SMHI

Berit Arheimer, SMHI, Changes in Hydrology and Society

Water research to support society: past, present and future

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Panta Rhei:
Hydro Sciences entering the Anthropocene?

Age of Man

Elizabeth Kolbert, 2011, on the NATIONAL GEOGRAPHIC website
Photograph by Jens Neumann/Edgar Rodtmann

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Tremendous environmental problems

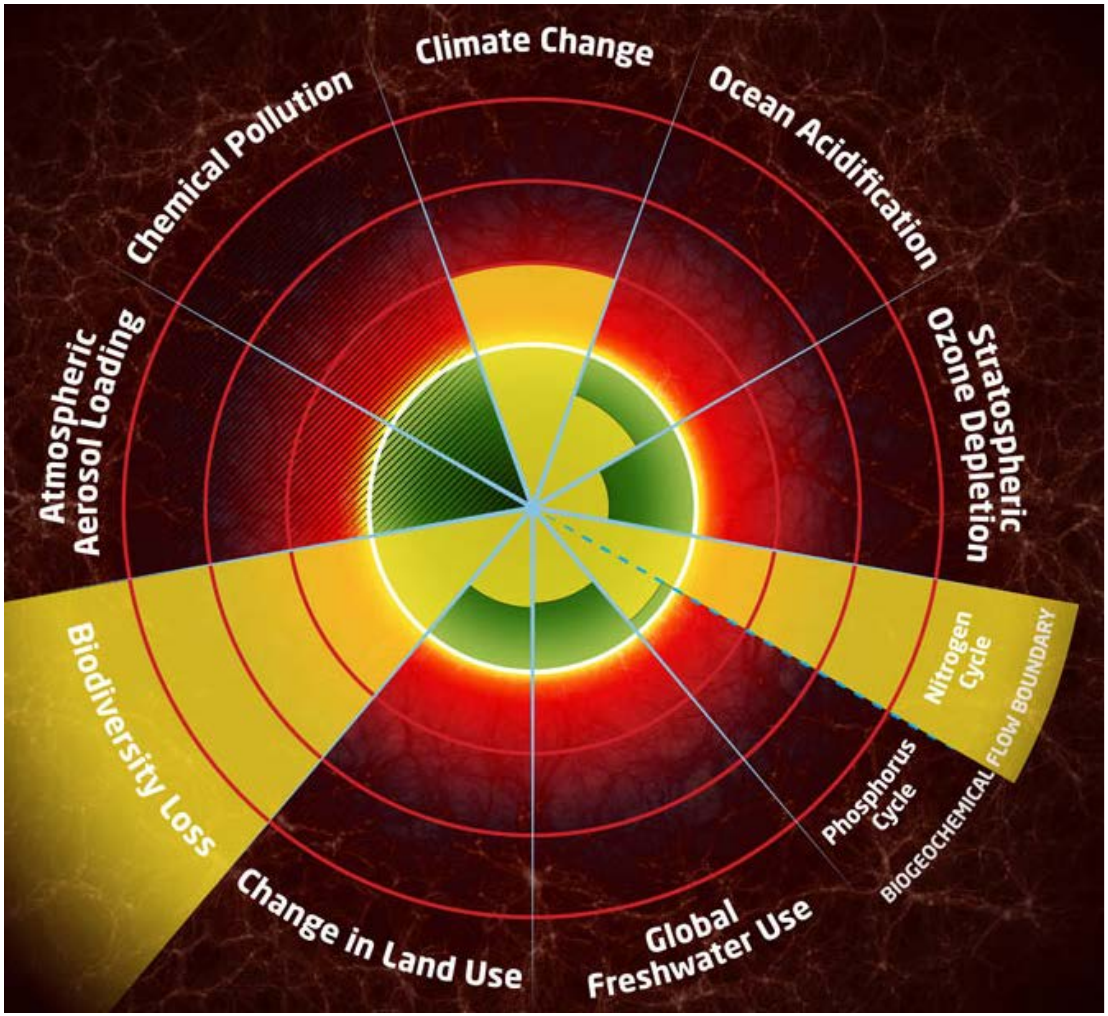
challenging hydrology and society







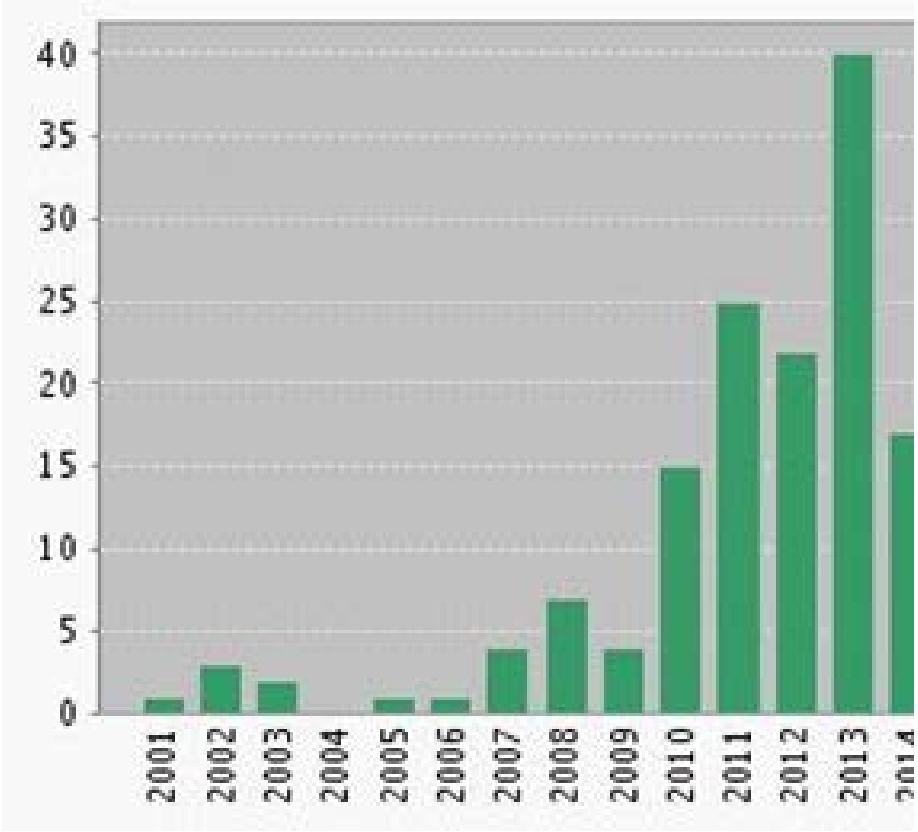


IGBP, 2011

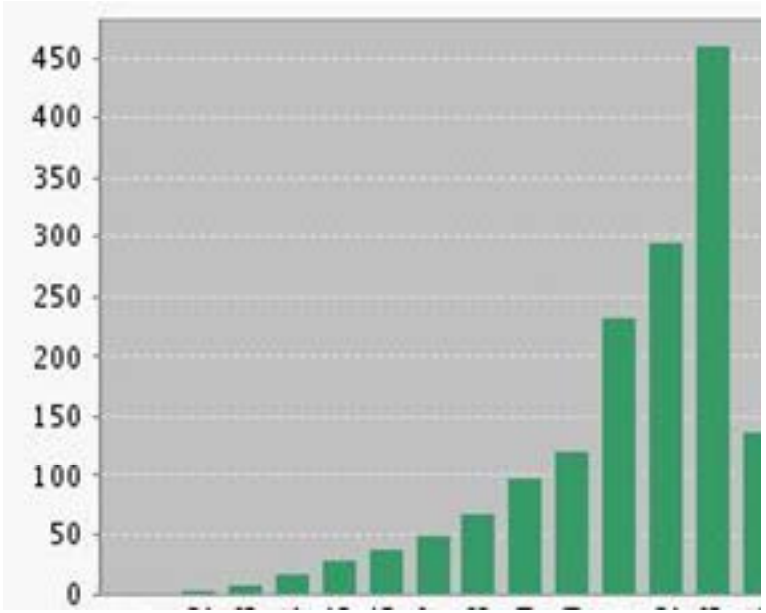
Anthropocene in Web of Science

Published Items in Each Year



The latest 20 years are displayed.

Citations in Each Year



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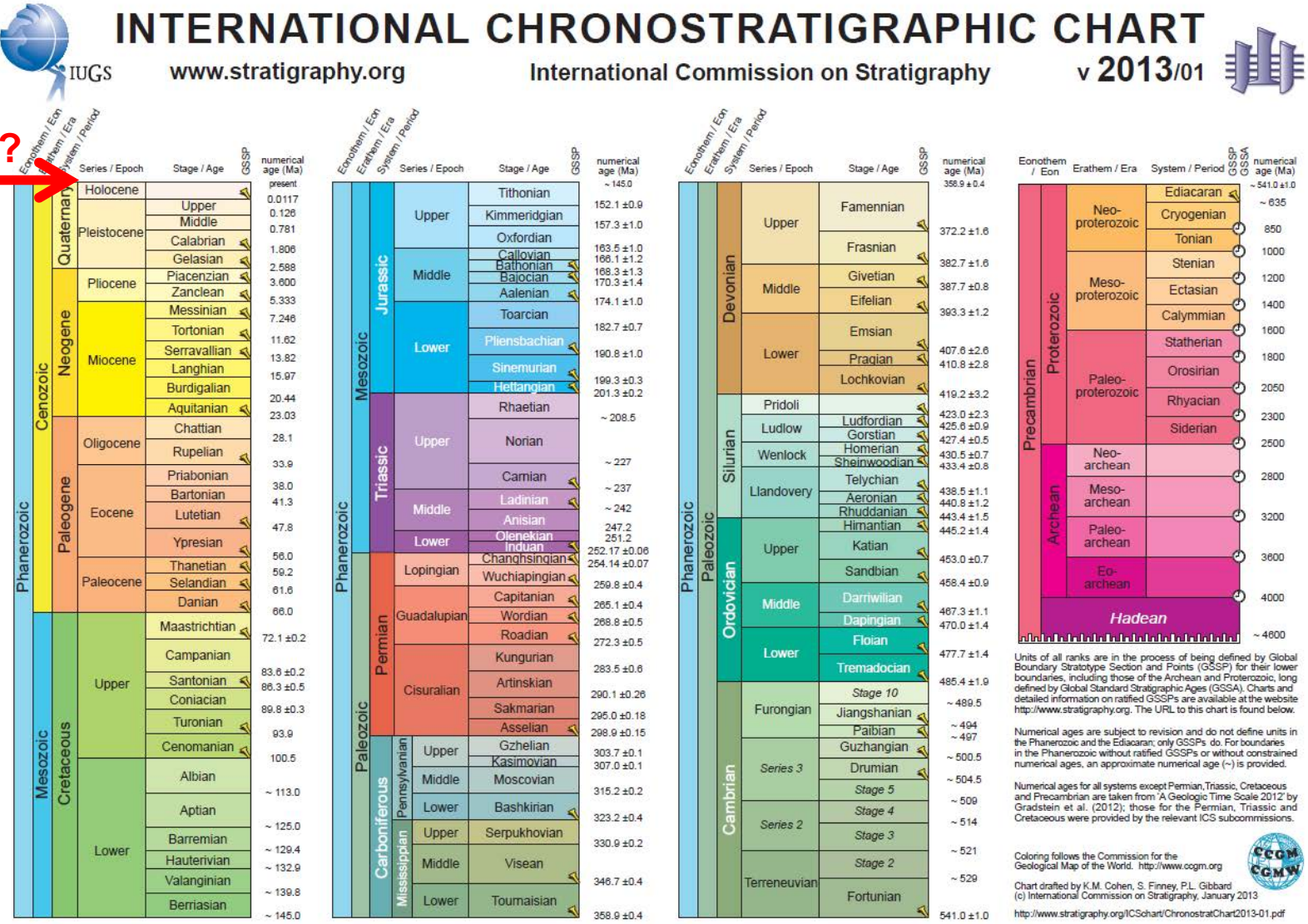
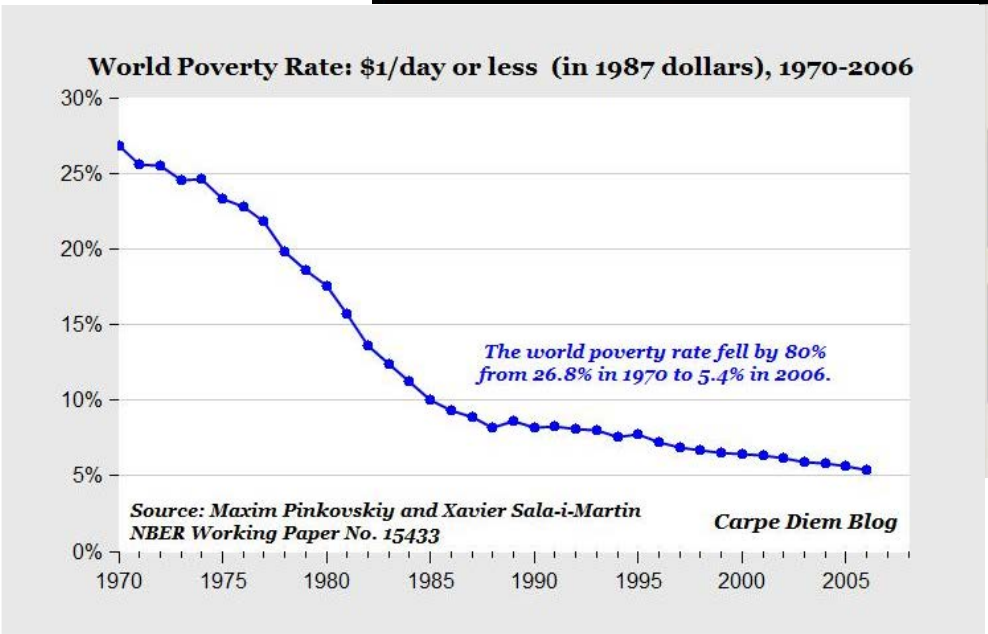
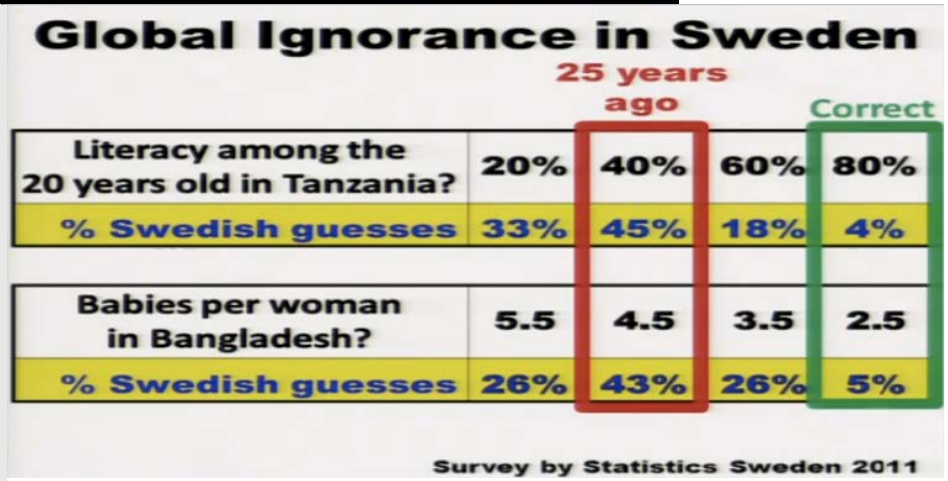
Holocene => Anthropocene?

