CLIMATE DRIVEN TRENDS IN DANISH RIVER FLOW –AND SOME EFFECTS ON NUTRIENT LOADS TO THE SEA

INSTITUT FOR ECOSCIENCE
AARHUS UNIVERSITET

CLIMATE THURSDAY
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RIVER FLOW AS A CLIMATE CHANGE INDICATOR

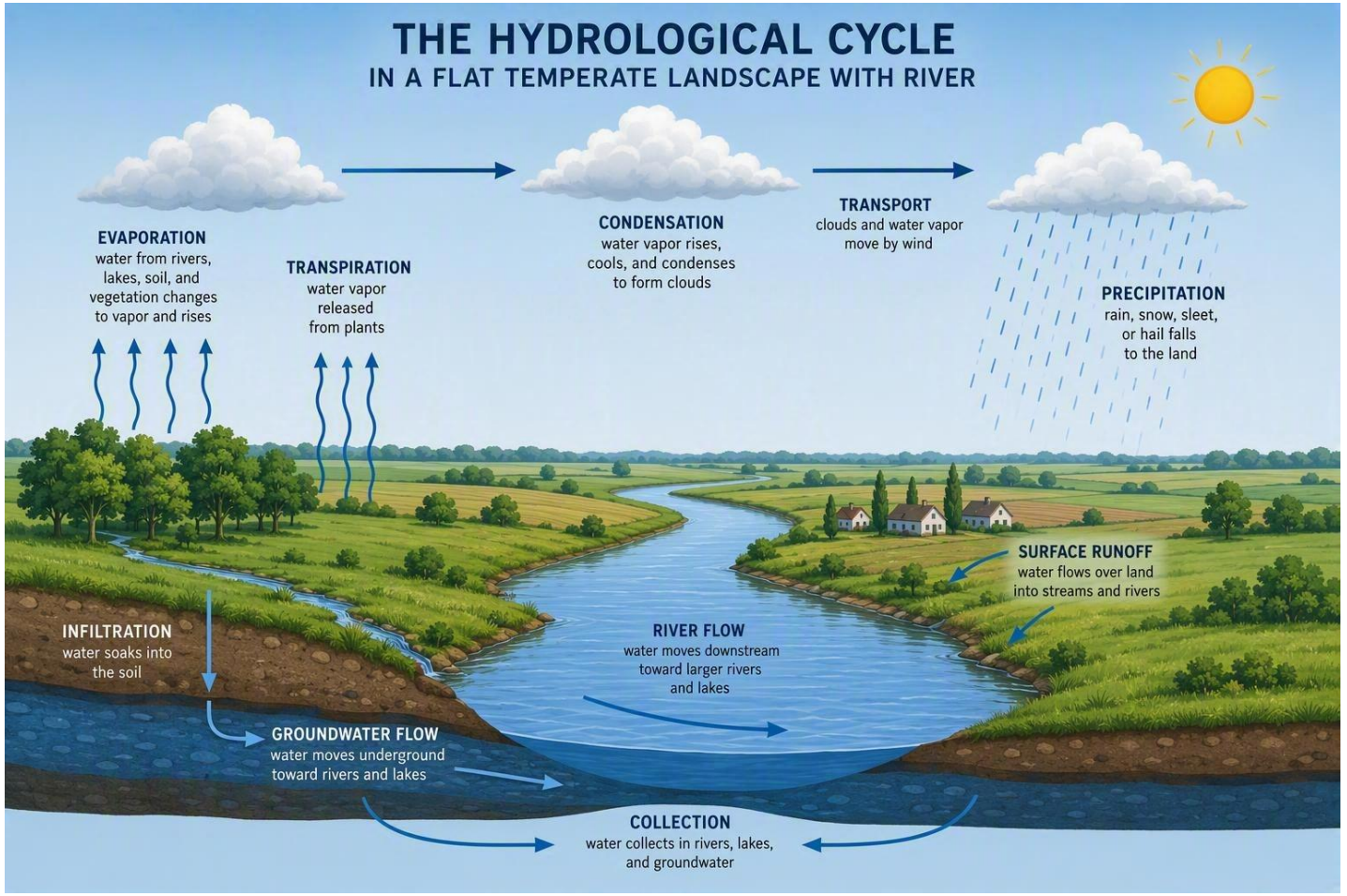
The river water flow integrades the hydrological system. Gives the integraded effect of changes in precipitation and evapotranspiration.

Changes in precipitation will have a direct effect on the riverflow. However, timing matters.
-changes in winter precipitation have more effect as the evaporation is low.

