



**Deltares**

## **Climate change impacts on low water**

**First messages from  
the 6th IPCC report for Europe  
and the CHR research agenda**

**Judith ter Maat**

IWRM and water security expert at Deltares  
Member of the CHR



**Some first, high-level messages from the 6<sup>th</sup> IPCC report**

# The WG-1 report in numbers

## Author Team

**234** authors from **65** countries

**28%** women, **72%** men

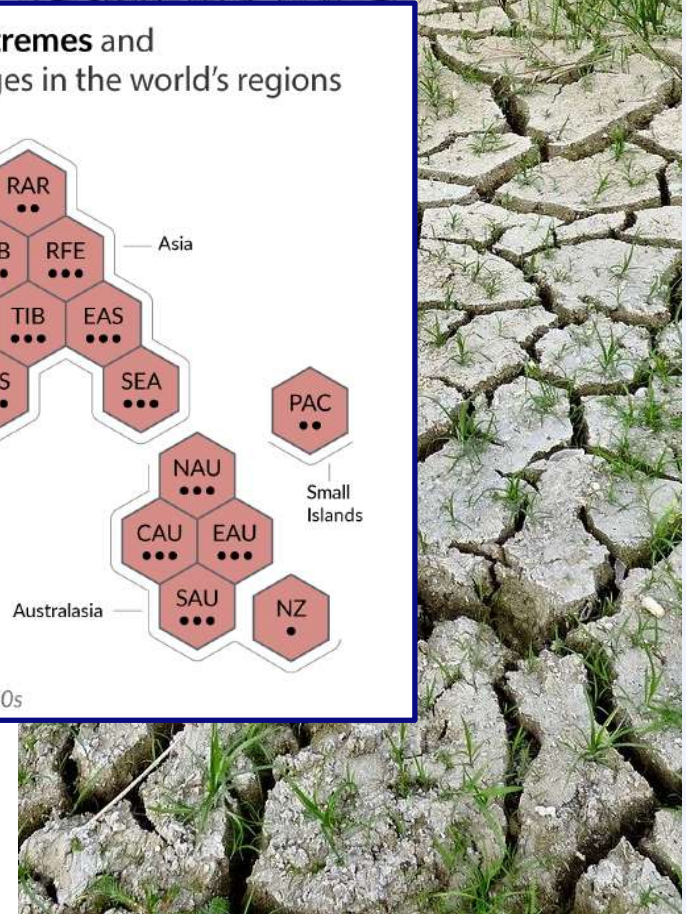
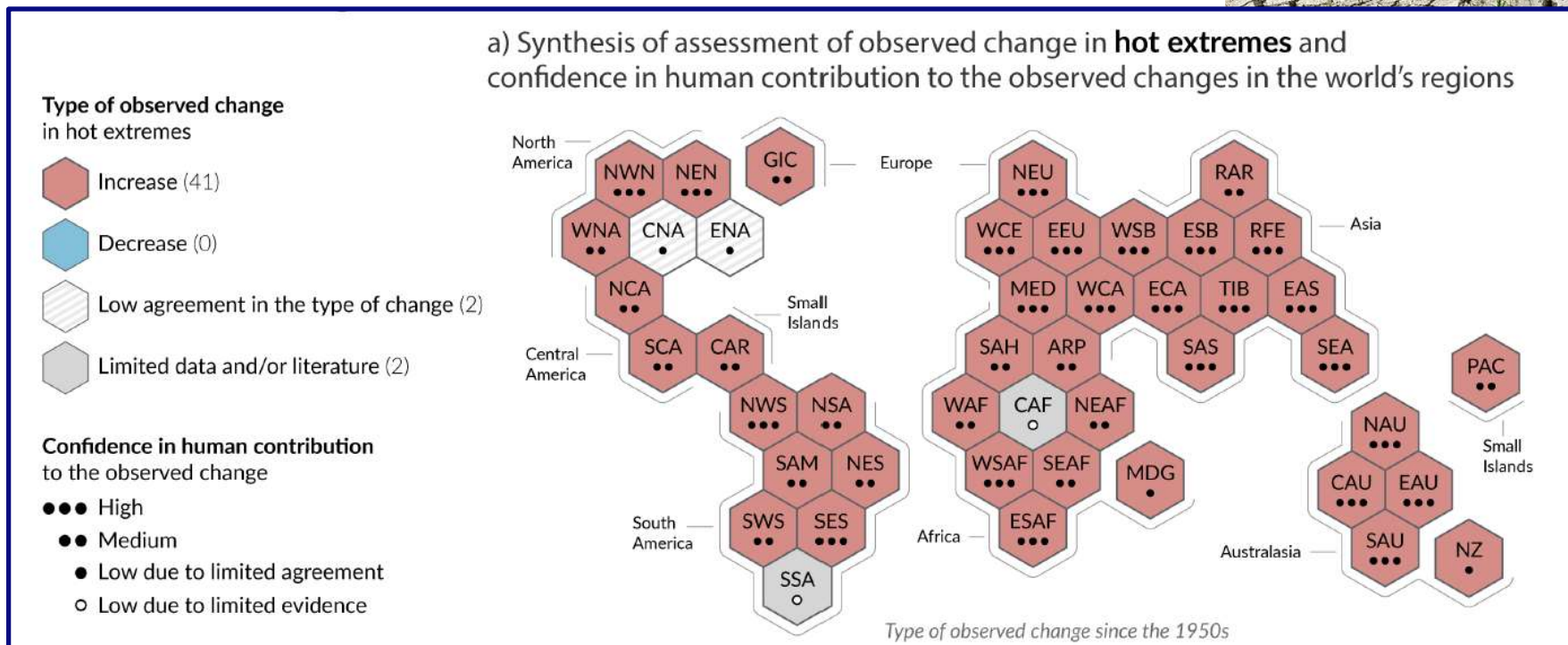
**30%** new to the **IPCC**

## Why a new report?

- Science has evolved
  - (most papers are newbies)
- Climate has evolved
  - (we've seen a lot of events)
- Society has evolved
  - (we have a Paris treaty now)

## Government Distribution

Climate change is **already** affecting every inhabited region on Earth, in multiple ways.