Anthropocene?



Don’t panic - things are improving!





http://www.gapminder.org/

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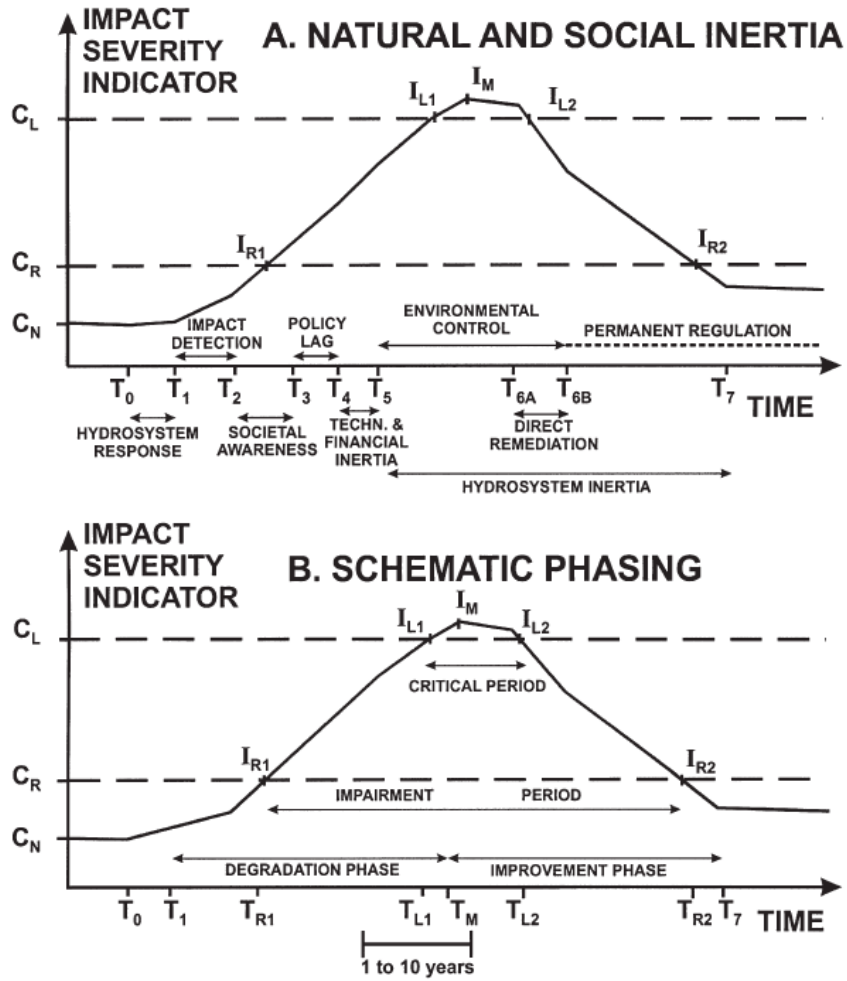
Successful restoration of water quality



Meybeck, M. 2002. Riverine quality at the Anthropocene: Propositions for global space and time analysis, illustrated by the Seine River. Aquatic Sciences 64 (4):376-393

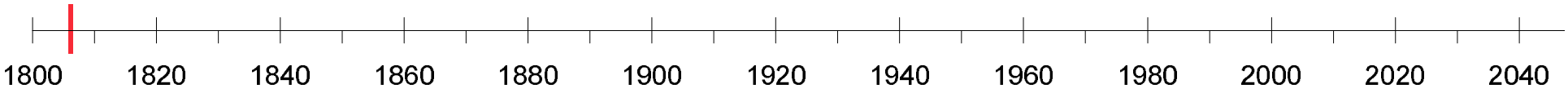
Case-study: SMHI

Hypothesis: Hydrologists are responsive to changes in hydrology and society

www.smhi.se

SMHI - the story of changes in hydrology and society

SOCIETY



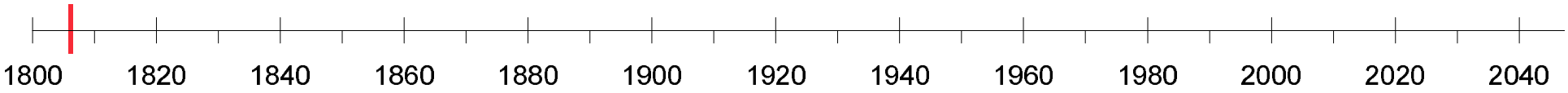
HYDROLOGY RESEARCH

SMHI

SMHI - the story of changes in hydrology and society

SOCIETY

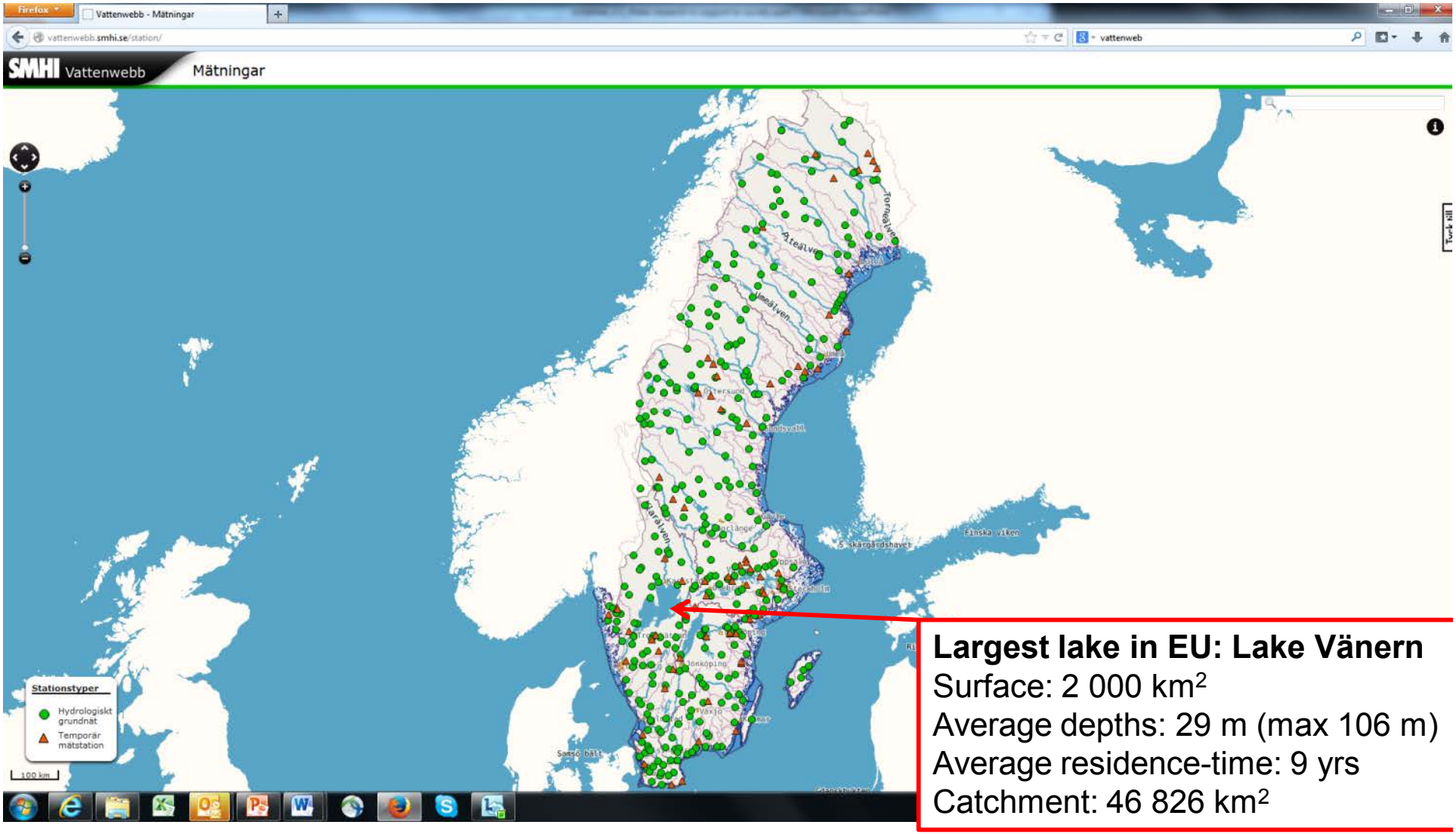
Transport, Agriculture:
shipping, log driving,
building canals



HYDROLOGY RESEARCH

Countinous
monitoring of
River flow;
Compiling
statistics for
infrastructure

Flow observations started with the large lakes in 1808



Largest lake in EU: Lake Vänern
Surface: 2 000 km^2
Average depths: 29 m (max 106 m)
Average residence-time: 9 yrs
Catchment: 46 826 km^2

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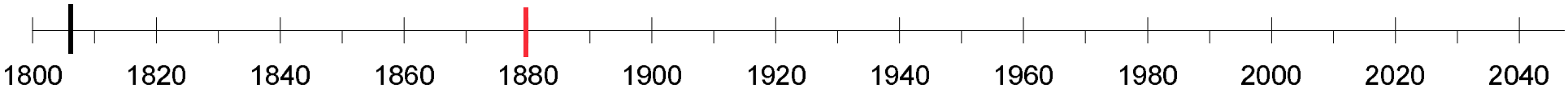
SOCIETY

Transport, Agriculture: shipping, log driving, building canals

Famine:
More arable land



HYDROLOGY RESEARCH

Countinous **monitoring** of River flow; Compiling **statistics** for infrastructure