-land cover changes will affact the hydrological cycle through changes in evaporation

- Fx afforestation will lower the river flow as it increases the evaporation
- Urbanisation usually increases riverflow as hard surfaces reduces evaporation

In a Danish setting the pricipitation is the dominant parameter



THE PAST

DANISH RIVER FLOW SINCE 1990

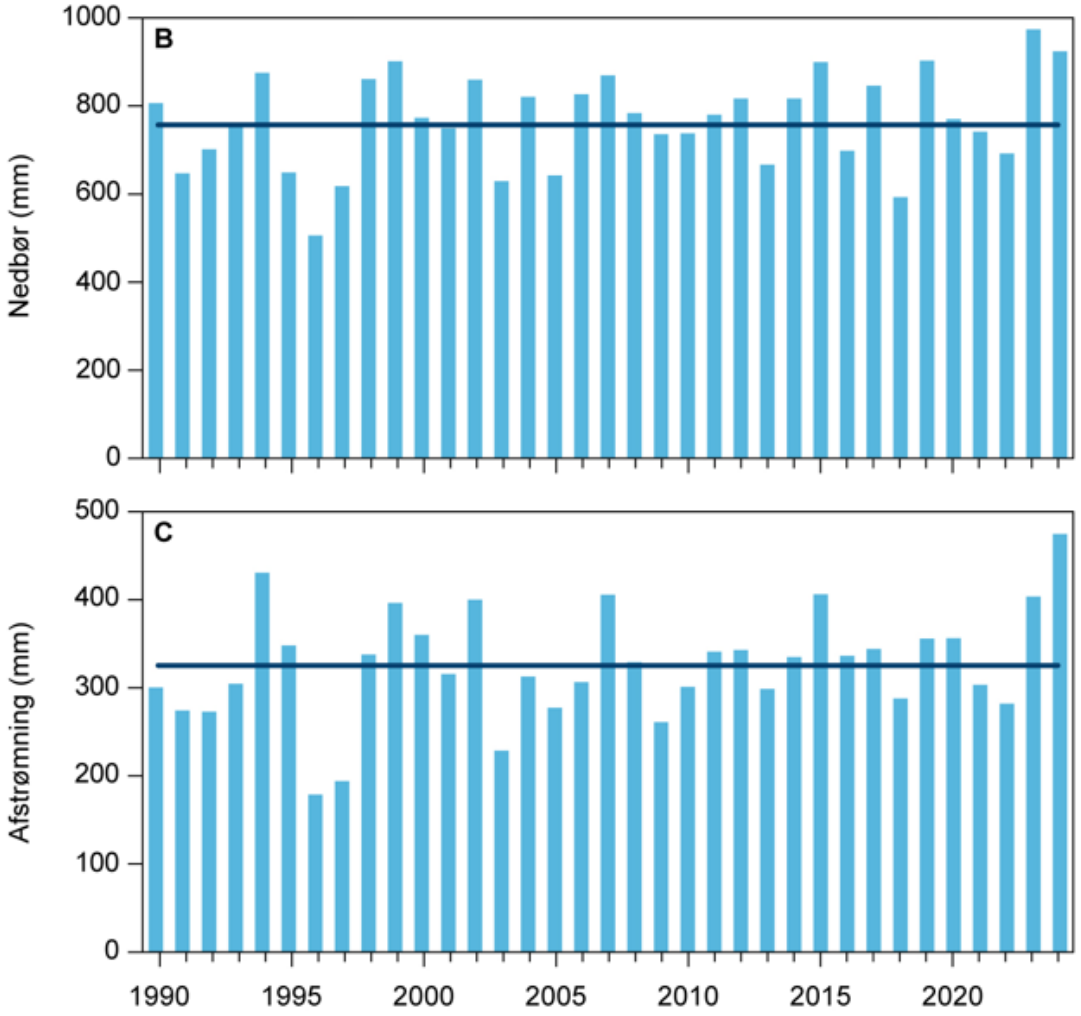
An assessment of the annual riverflow to the sea is made each year.

-Meassurements made by the EPA (SGAV) – modelling by GEUS (geological survey) and assessment by Aarhus University.

Measured for about 60% of the land area.

Average runoff 1990-2024 327mm/yr

About 42% of the precipitation leaves the land as river flow (58% evaporates)