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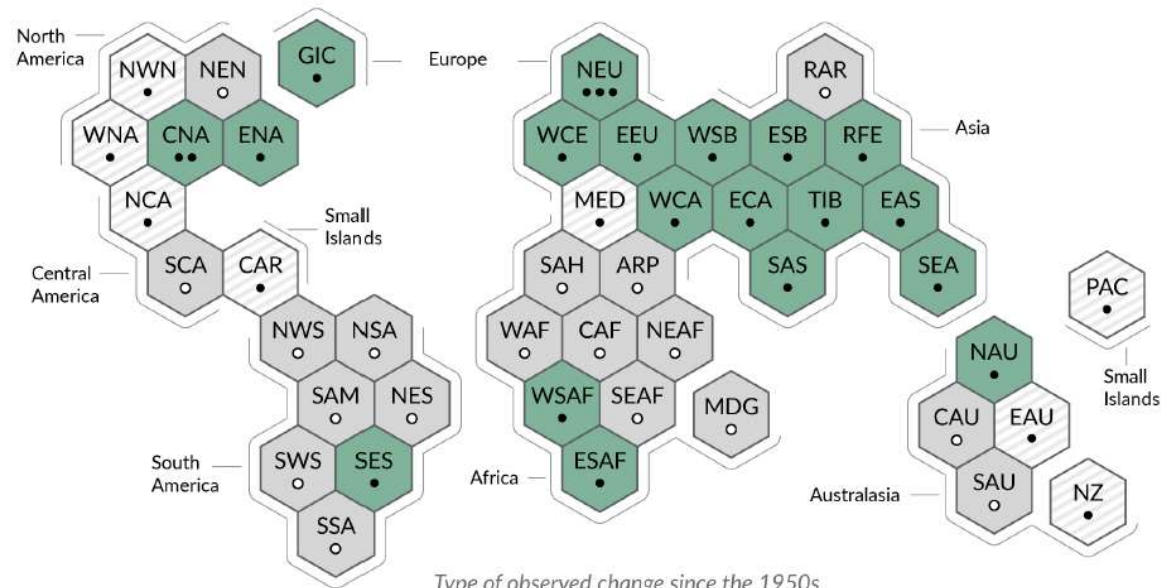
b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in heavy precipitation

- Increase (19)
- Decrease (0)
- Low agreement in the type of change (8)
- Limited data and/or literature (18)

Confidence in human contribution to the observed change

- High
- Medium
- Low due to limited agreement
- Low due to limited evidence



Type of observed change since the 1950s



Climate change is **already** affecting every inhabited region on Earth, in multiple ways.



c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions

Type of observed change in agricultural and ecological drought

● Increase (12)

● Decrease (1)

▨ Low agreement in the type of change (28)

○ Limited data and/or literature (4)

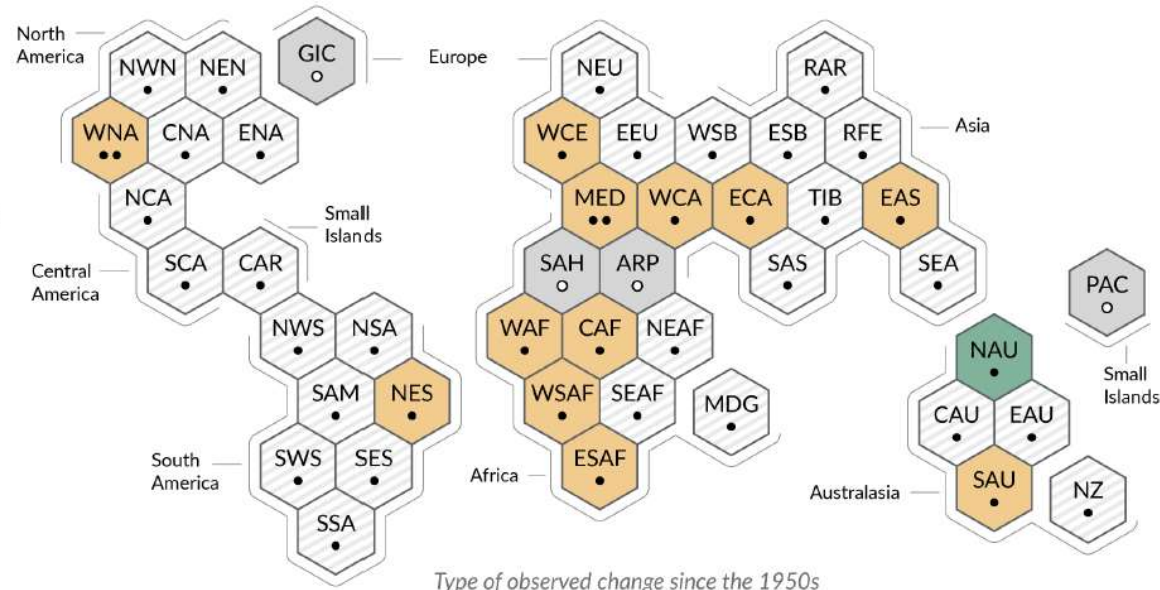
Confidence in human contribution to the observed change