Observing effects of lake drainage

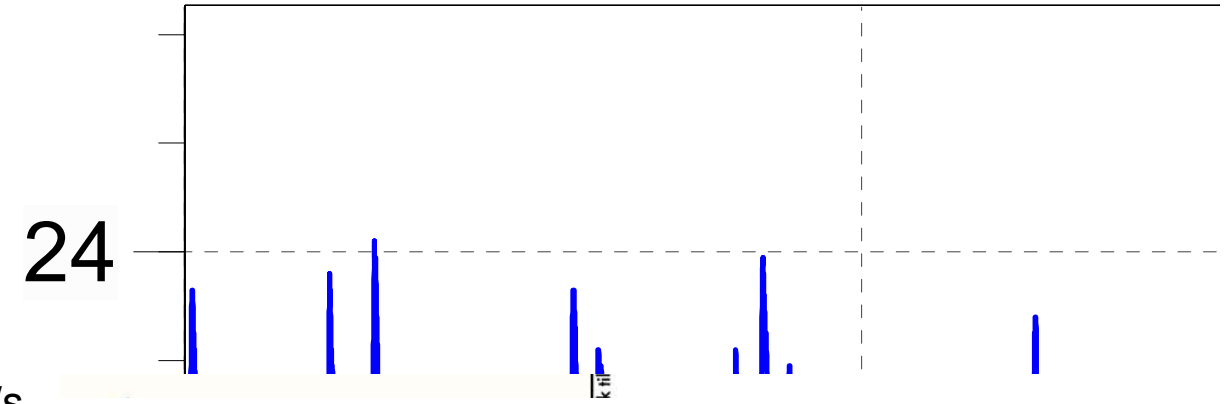
Lake Hjälmaren

m

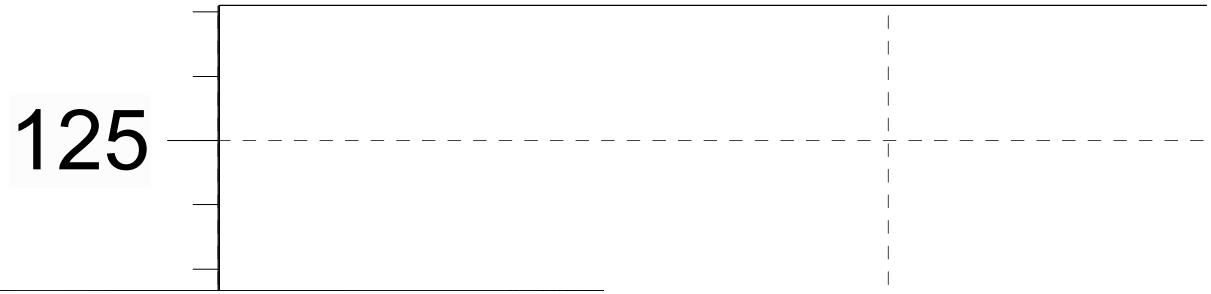
190 km² drained during 1880's

m³/s

Water level



Water flow



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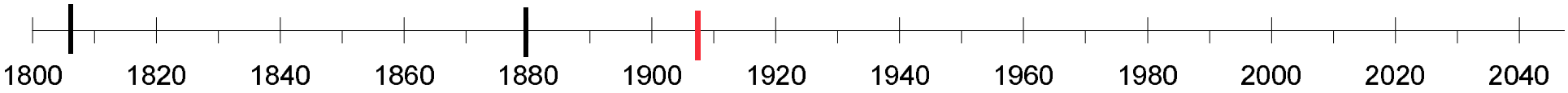
SOCIETY

Industrialisation:
Energy problem

Transport, Agriculture: shipping, log driving, building canals

Famine:
More arable land



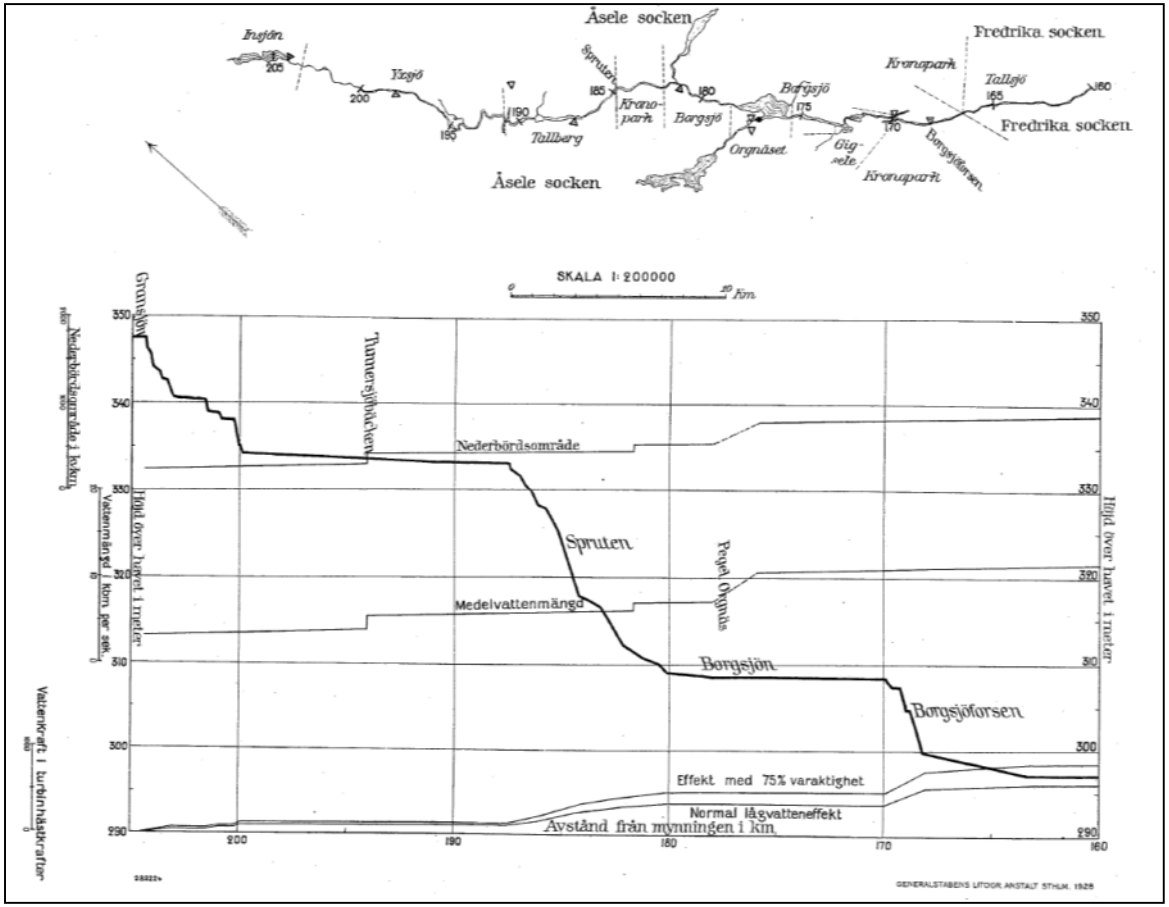
HYDROLOGY RESEARCH

Observing effects of lake drainage

Countinous **monitoring** of River flow; Compiling **statistics** for infrastructure

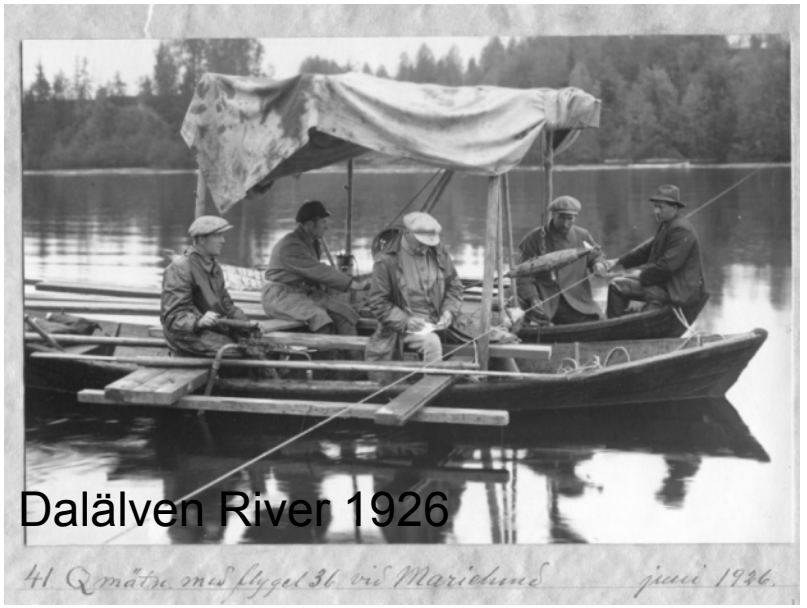
Mapping hydropower potential (water divides, falls, flow)

Mapping water divides and falls



Monitoring of river flow in the North


Ljusnan River 1913



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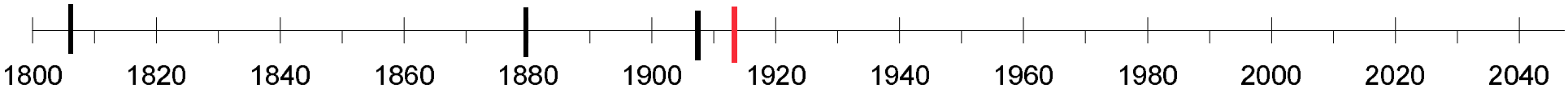
SOCIETY

Industrialisation:
Energy problem

Hydropower operation

Transport, Agriculture: shipping, log driving, building canals

Famine:
More arable land



HYDROLOGY RESEARCH

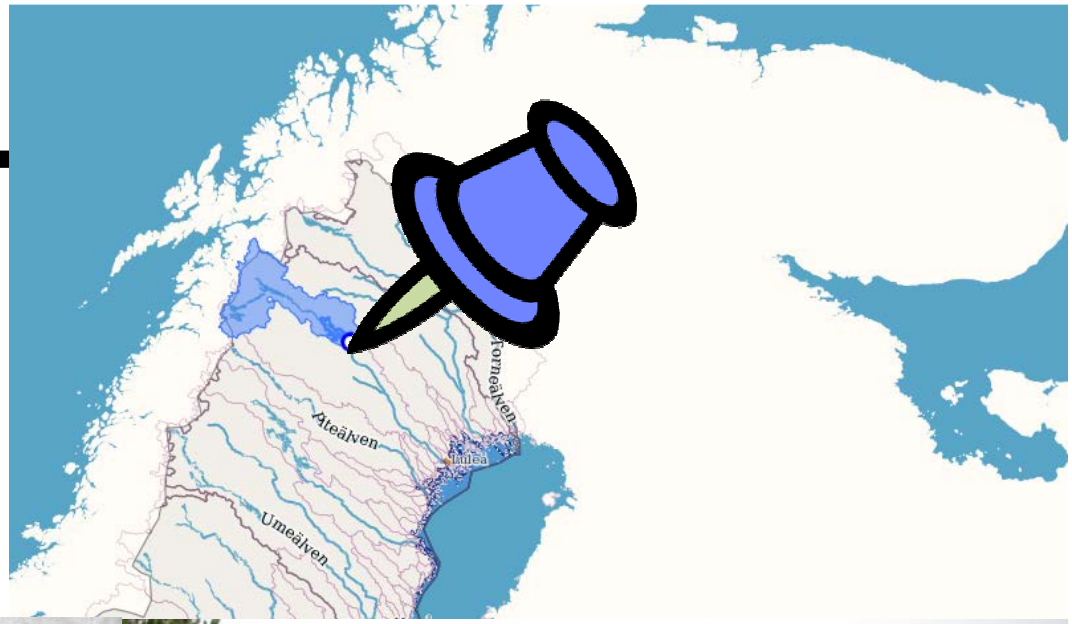
Observing effects of lake drainage

Countinous **monitoring** of River flow; Compiling **statistics** for infrastructure