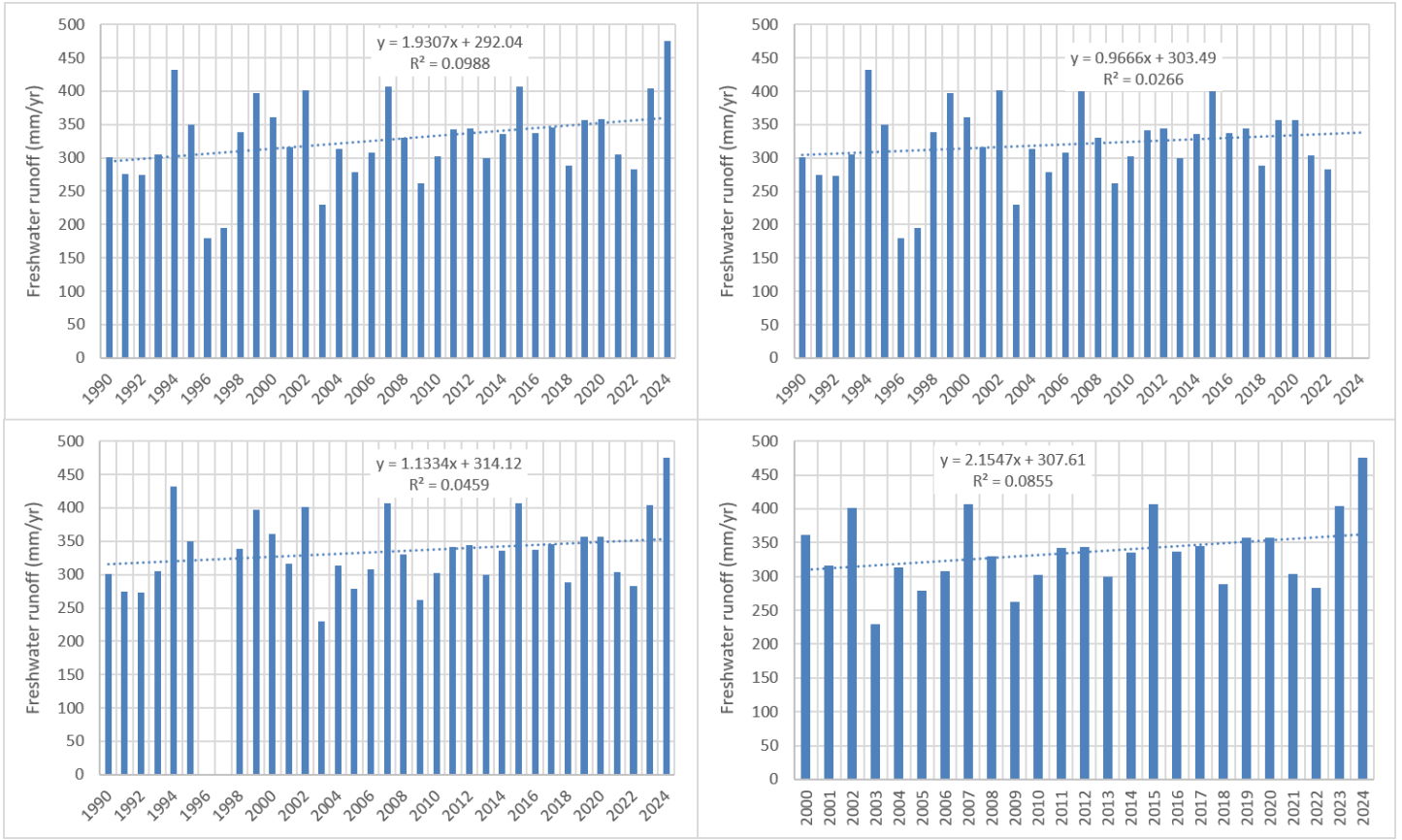


TREND

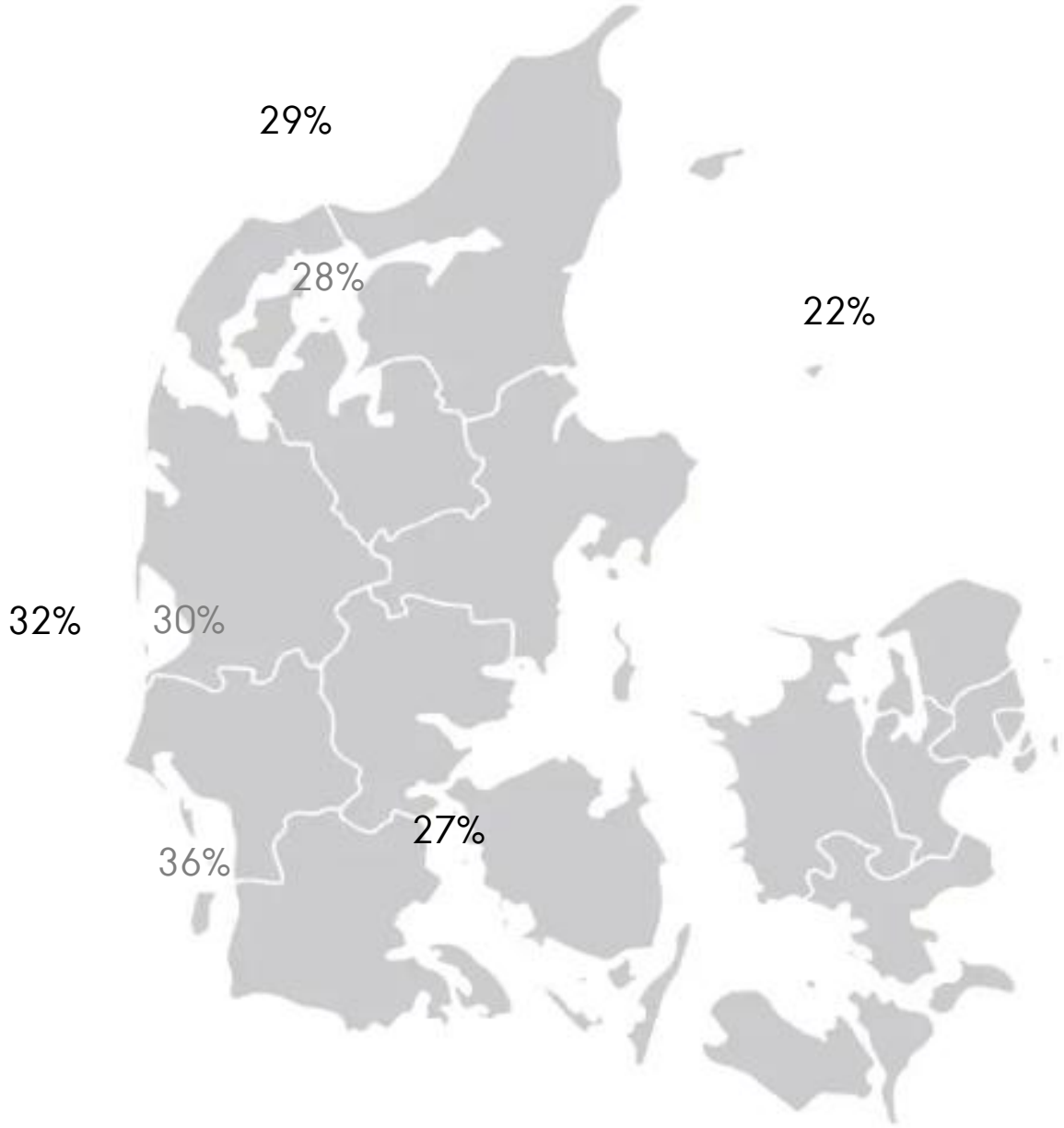
Is there a trend/development over time

- the record-high runoff in 2024 tiped the scale towards a significant (P<0,05) trend of 22% increase

- but a few dry years might make the trend unsignificant again



GEOGRAPHICAL TRENDS SINCE 1990