●●● High

●● Medium

● Low due to limited agreement

○ Low due to limited evidence



Type of observed change since the 1950s

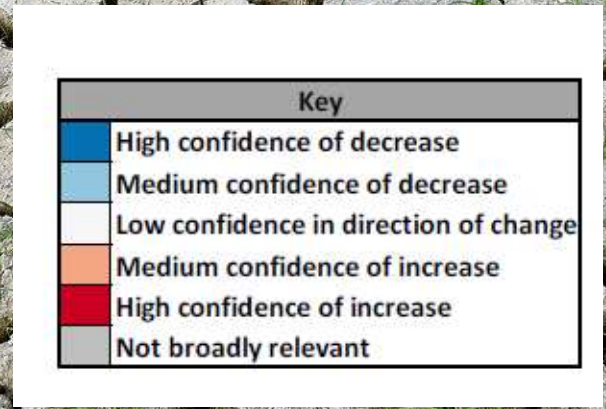
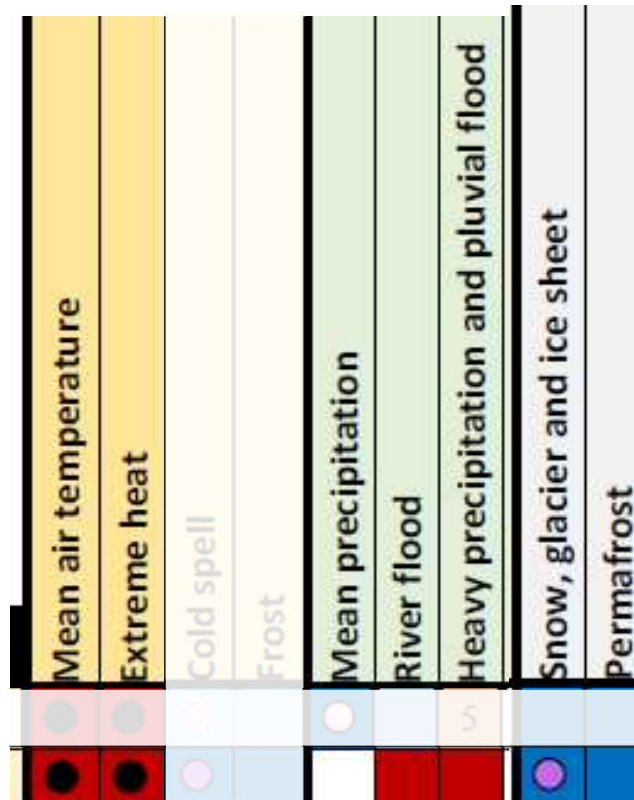


# River discharge and fresh water supply



- Warmer
- Wetter
- More extreme temperature and precipitation
- Increased flood likelihood
- Less snow and glaciers

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## The CHR research agenda



### Climate change (ASG / Rheinblick II)

- Mountain/basin hydrology
- Glacier and snow melt
- More detailed calculations for floods and droughts

### Sediment

- Understanding physics
- Recommendation for sediment management

### Land-water use/ Socio-economics (SES)

- Socio-economic scenarios
- Water demand and water distribution
- Impact on Rhine discharge


### “Synthesis“

- Integrated overview / Synthesis problem statement and future risks and uncertainties
- Together with Rhine committees and other stakeholders to present meaningful indicators
- Engaging researchers; knowledge exchange
- ...

## The CHR research agenda

**The International Commission for the Hydrology of the Rhine basin (CHR)** is an organization in which the scientific institutes of the Rhine riparian states formulate joint hydrological measures for sustainable development of the Rhine basin

Photo Ricardo Smit



**Melt water from glaciers and snow is missing in the future**  
More often low-water situations in the Rhine from Basel to the North Sea will occur. We need to be prepared for longer extreme drought periods and more extreme events.

**The CHR research messages**

Photo Ricardo Smit

# Fraction Snow and Glacier melt in the discharge of the Rhine and its tributaries in a changing climate (ASG)

- With its source in the Alps, the hydrological regime of the Rhine is influenced by meltwater in spring and summer.
- Under the influence of a warming climate the surface of glaciers in the Alps is rapidly shrinking.
- Climate change influences weather patterns and also the distribution of solid and liquid precipitation.
- This is important for water availability in the entire catchment area.

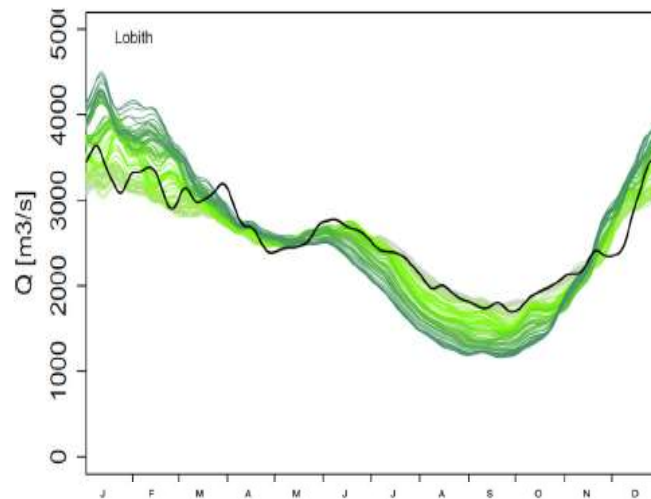
ASG1 (past) and ASG2 (future) studies conducted by Uni Freiburg, Uni Zurich and Hydron (project duration 2012-2016 resp. 2018-2022).