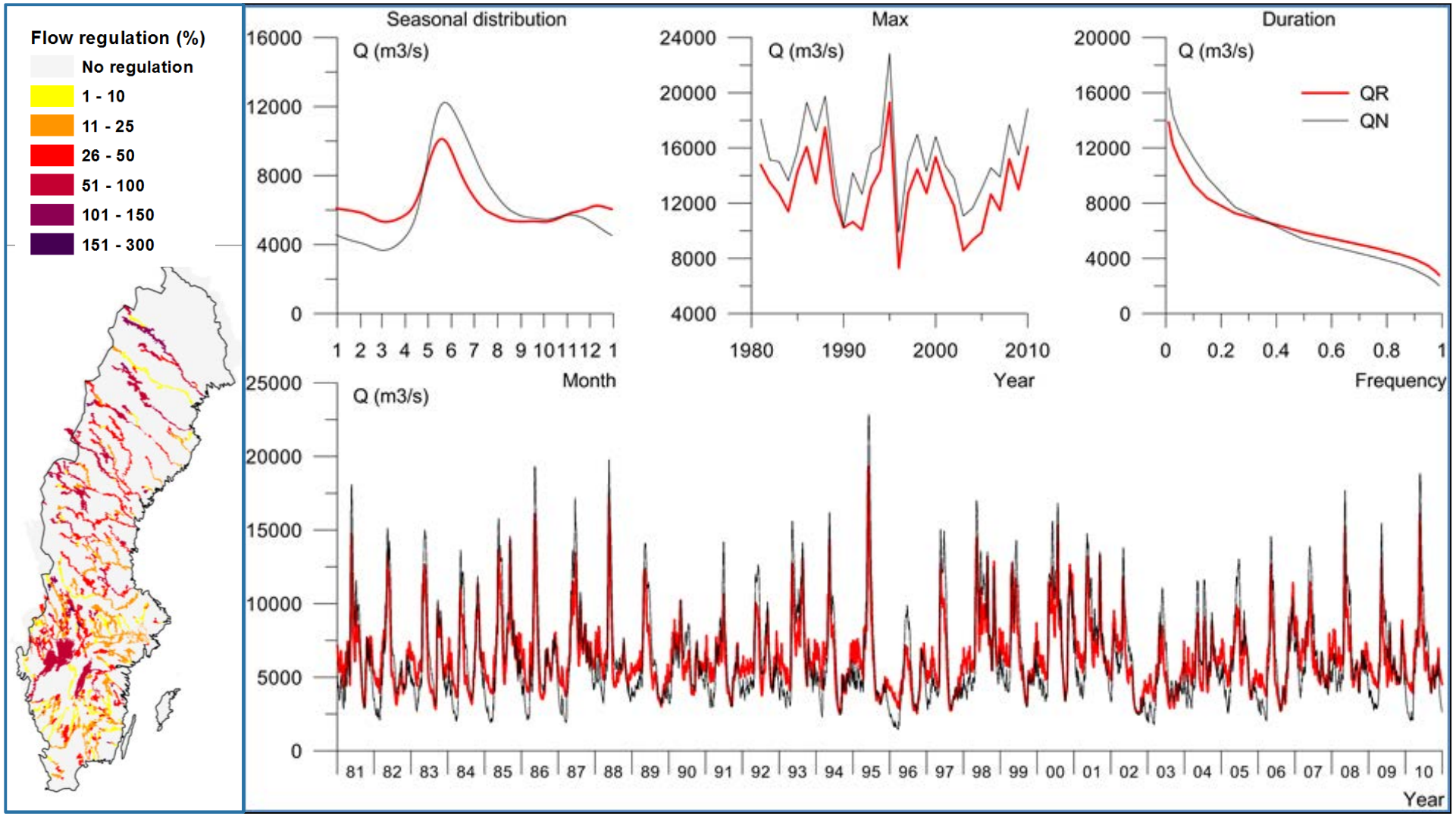
Spring-flood forecasts

Mapping hydropower potential
(water divides, falls, flow)

Porjus:
1910 vs 2010



Estimated hydropower-effect on river flow to the sea



Arheimer, B. and Lindström, G. 2014. Electricity vs Ecosystems – understanding and predicting hydropower impact on Swedish river flow. IAHS Publ. 364

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SOCIETY

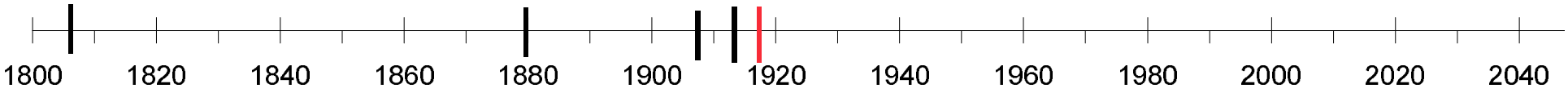
Industrialisation:
Energy problem

Hydropower
operation

Transport, Agriculture: shipping,
log driving, building canals

Famine:
More arable land

Hydropower
vs ice stability



HYDROLOGY RESEARCH

Monitoring ice
(cover, break-up,
thickness)

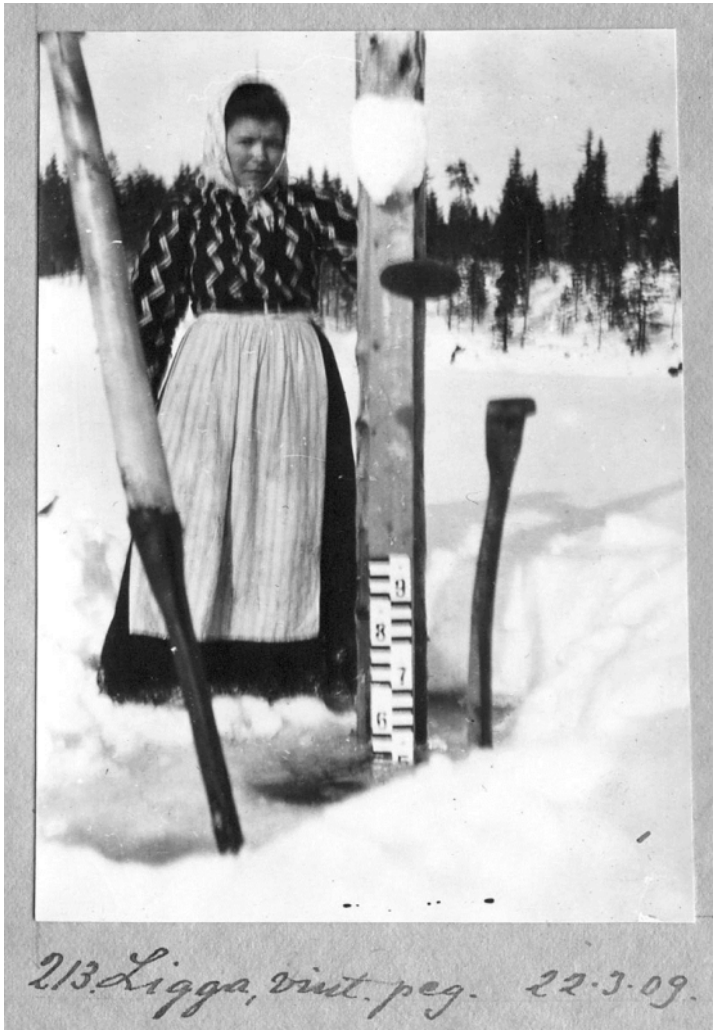
Observing effects
of lake drainage

Countinous
monitoring of
River flow;
Compiling
statistics for
infrastructure

Spring-flood
forecasts

Mapping hydropower
potential
(water divides, falls, flow)

SMHI ice service



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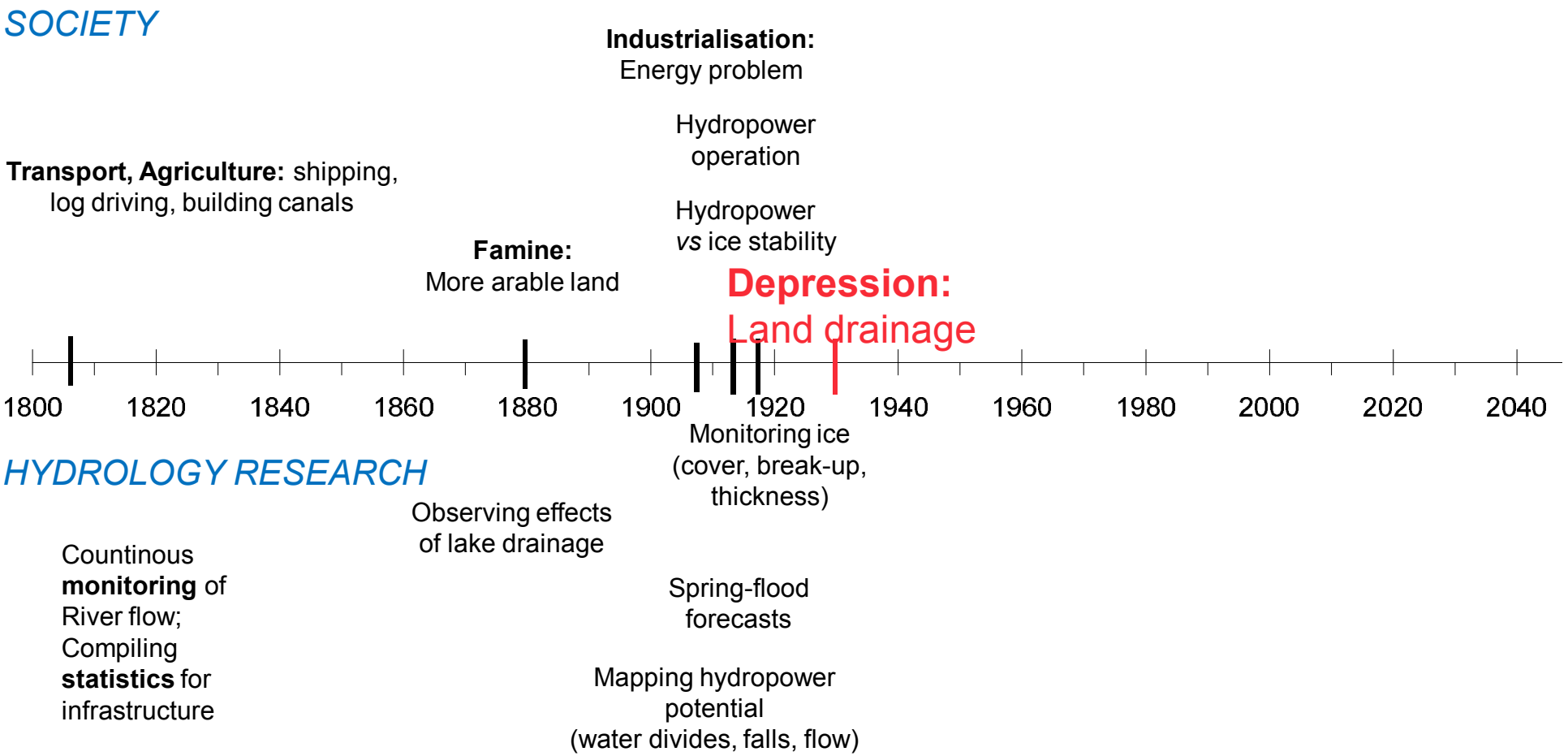
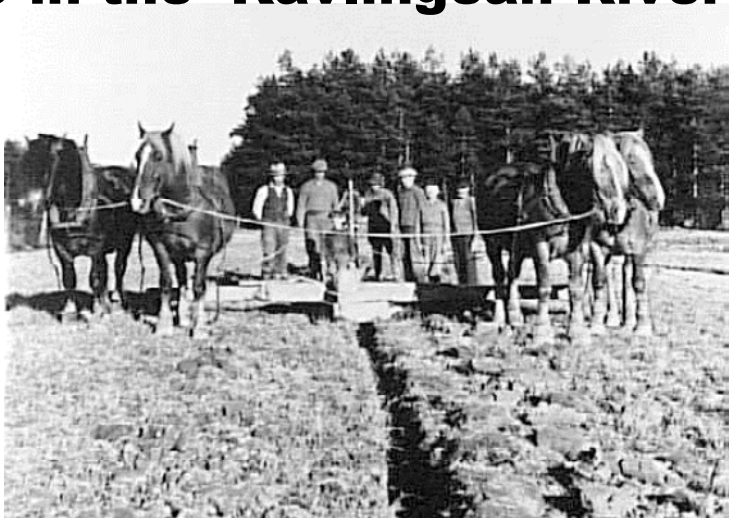
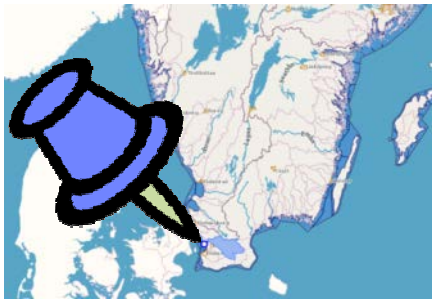


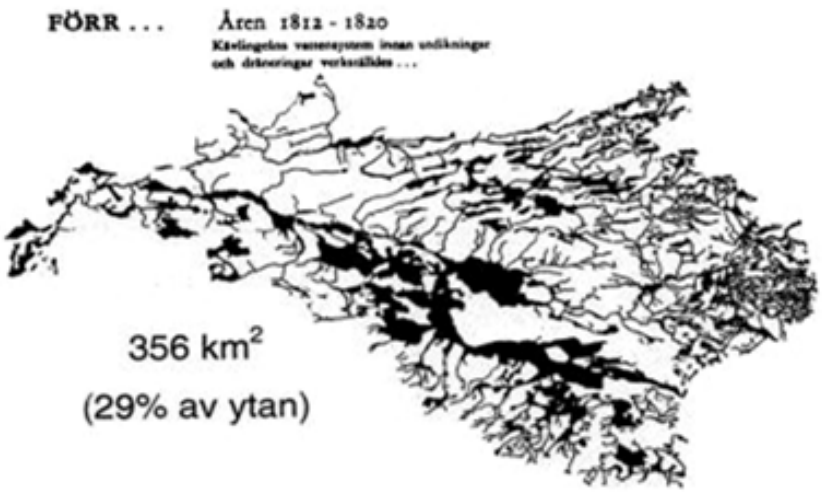
Land drainage in the Kävlingeån River





1812-1820

Wetlands = 29% of the catchment



1950-1953

Wetlands = 3% of the catchment

Source: Ph Wolf, Utdikad civilisation (1956)