LONGER TIME SERIES

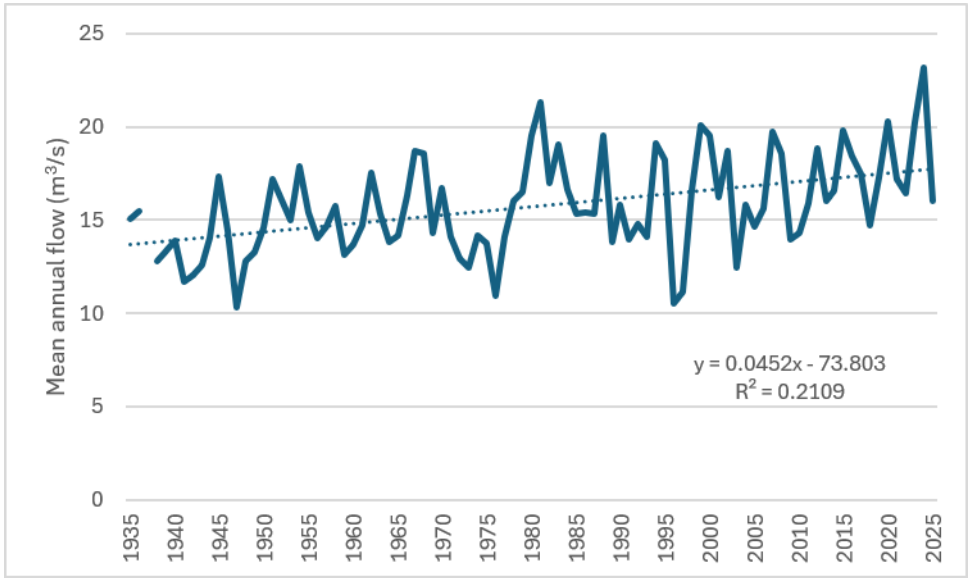
Time series >100 years exists. Can be found on https://odaforalle.au.dk/ (english version underway)

- Methods of measuring streamflow has changed over time and methods of converting spot measurments and water level registrations has also developed a lot over time