# ASG II projections in line with earlier projections from Rheinblick II

Selection from EURO-CORDEX for Rhine river flow projections:

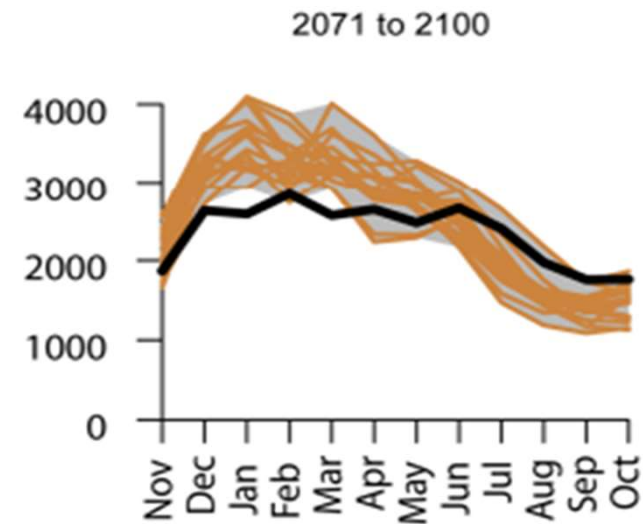
- Only RCP8.5 considered (worst case)
- A number of scenarios (7) from the CORDEX ensemble developed for Europe were used.

- Decrease in end of summer discharge Lobith
- Increases in winter discharge and spring



**CHR ASGII** – reference (black),  
future projections (green)

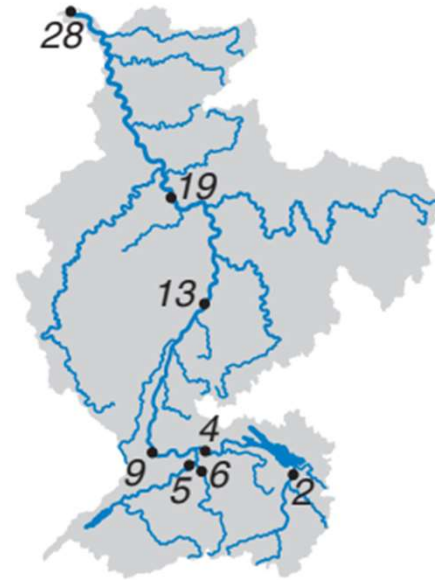
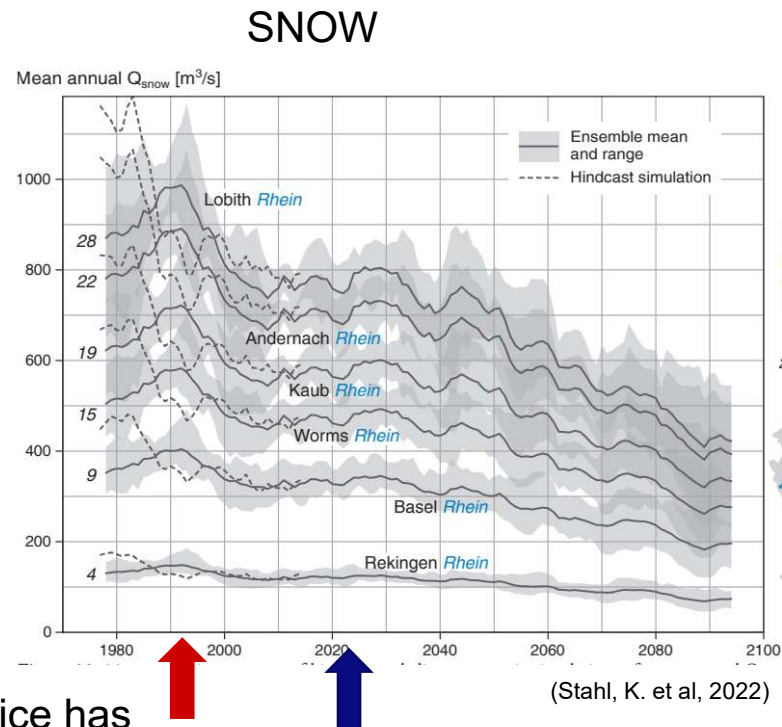
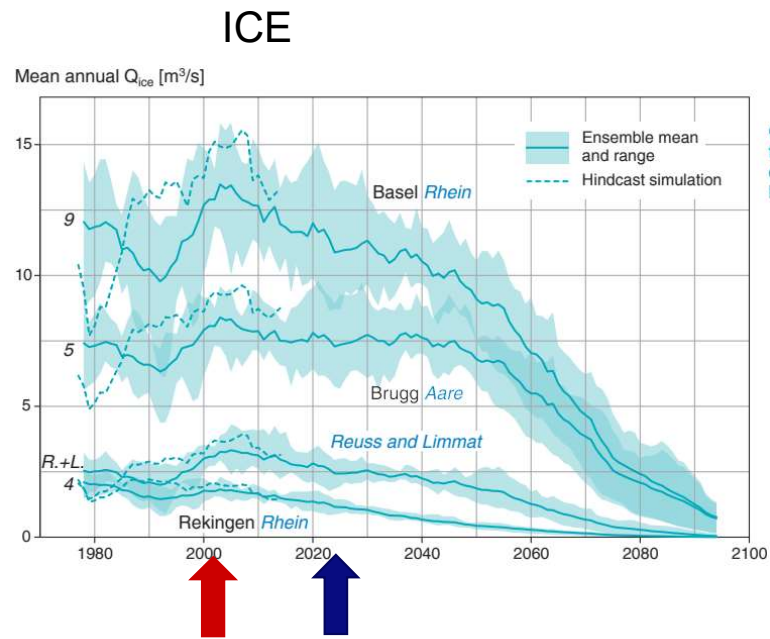
(Stahl, K. et al, 2022)



**CHR Rheinblick** – reference (black),  
future projections (orange)

(Görgen, K., 2010)

# ASG2: results (1): ice and snow



The turnaround for the max. contribution of ice has already passed. Similar is valid for snow.  
 The fraction of ice melt is rapidly decreasing after 2045 and almost disappear by the end of the century.