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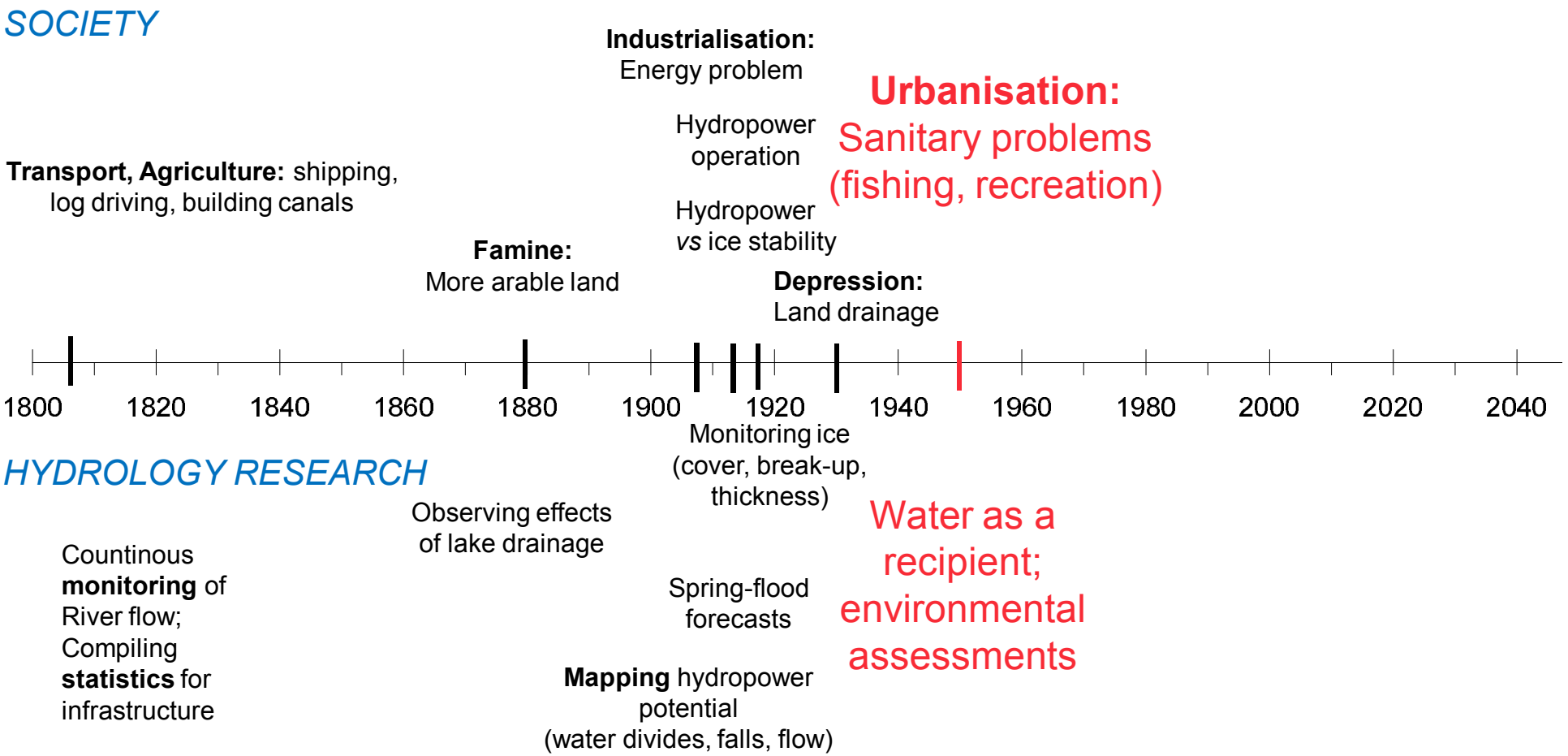

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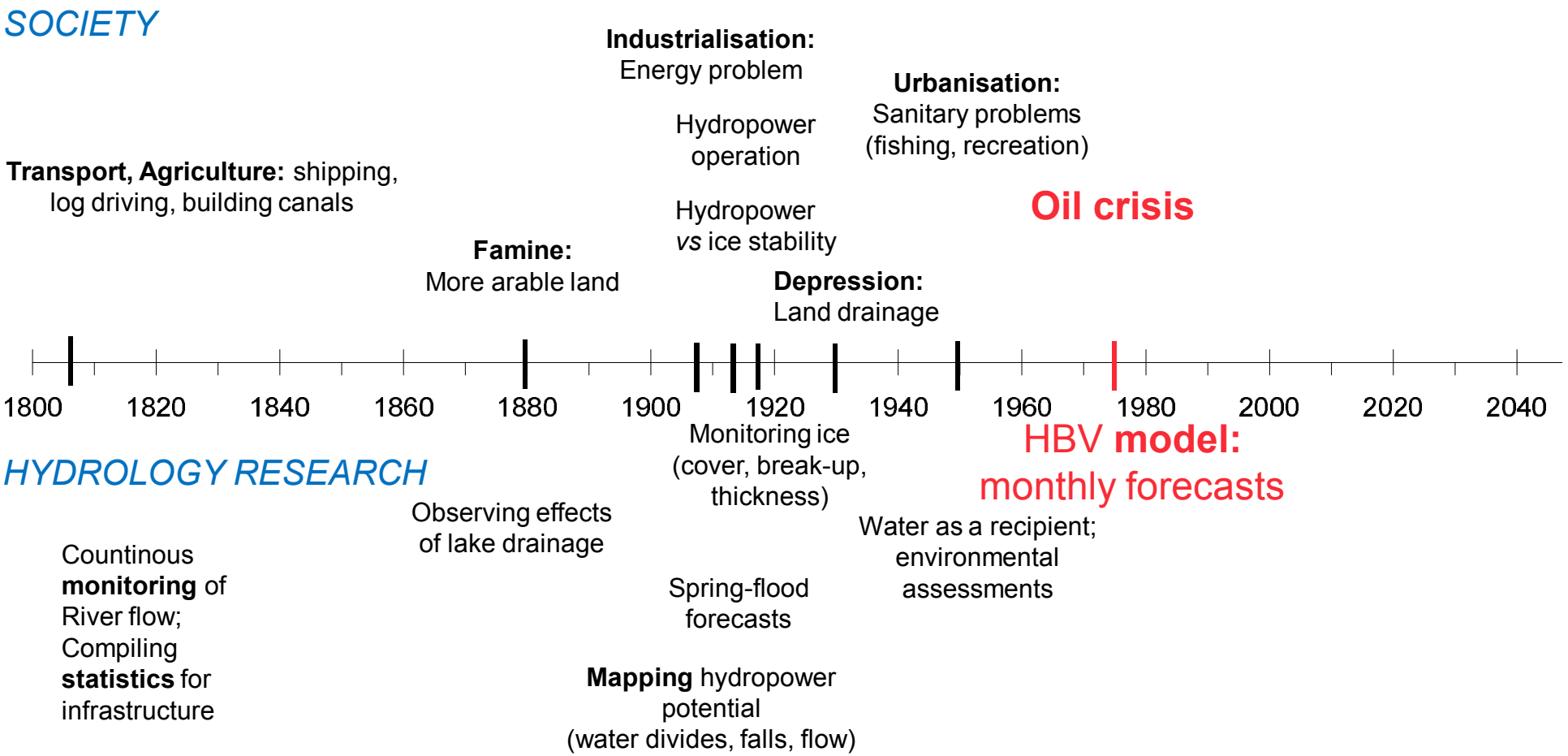
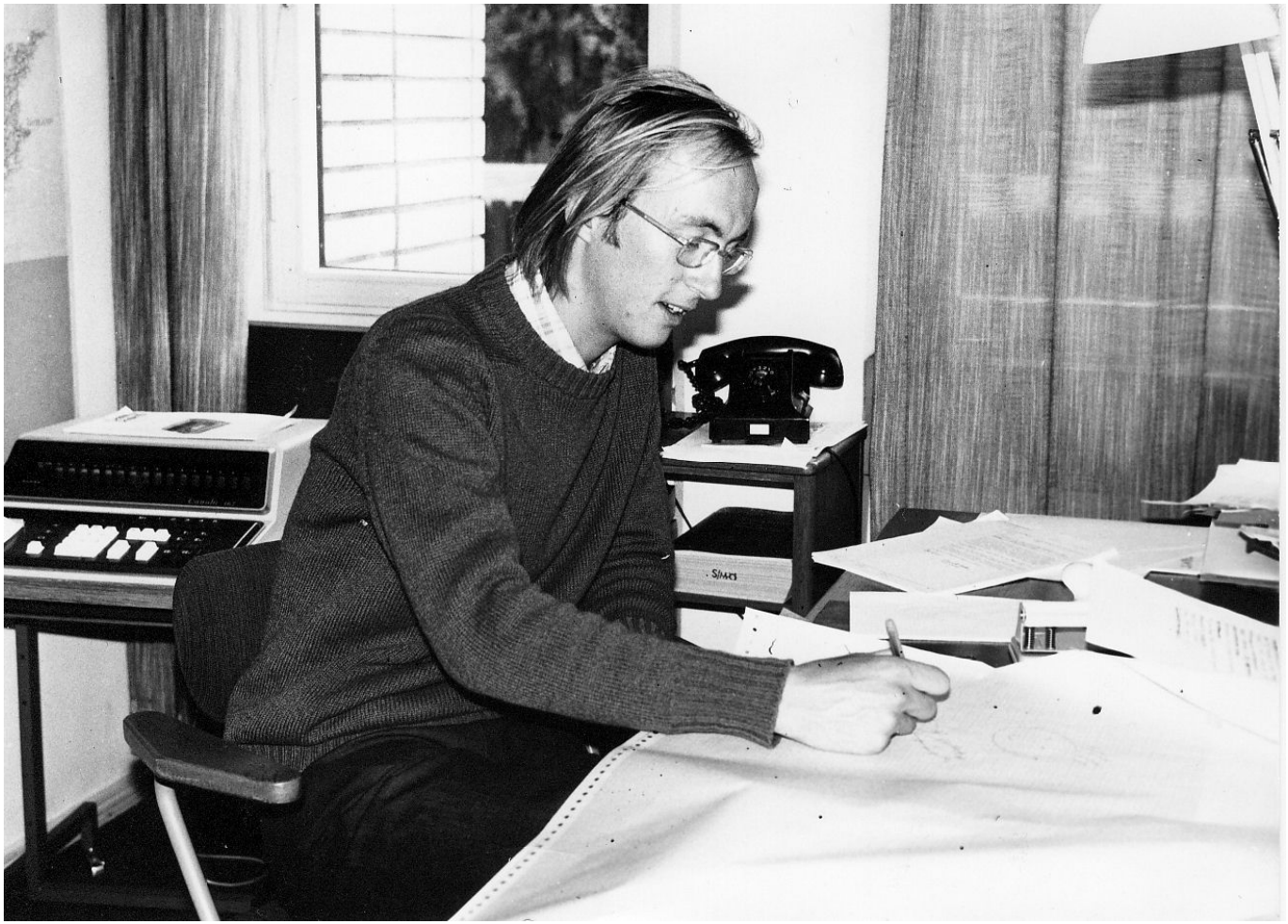
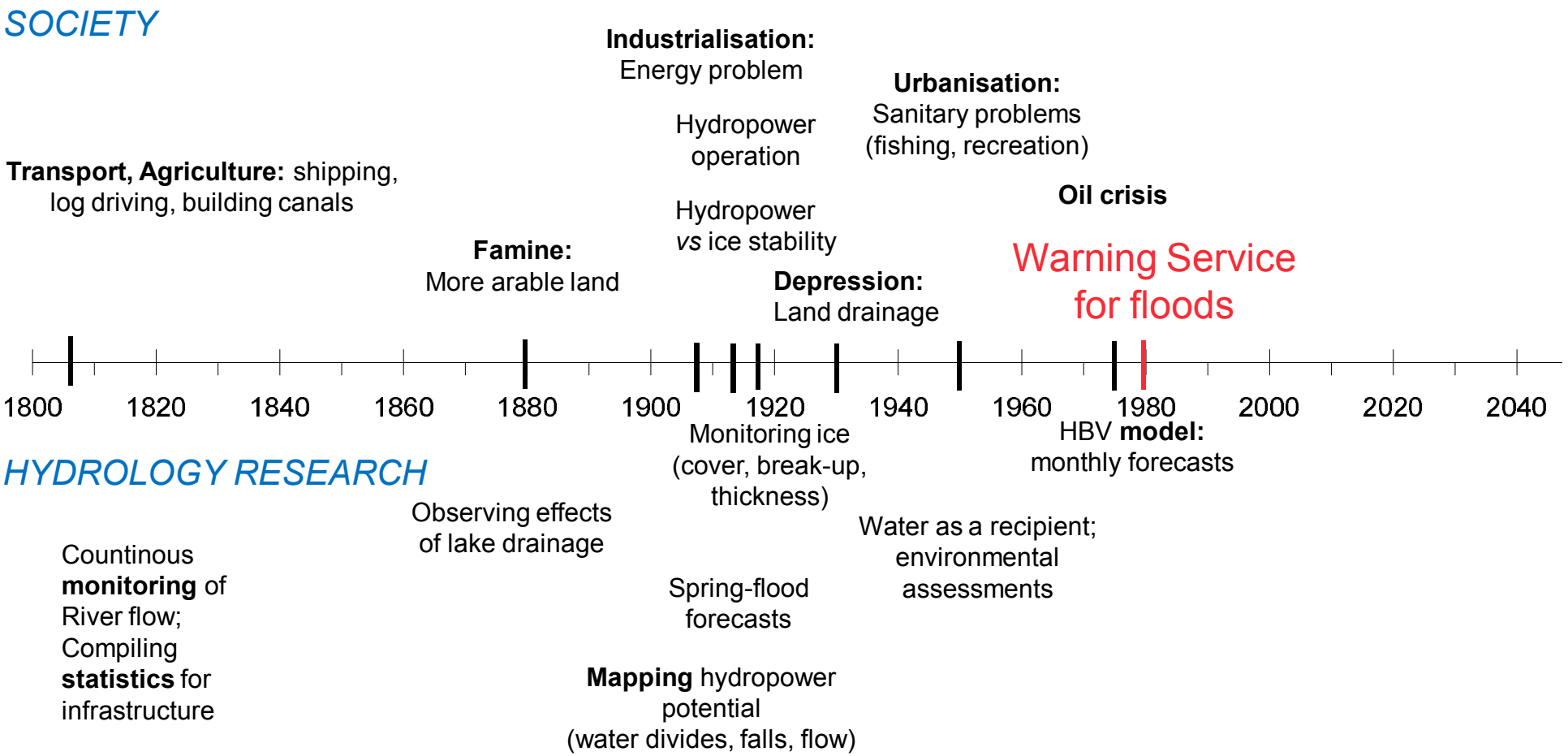