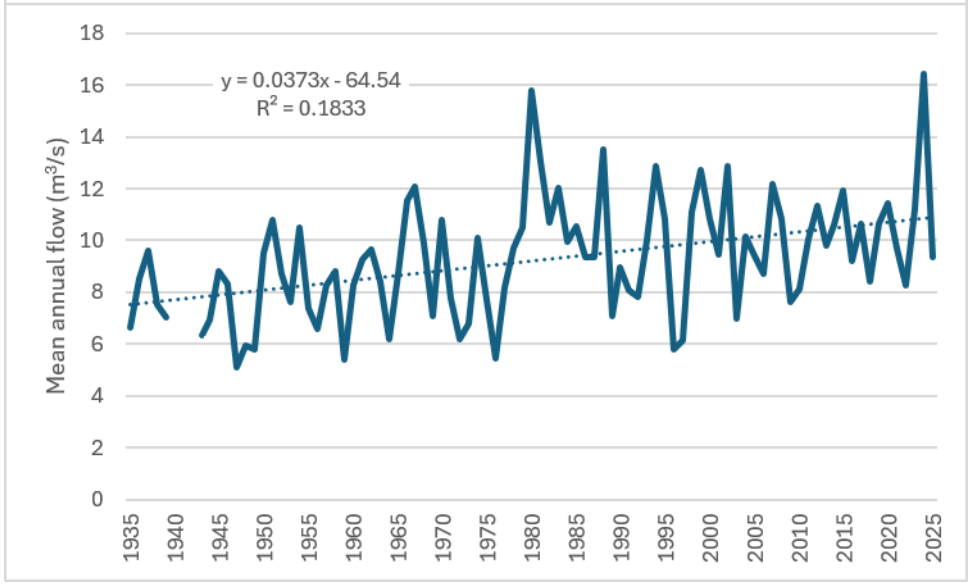
=> inconsistent methodolegy effects the results

WEST

Skjern river

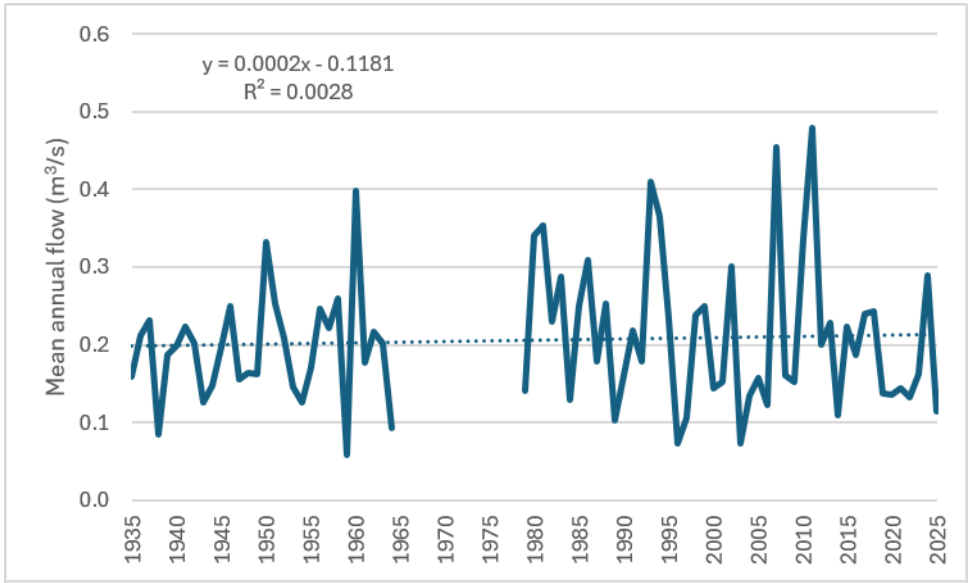


Ribe River

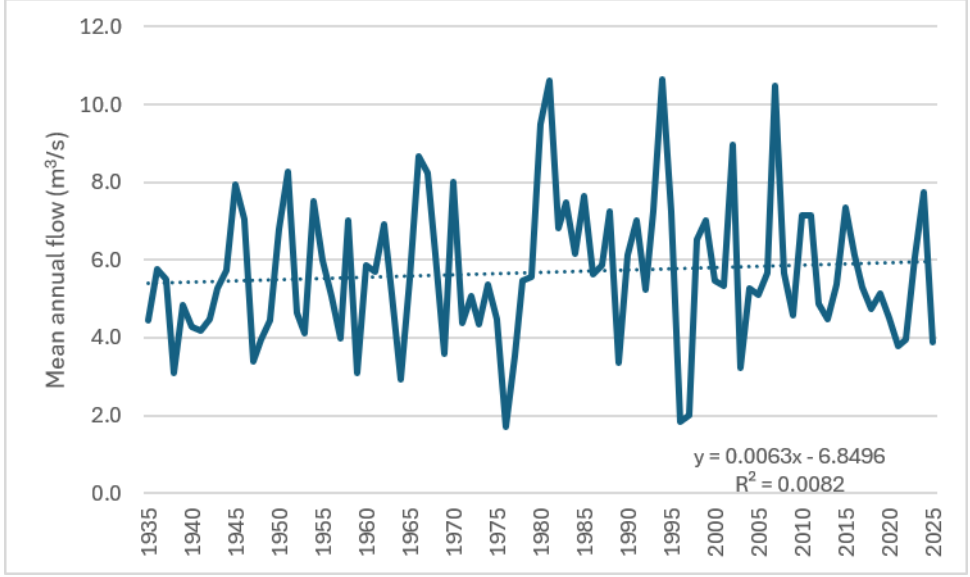


EAST

Tingsted river (Falster)