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## ASG2: results (2): low flow

Around 2045, a turnaround starts, which may lead to a 23% lower minimum discharge at Lobith in 2100.

Conclusion: Based on used models/scenarios (RCP8.5), we may assume that the total stream flow will be stable - also in the long run - and that the low flows will remain in the familiar range during the next three decades, after which they will decrease quite rapidly during the next 50 years.

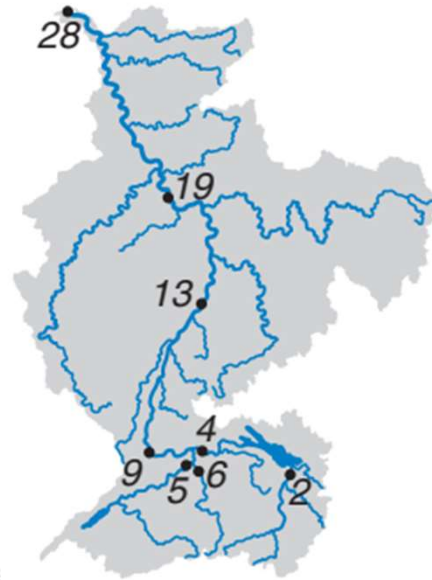
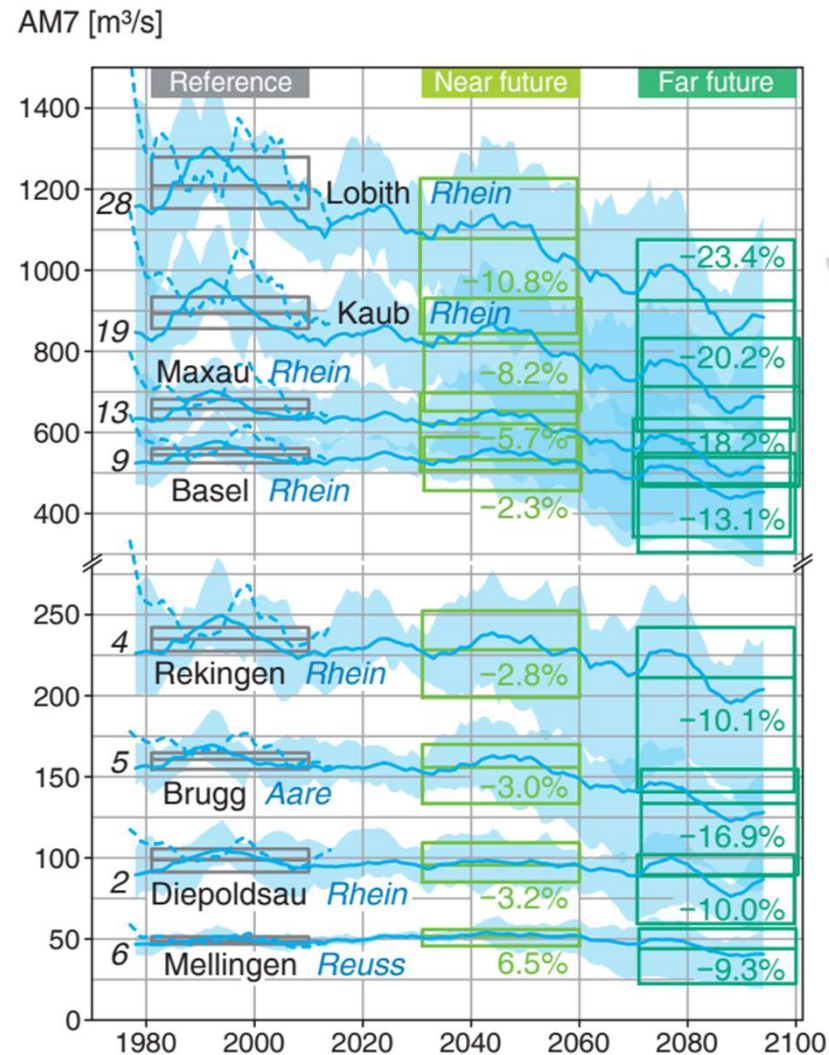


Figure 18. Time series of modeled low flows (annual 7-day-minima, AM7) at gauging stations in the Rhine basin (11-year moving averages).

(Stahl, K. et al, 2022)

## ASG2: results (3): impact for navigation example

### Assumptions: Impaired navigation based on gauge Kaub

Water level below 78cm (GIW 2015) GIQ = 784 m<sup>3</sup>/s

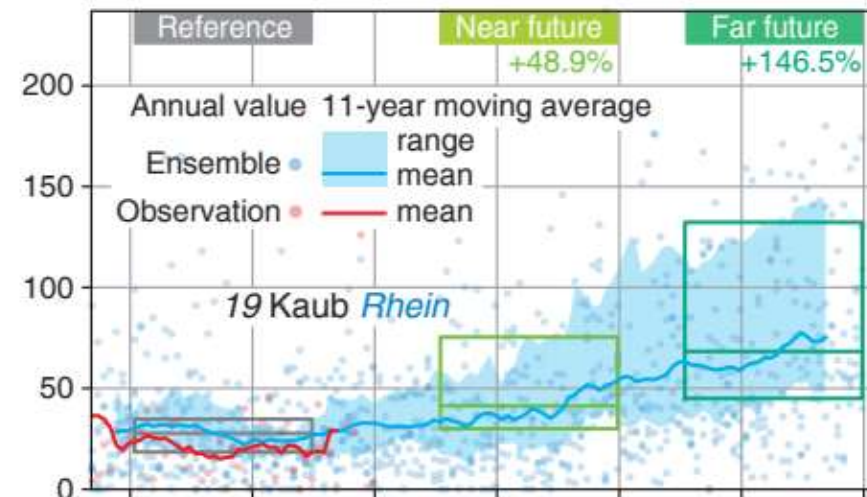
Exceedance of HSW: Hochwassermarke I (water level > 460 cm, Q > 3445 m<sup>3</sup>/s)

Based on these applicable thresholds, restrictions to navigation could prevail, on average, for more than two months per year at the end of the century.