Sten Bergström, 27 yrs

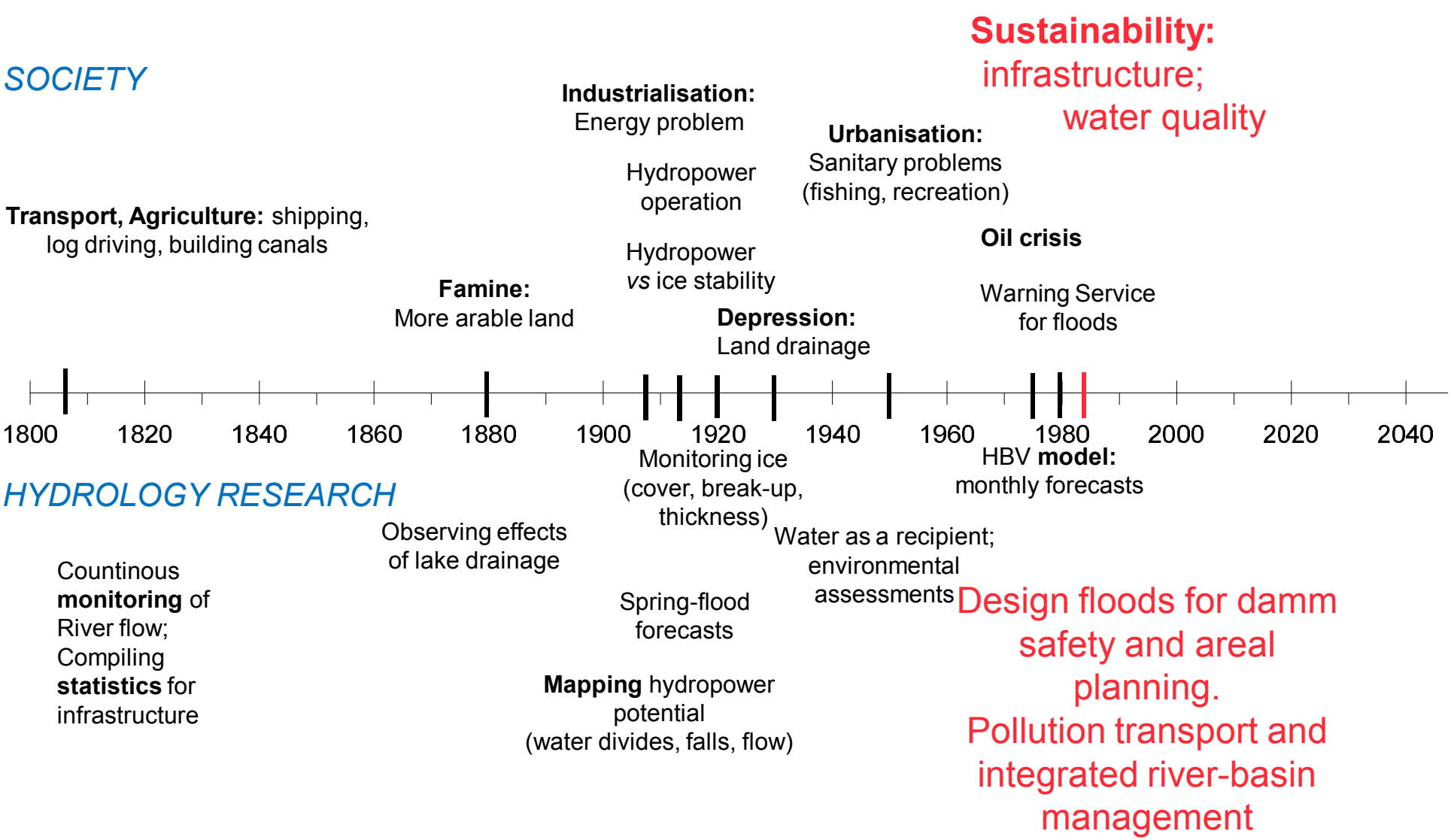


Bergström, S., 1976. Development and application of a conceptual runoff model for Scandinavian catchments. Norrköping: SMHI Reports RHO, no. 7.

SMHI - the story of changes in hydrology and society

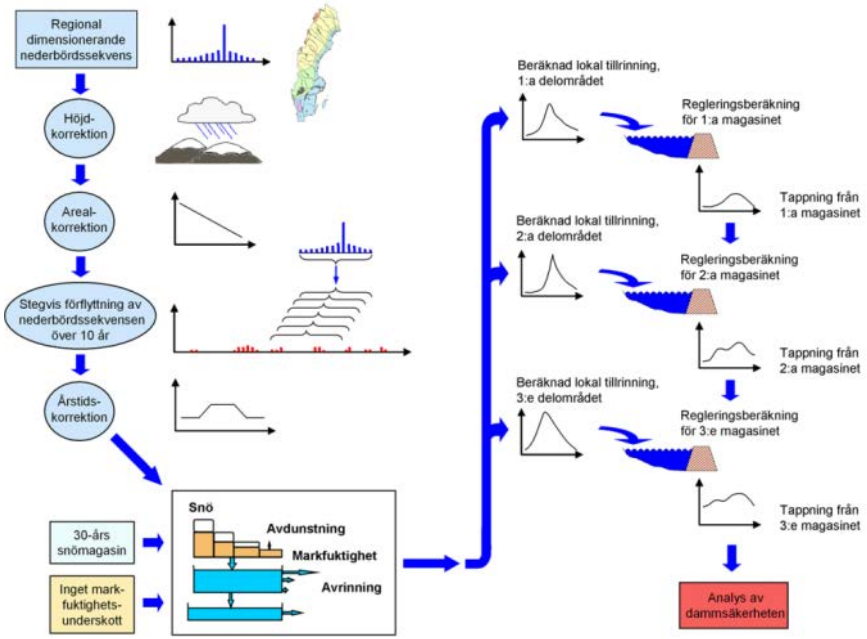


SMHI - the story of changes in hydrology and society



Noppikoski dam break 1985

Workflow for calculating design floods for hydropower dam safety



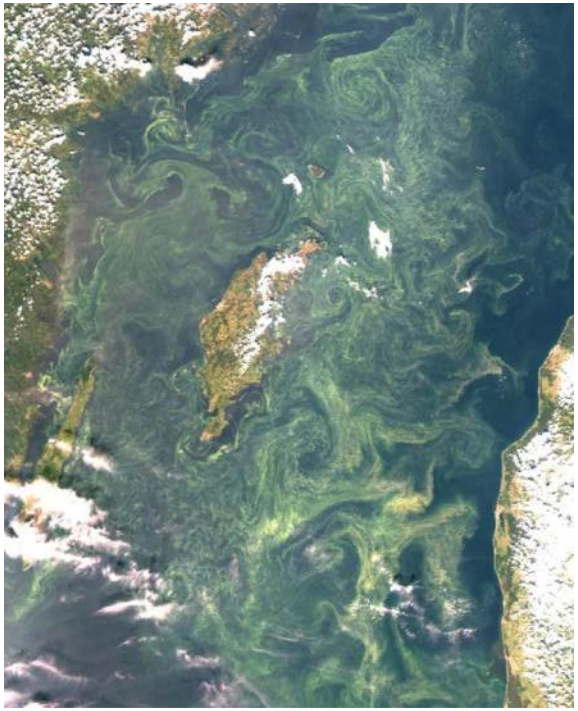
Diffuse pollution

1980's: Acidification

=> PULSE model

1990's: Eutrophication of Baltic Sea

=> HBV-NP model



Arheimer, B. and Brandt, M., 1998. Modelling nitrogen transport and retention in the catchments of southern Sweden. Ambio 27(6):471-480.