Suse River

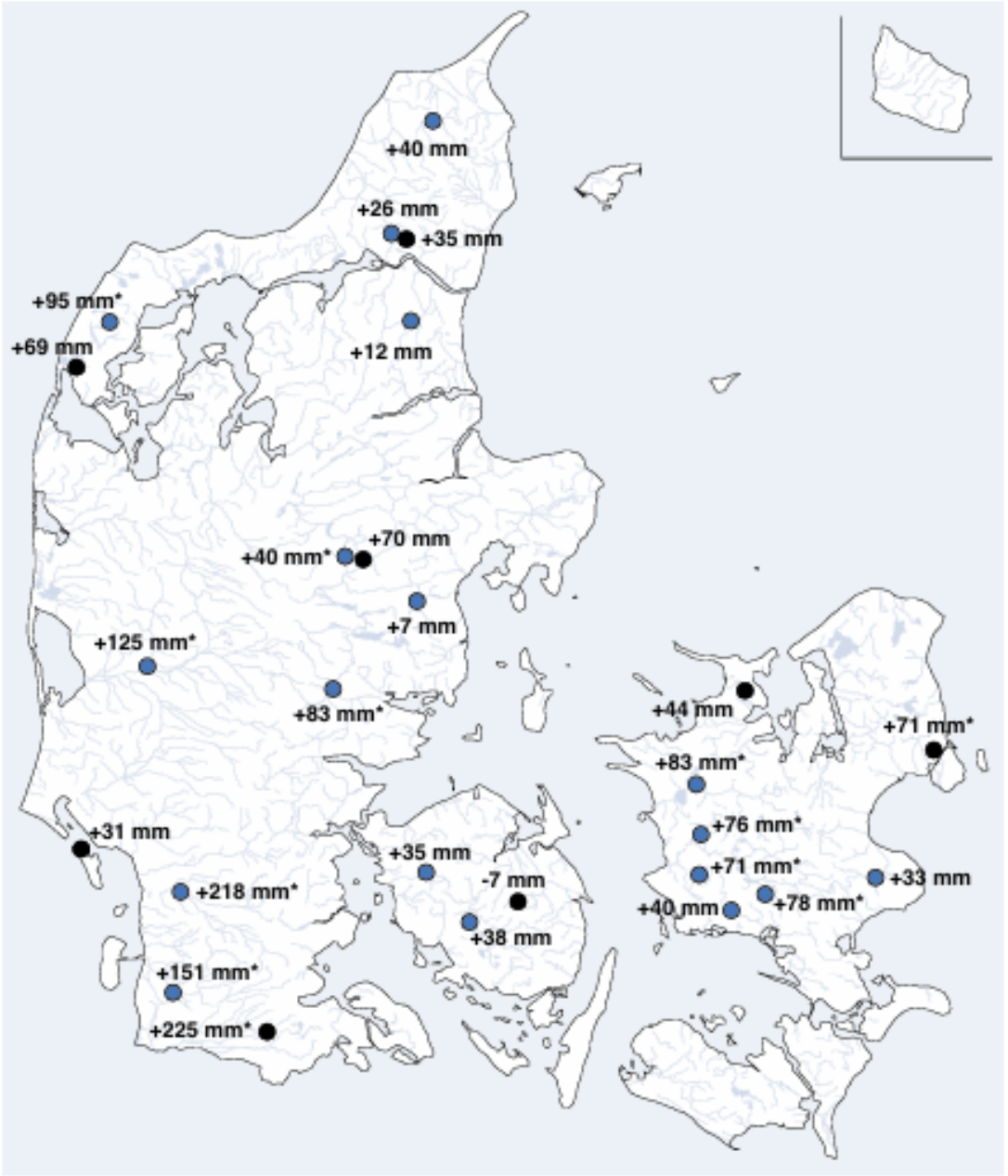


20TH SENTURY

Analysis of long time series of river flow and precipitation (1917/1936 – 2001).

Shows increases in both precipitation and river runoff during the 75 year period.