Report available on [CHR website](#)

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Duration of impaired navigation periods [days per year]



(Stahl, K. et al, 2022)

# Risk assessment for navigation

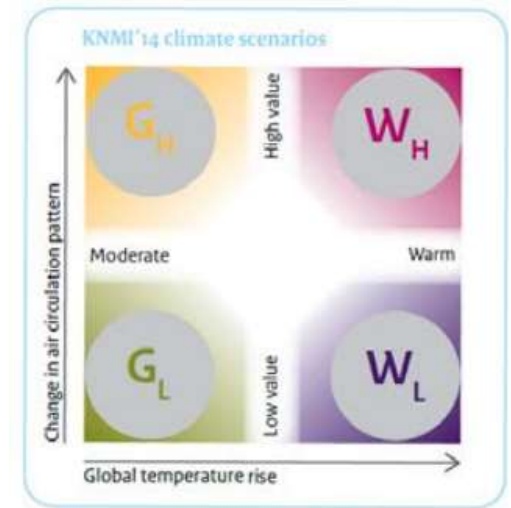
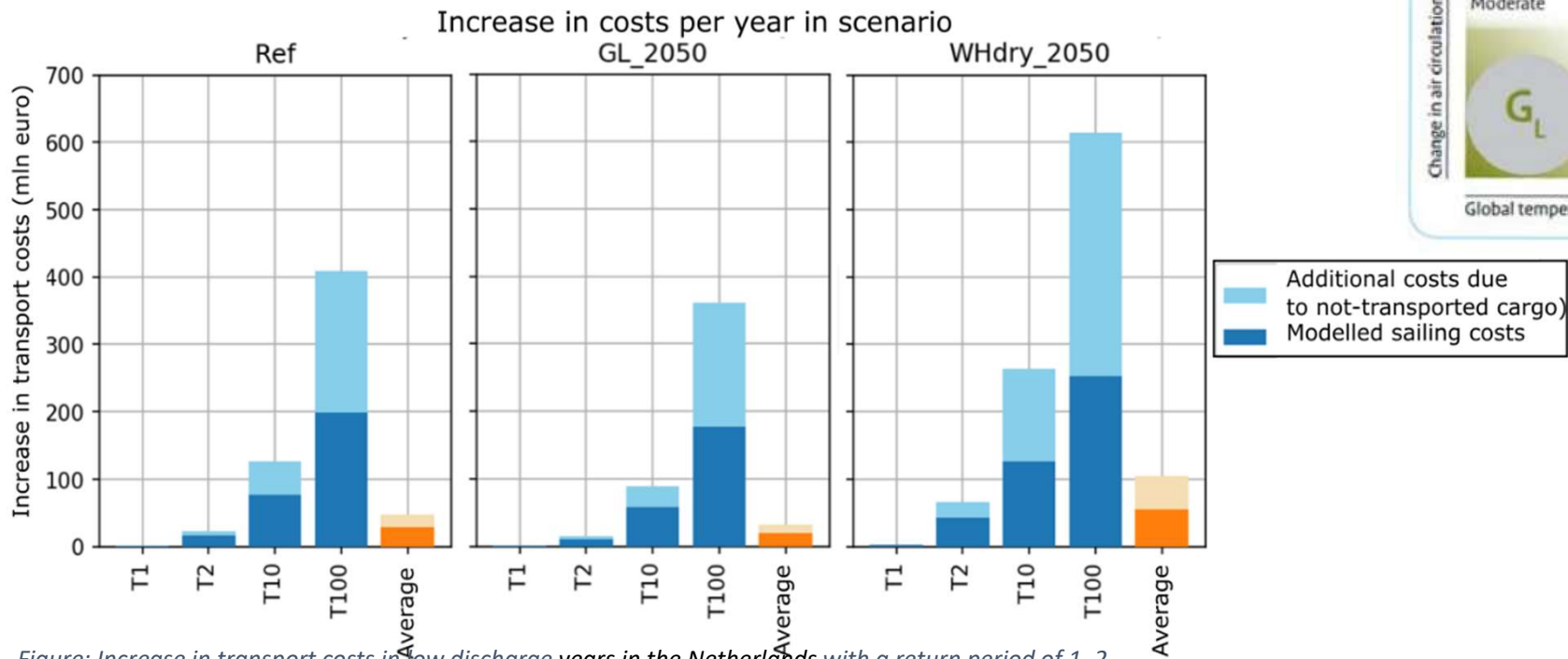


Figure: Increase in transport costs in low discharge years in the Netherlands with a return period of 1, 2, 10 and 100 years, and the yearly average over a long time. For the reference scenario (left) and a scenario with moderate climate change (centre) and high climate change (right). These costs in a year without drought problems are approximately 2 billion euro. An assumption is done for the costs for the cargo that cannot be transported over water.



An aerial photograph of a wide river, likely the Rhine, flowing through a landscape. A bridge with multiple concrete piers spans the river in the middle ground. The banks are green with grass and some trees. In the background, a city with various buildings is visible under a clear sky. The overall scene is bright and clear.