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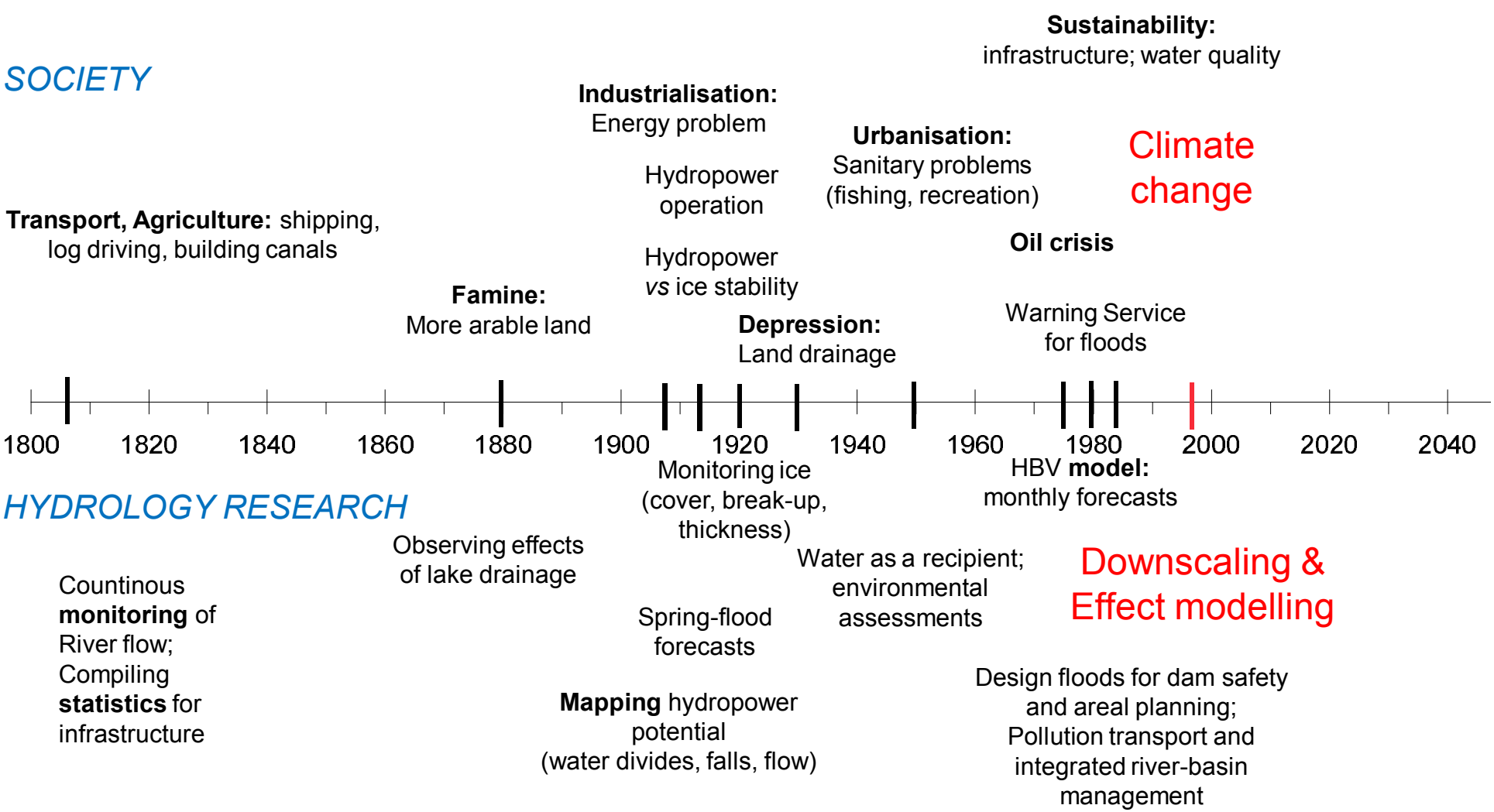
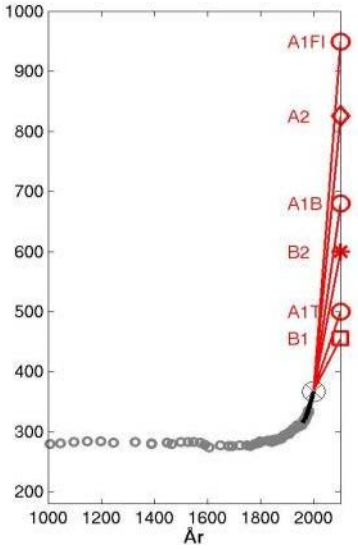
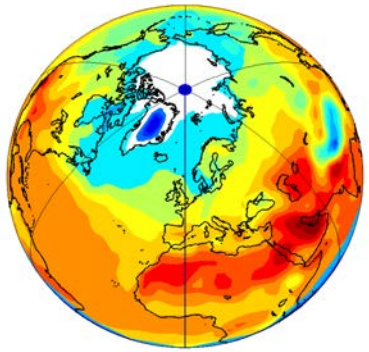


Workflow for climate change impact studies

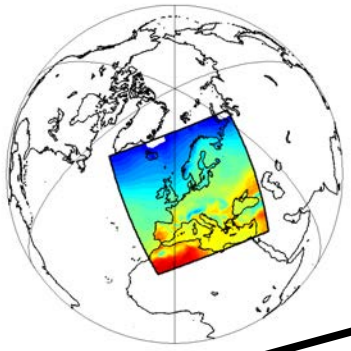
Emissions

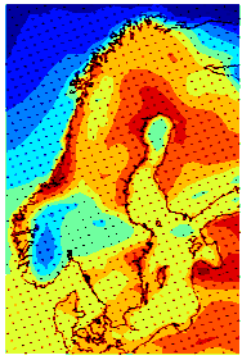


Global climate model



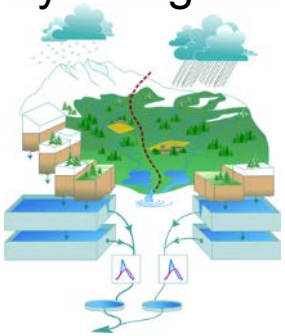
Regional climate model





scaling

Hydrological model



- Δ Water balance and river flow
- Δ Design variables
- Δ Nutrient fluxes
- Δ State variables

End-user dialogues

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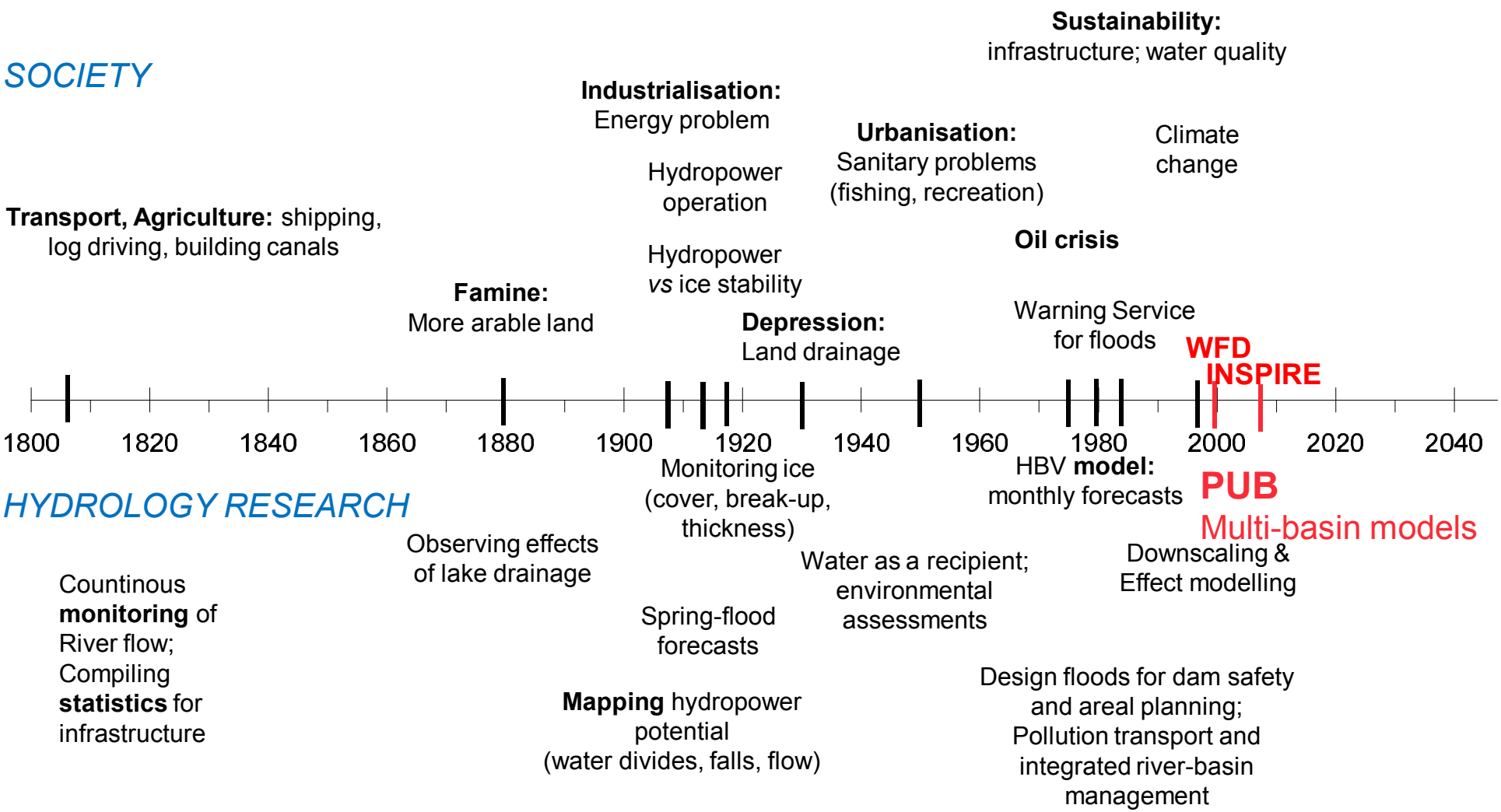
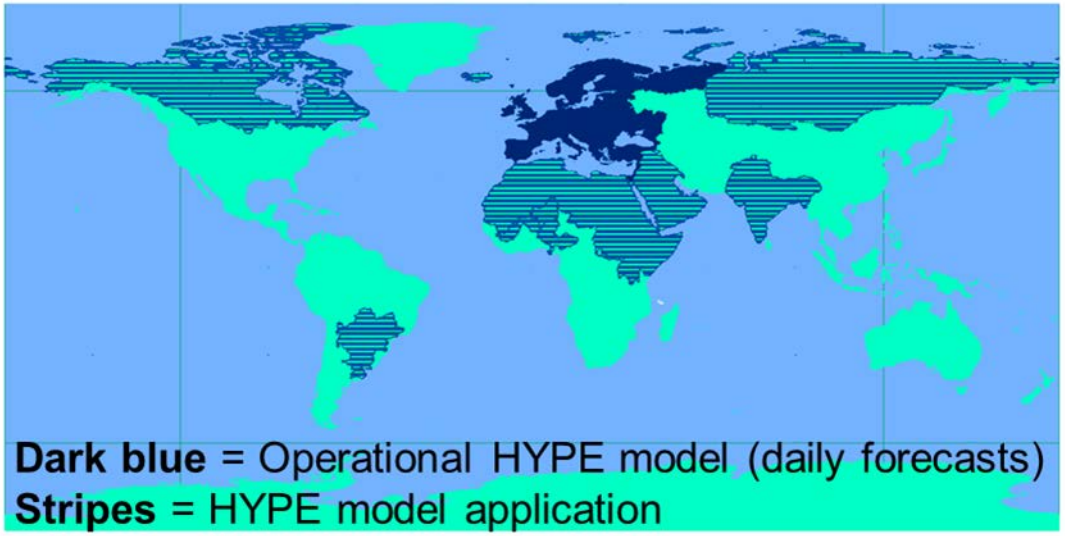


EU directives WFD + INSPIRE =

Predictions in Ungauged Basins *through* Large scale multi-basin modelling

http://vattenwebb.smhi.se/

http://hypeweb.smhi.se/

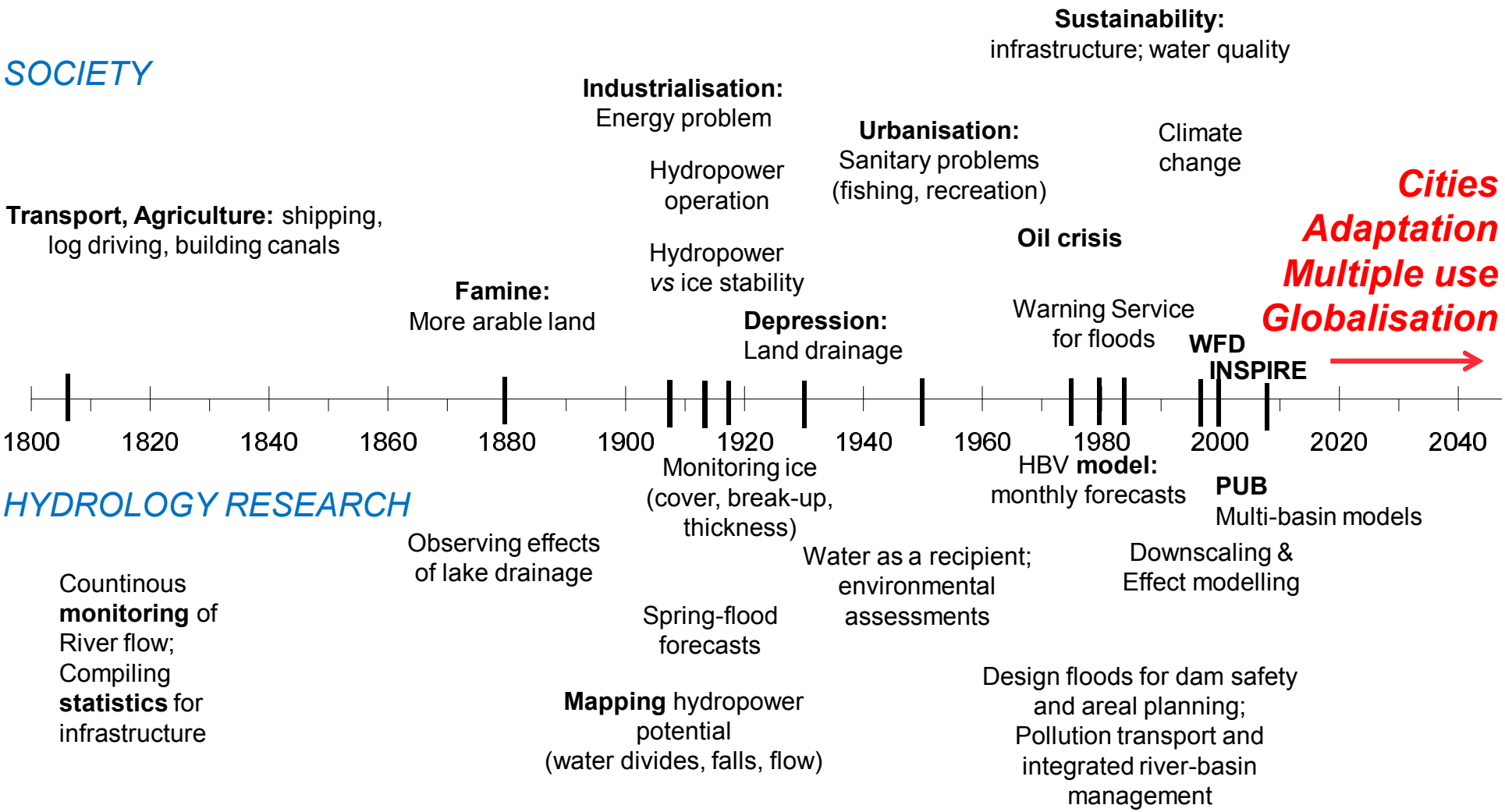


Case-study: SMHI

www.smhi.se

Result: I cannot reject the hypothesis that hydrologists are responsive to changes in hydrology and society

SMHI - future changes in hydrology and society?