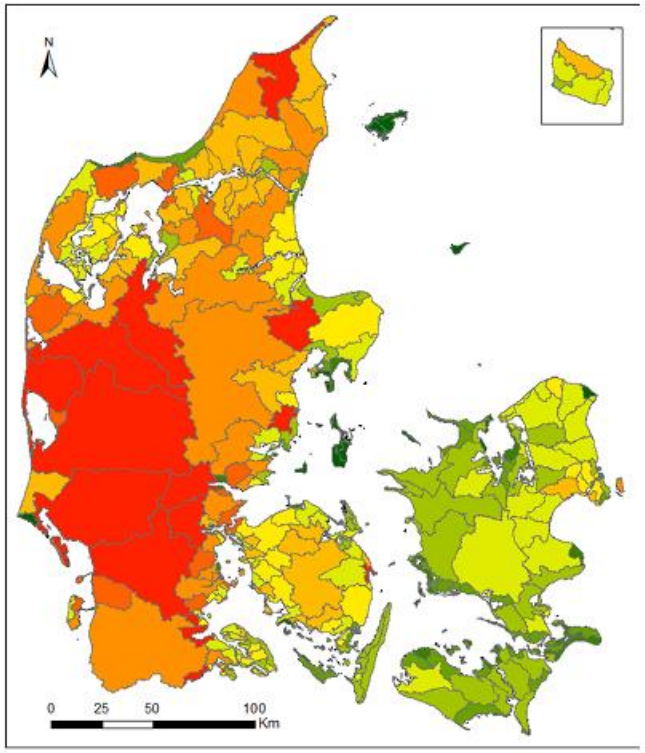
- Most in the south west
- Least in the middle

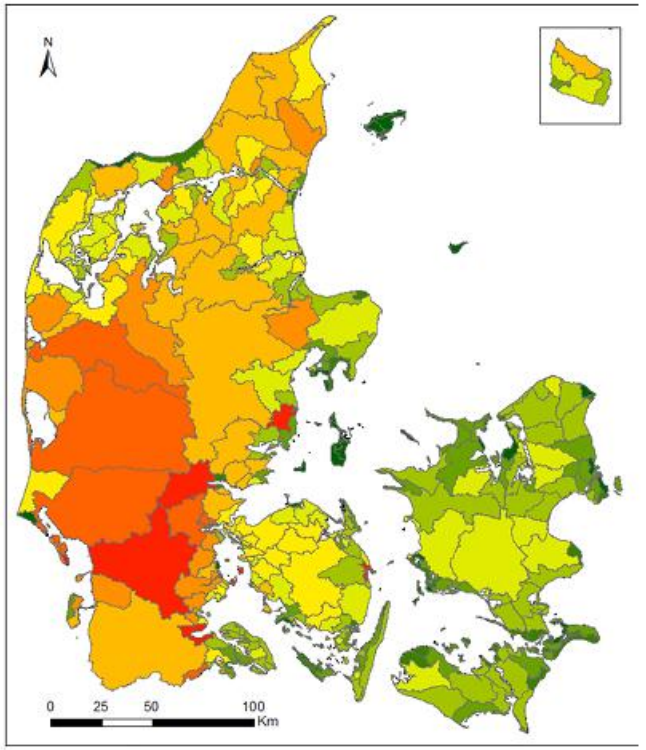


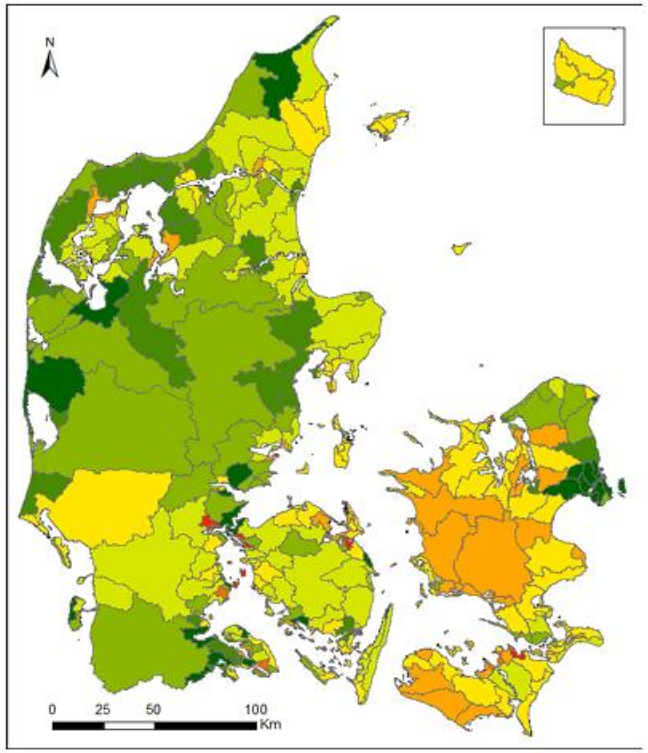
Figur 5. *Stigningen i årlige afstrømning og årlig nedbør beregnet over en 75 års periode ved de 18 vandløbsstationer (omregnet til mm) (blå cirkler) og de 8 klimastationer (sorte cirkler). Statistisk signifikante ændringer (P < 5%) er vist med en stjerne efter tallene i figuren.*

