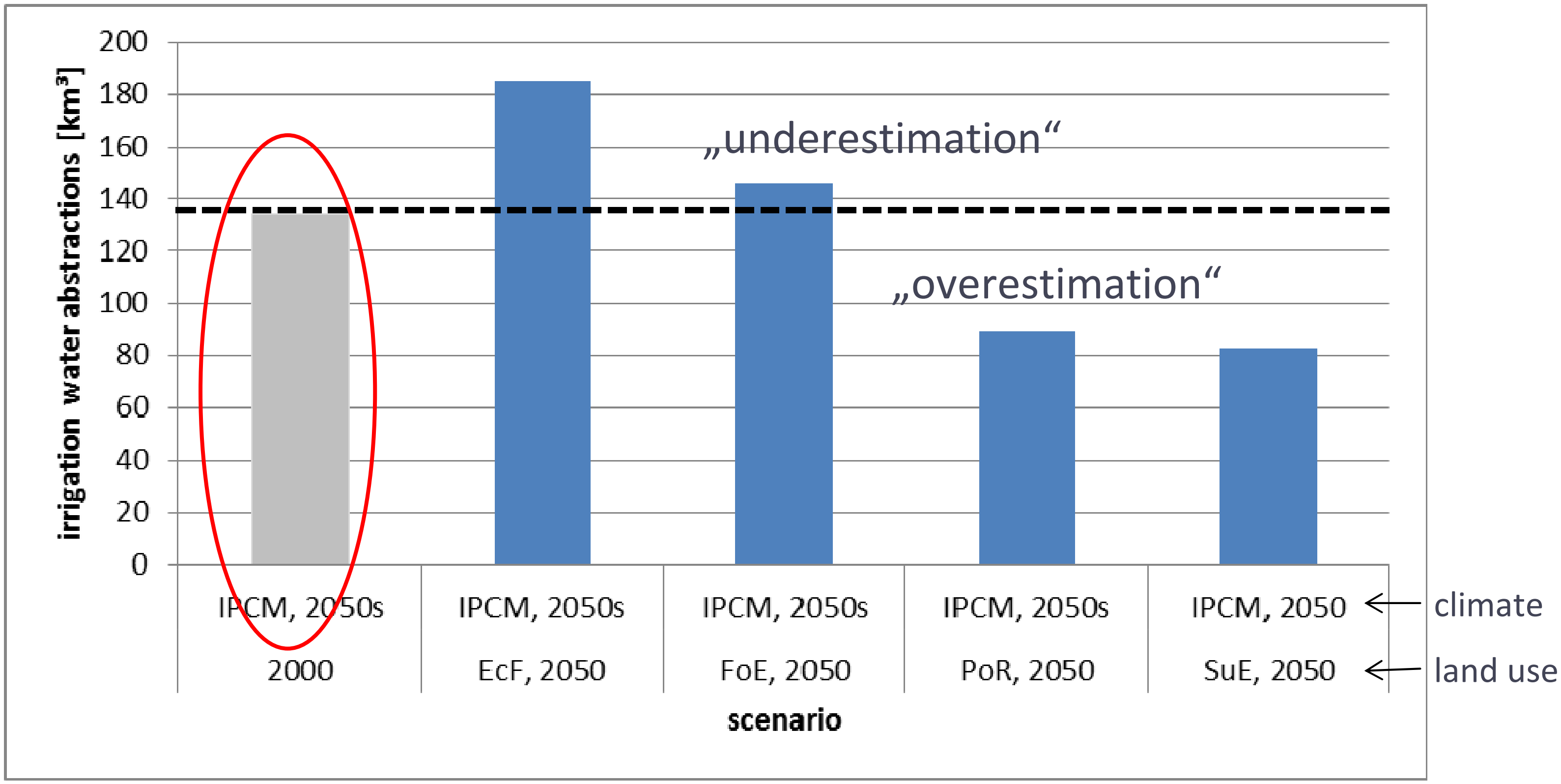
Flörke et al. 2013





Flörke et al. 2013

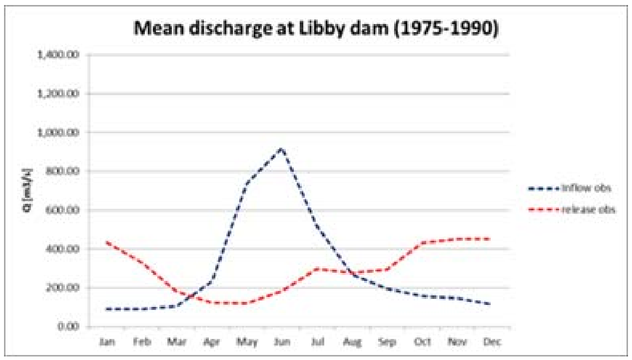
Example 1: irrigation water abstractions