**Melt water from glaciers and snow is missing in the future**

More often low-water situations in the Rhine from Basel to the North Sea. We need to be prepared for longer extreme drought periods and more extreme events.

**Growing water demand from nature, society and economic sectors will increase low flow risks**

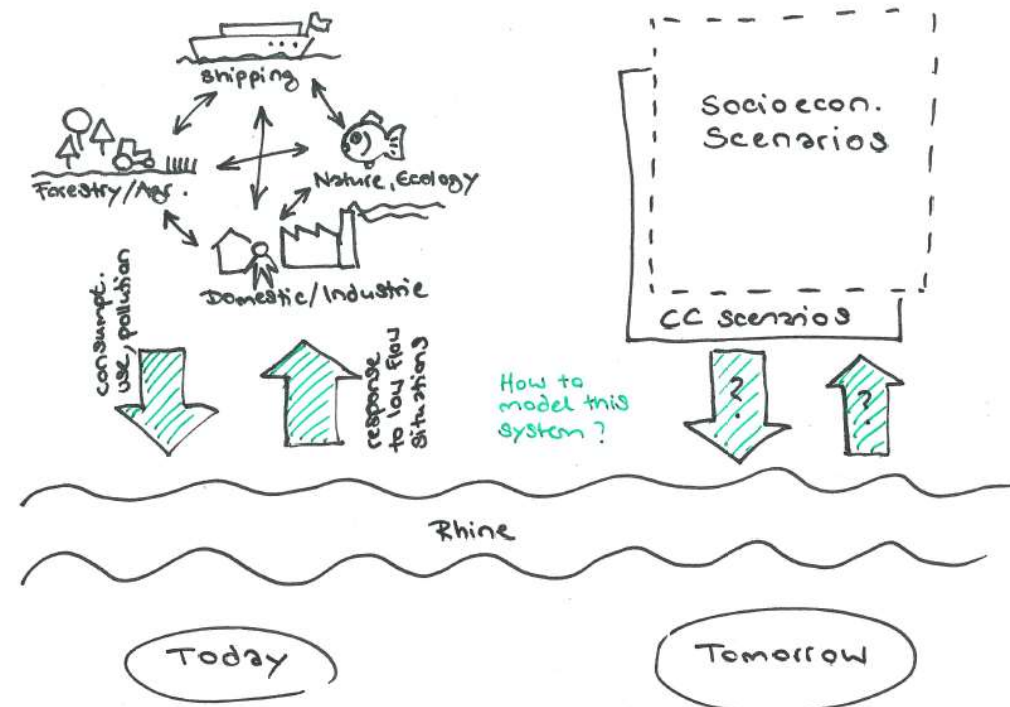
Cross-sectoral linkages and trade-offs in water use and allocation under climate change must be identified and incorporated in river basin planning.

**The CHR research messages**

Photo Ricardo Smit

# Socio-Economic Scenarios

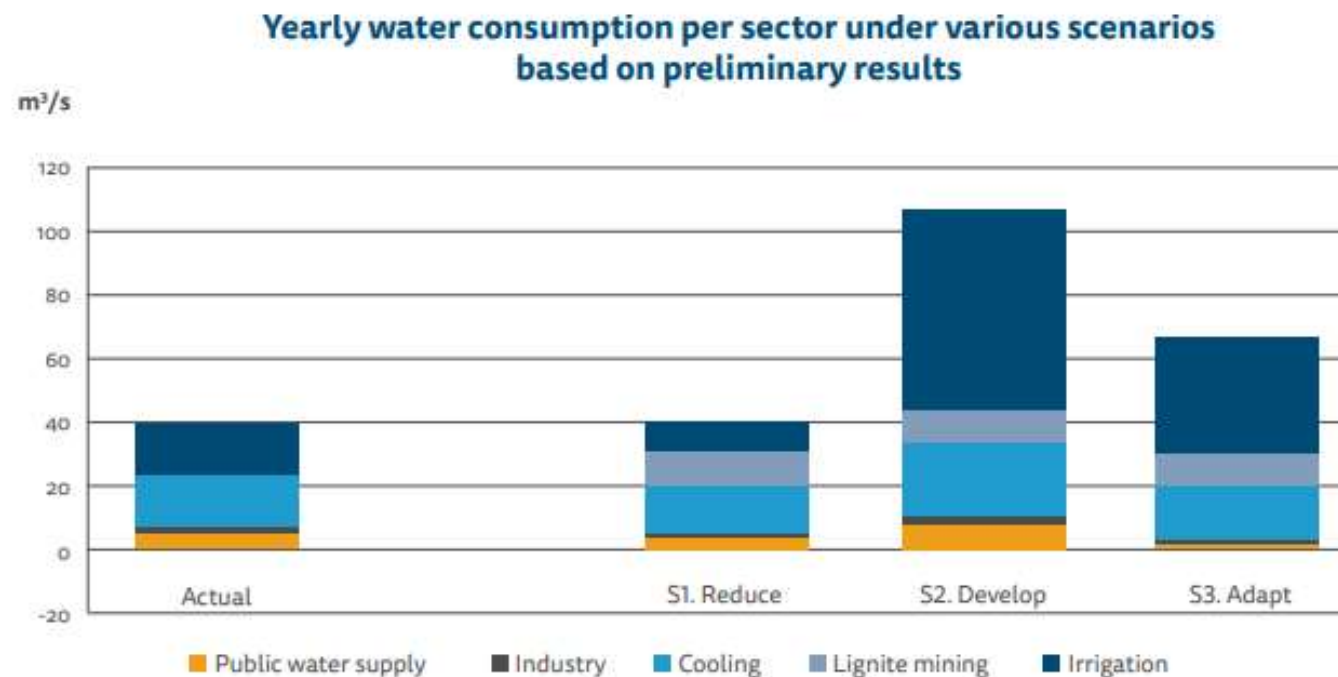
- Project duration: 2013 – ... (Deltares, Netherlands, with BfG and others)
- Several results online available on CHR website, e.g.:
  - Integrated overview
  - RIBASIM scenario tool development report



# First integrated overview of effects of socio-economic scenarios on the discharge of the Rhine (2019)

– expert workshop and open data

Under future scenarios, water consumption in the Rhine river basin could increase from **50-75 m<sup>3</sup>/s** to **200-250 m<sup>3</sup>/s** in summer.