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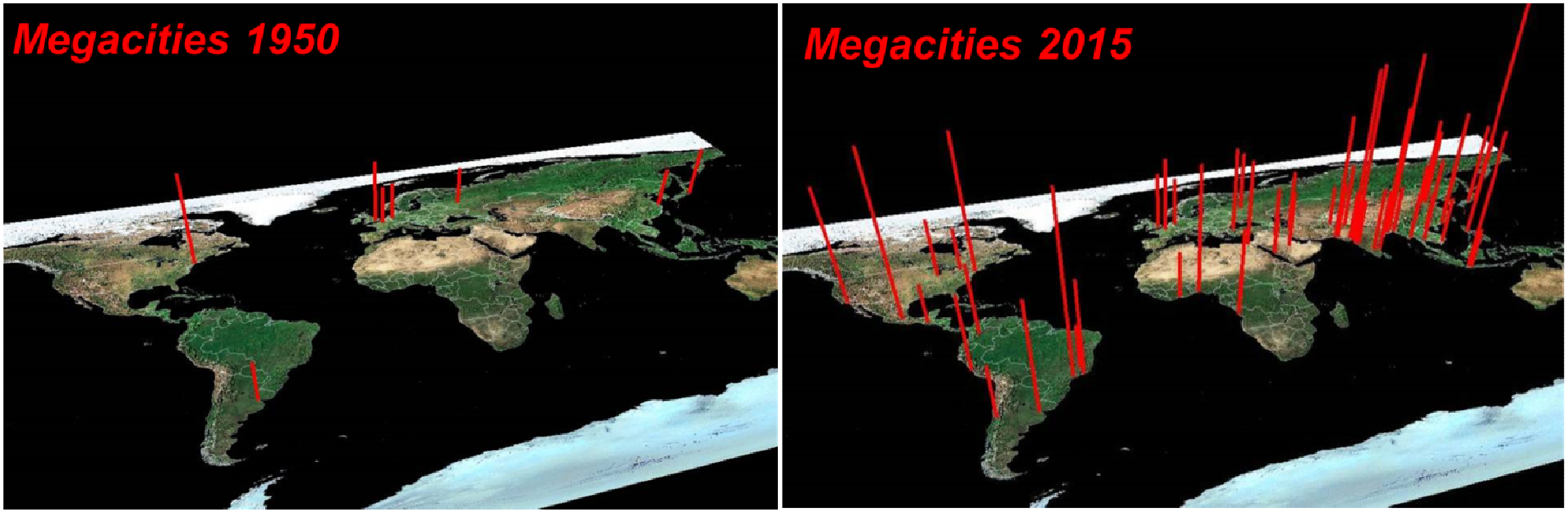
Megacities (>10 million inhabitants)**:**

Future societal needs will be linked to people's needs



Population world-wide in cities:

1950 30%

2007 50%

2030 60%

Source: U.N. Population Division

Copenhagen: 2 July 2011

150 mm of rain in 2 hrs - 1 billion Euro in insurance costs!

Adaptation – e.g. growing cities, more river flow *and* sea-level rise

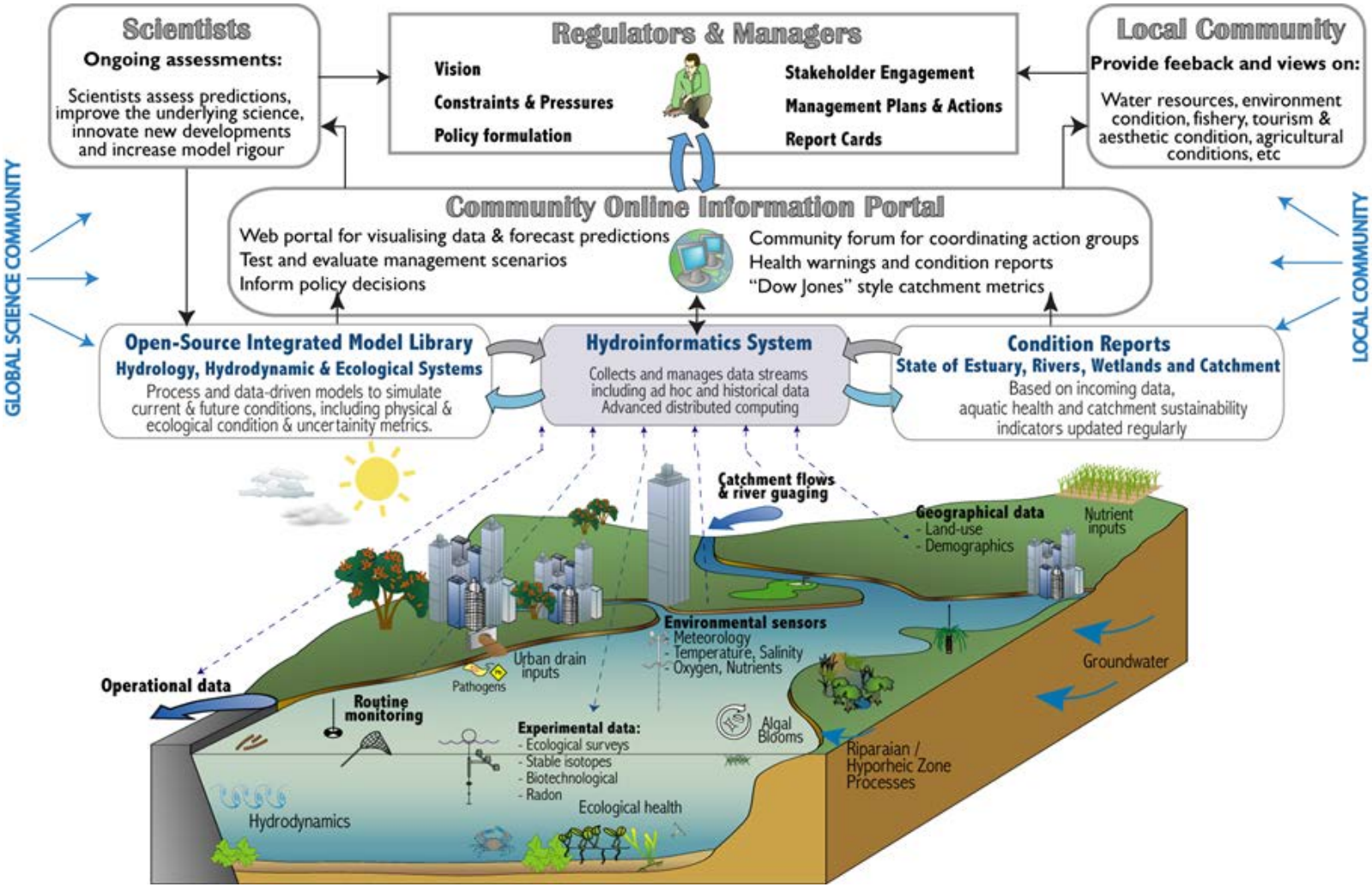
Rotterdam (Maeslant barrier)

Thames Barrier

St Petersburg

Stockholm ?

Multiple use: holistic view and knowledge sharing

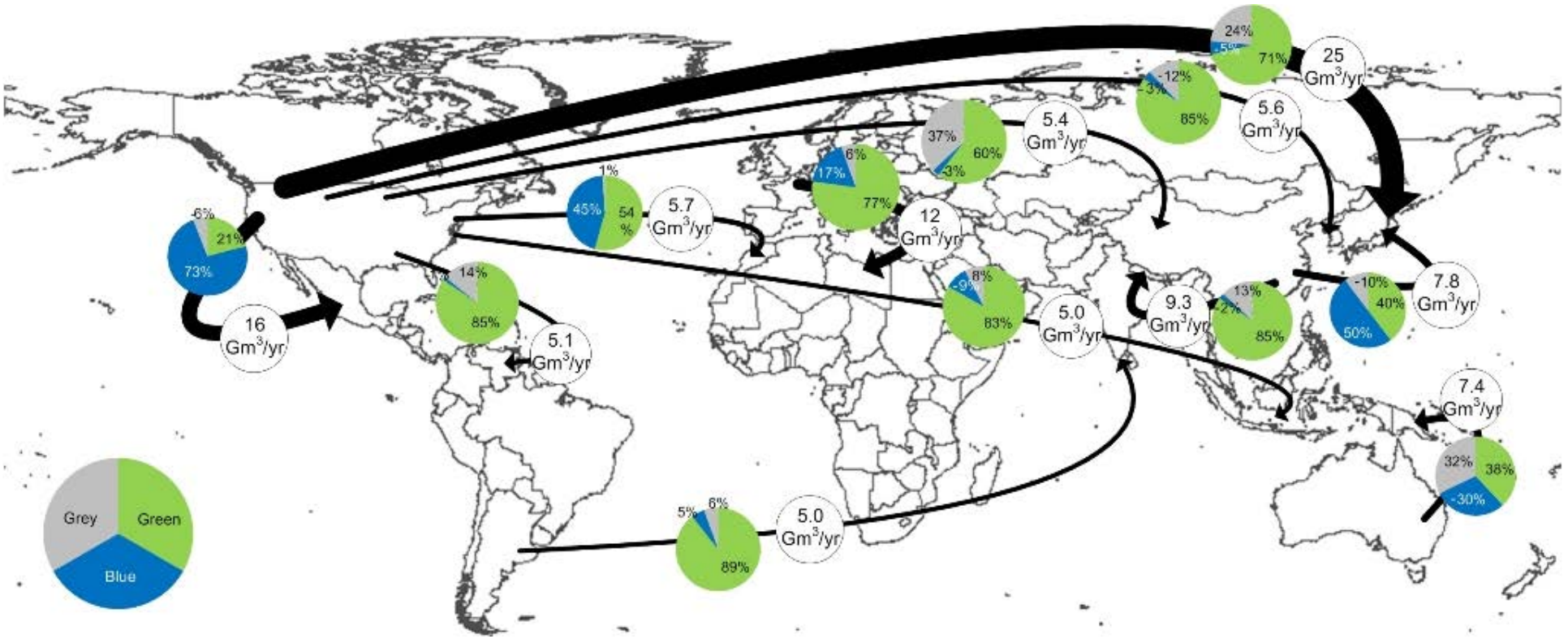


Hipsey, M.R. and Arheimer, B., 2013. Challenges for water-quality research in the new IAHS decade on hydrology under societal and environmental change. IAHS Publ. 361:17-29.

Globalisation

Water conflicts OR cooperation?

Global water savings associated with international trade in agricultural products (1996-2005).



Mekonnen, M.M. and Hoekstra, A.Y. 2011. National water footprint accounts: the green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No.50, UNESCO-IHE.

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Water research to support society

Scientists have choices in what role they play towards societal changes:

Pure Scientist **Does research, e.g. on whale migration. Has no connection to current decision context**	**Issue advocate** Recommends a specific decision, e.g., no more than 1,000 whales should be taken per year.
Science Arbiter **Answers questions posed in decision context, that can be resolve empirically, such as, how many whales are their in the ocean? Nebulous, value-laden terms like "damage" are to be precisely specified or avoided in the process of formulating questions**	Honest broker **Provides a set of options and their consequences. E.g., Taking 0 whlaes has these consequences, taking 0-400 these, >400 these, and so forth. Consequences should be defined broadly, to include the set of relevant values at stake, e.g., environmental economic, political, etc**

Roger A. Pielke, Jr. 2007. The Honest Broker: Making Sense of Science in Policy and Politics. Cambridge University Press

Conclusions

- 'Times they are a changing' but all changes are not necessarily all bad – ***Don't panic!***
- Hydrologists have long records of tackling changes in hydrology and society – ***We can make it again!***
- It's time to include humans in hydrological models or analysis, AND become aware of scientists' roles for decision-making – ***We can make a difference!***