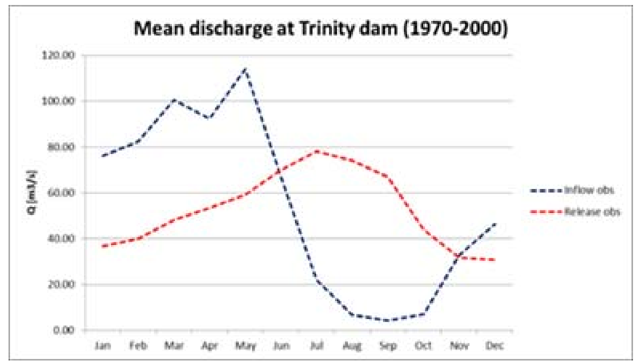


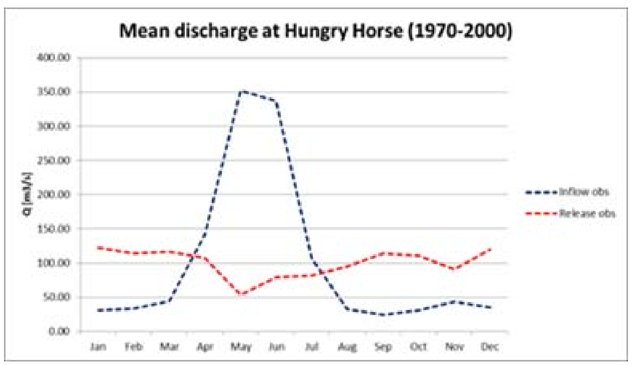
Schaldach et al 2012

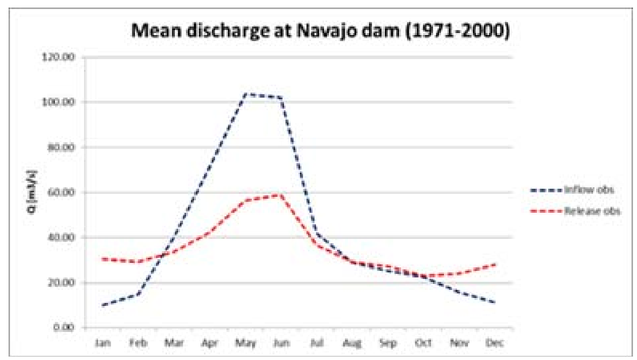
Example 4: flood control

Management of dams and reservoirs