(Ruijgh et al, 2019)

# Modelling “What if...?” scenarios – CHR SES and EU Stars4Water



(Figure RIBASIM scenario planning tool (Van der Krogt, W. et al, 2022))



**Melt water from glaciers and snow is missing in the future**

More often low-water situations in the Rhine from Basel to the North Sea. We need to be prepared for longer extreme drought periods and more extreme events.

**Growing water demand from nature, society and economic sectors will increase low flow risks**

Cross-sectoral linkages and trade-offs in water use and allocation under climate change must be identified and incorporated in river basin planning.

**Catalyzing collaborative actions for fair and sustainable use of the river system and adaptation to climate change**

Evidence-based support for informed decision making require data sharing and open information system.

**The CHR research messages**

Photo Ricardo Smit

# CHR information system

- making datasets from/for research available

KHR Infosystem

Place name, street name, district name, POI, etc.

Measure  
Draw  
Query map features  
Export  
Maps  
Share  
Language selector  
Collapse

KHR Infosystem

### KHR Infosystem

#### CHR`s Strategy

##### Vision

Agreed working and funding structures are available within the Rhine-bordering countries. These allow the CHR to continually generate adequate and future-oriented scientific knowledge pertaining to the hydrology of the Rhine, for the targeted use of policy-makers and stakeholders. The CHR is a leading worldwide example of successful and peaceful international collaboration when it comes to transboundary river basins.

##### Mission

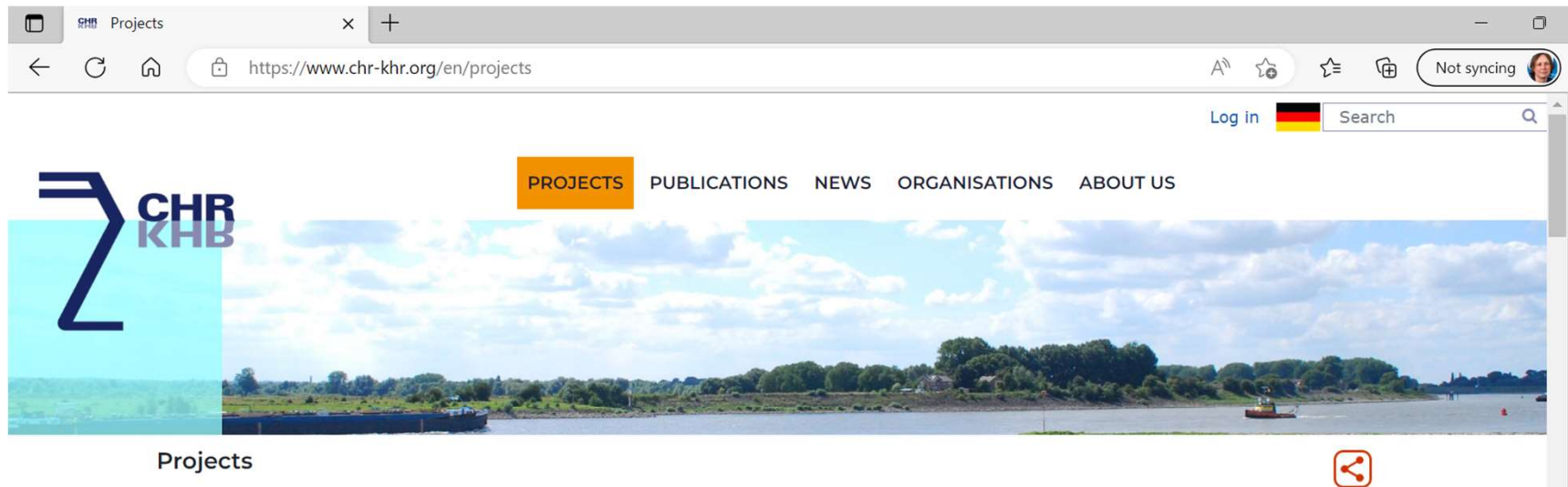
The CHR provides a scientific knowledge base for the hydrology of the Rhine catchment area, conducting both solicited and unsolicited research. The CHR makes these results available to scientists, decision-makers and stakeholders in the region. Consequently, we are focussing on advising politically-active and technically-oriented organizations, such as the International Commission for the Protection of the Rhine (ICPR) and the Central Commission for Navigation of the Rhine (CCNR), to support them with reliable science-based information for the implementation of guidelines, policy, management and decision-making.

Don't show again

100 km | Scale: 1:8.000.000 | Reference system: EPSG:3857 | Mouse position: 386365.16, 5566861.94

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# More information? [Publications](https://www.chr-khr.org/en/publications) | [International Commission for the Hydrology of the Rhine basin \(CHR\)](https://www.chr-khr.org/en/international-commission-for-the-hydrology-of-the-rhine-basin) ([chr-khr.org](https://www.chr-khr.org))



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Any questions?  
[Judith.terMaat@deltares.nl](mailto:Judith.terMaat@deltares.nl)