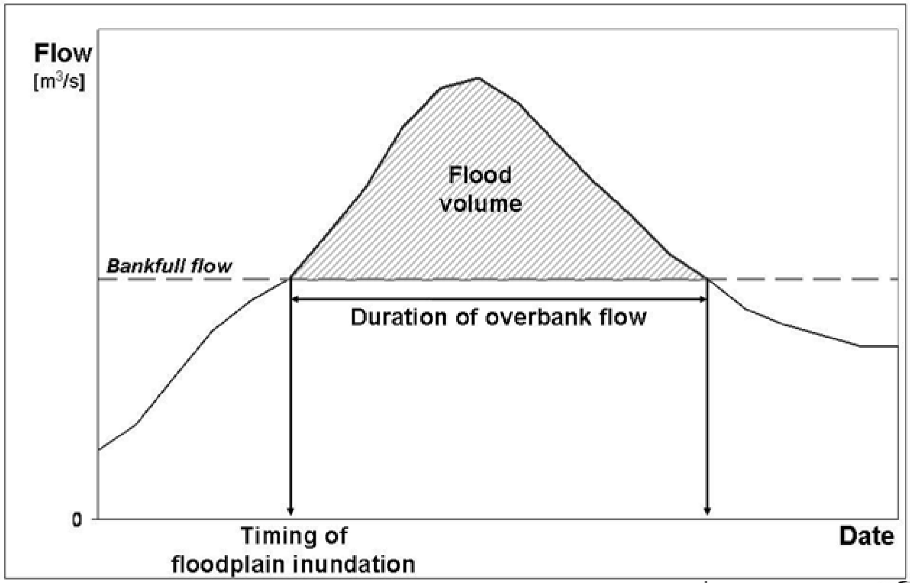


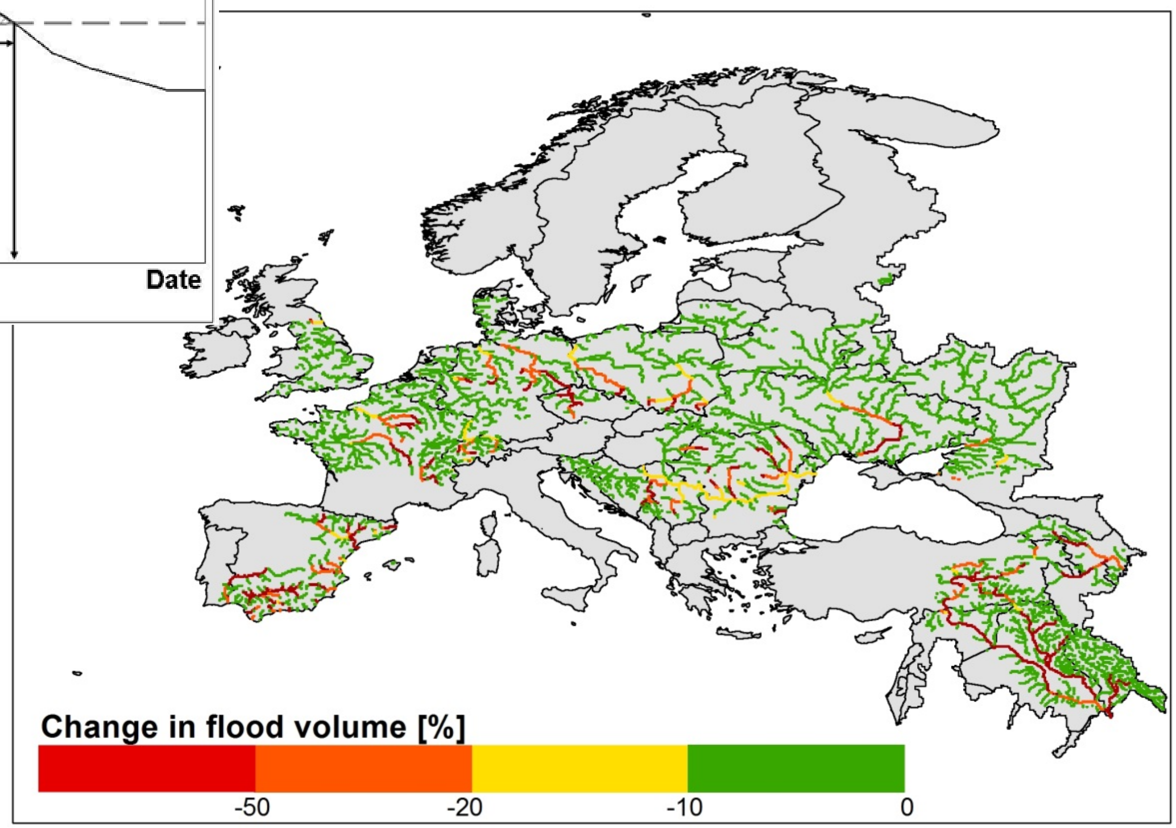






Example 5: flood volume





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Methodology

WaterGAP3 modeling framework