YEAR 1900

We modelled the stream flow in year 1900 based on historical climate data







Discharge present (mm/yr)

< 50	250 - 300
50 - 100	300 - 350
100 - 150	350 - 400
150 - 200	400 - 450
200 - 250	> 450

Discharge 1900 (mm/yr)

< 50	250 - 300
50 - 100	300 - 350
100 - 150	350 - 400
150 - 200	400 - 450
200 - 250	> 450

Change in discharge (mm/yr)

< -100	-25 - 0
-100 - -75	0 - 25
-75 - -50	25 - 50
-50 - -25	> 50

CONCLUSIONS

Stream flow in danish water courses has generally

- Increased since 1900 years for most of the country and for the period with measurments since about 1920

- Increased in the western & northern part since 1990
- No real trends in the central and eastern part since 1990

THE FUTURE

FUTURE STREAM FLOW

Future streamflow is studied by taking results from climate models and running it through a hydrological model that converts precipitation and other wether parameters into stream flow.

Climate model => hydrological model => stream flow

The change in stream flow over time is found by comparing with comparable stream flow from a historical time period

There are different techniques for making this comparison.

Climate model data ”down scaled” and made ”realistic” in order to produce realistic future stream flows.

SOME DANISH STUDIES

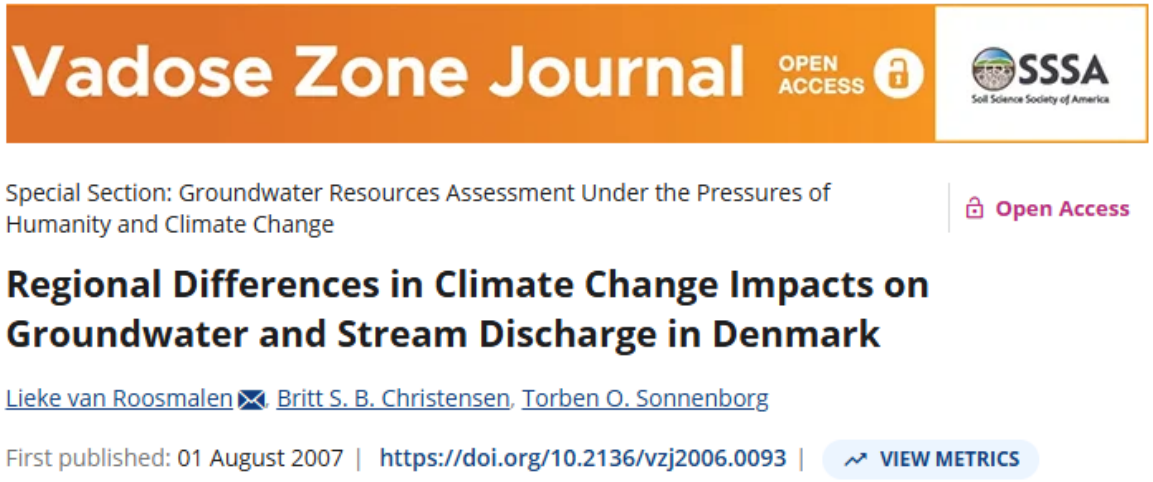
Started with studies of just the stream flow and differences cross the country

Different climate models yields different results

Different scientifoc tethods yields different results

Different hydrological models yields different results

Hydrological models: NAM, MikeShe (DK-model), SWAT, are the most used in DK



SOME RESULTS - ON THE 2071-2100 PERIOD

For Denmark an projected increase in precipitation of 6-7% yeilds an increase in stream flow of about 14%

Discharge exceeded in % of time	River Grindsted at Egbro Δ%	River Odense at Nørre Broby Δ%
0.1	25	12
1	20	11
5	16	17
10	13	21
90	5	−20
95	9	−31
99	10	21
99.9	16	81

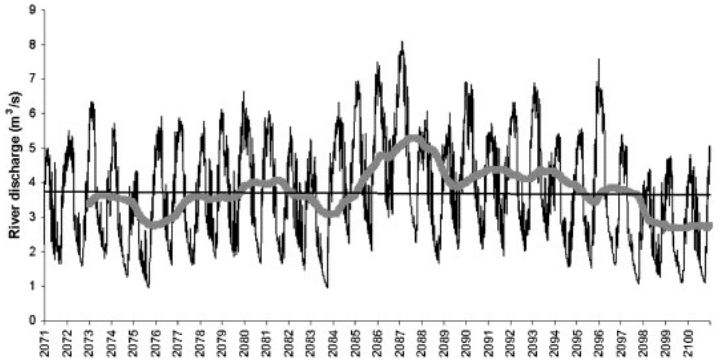


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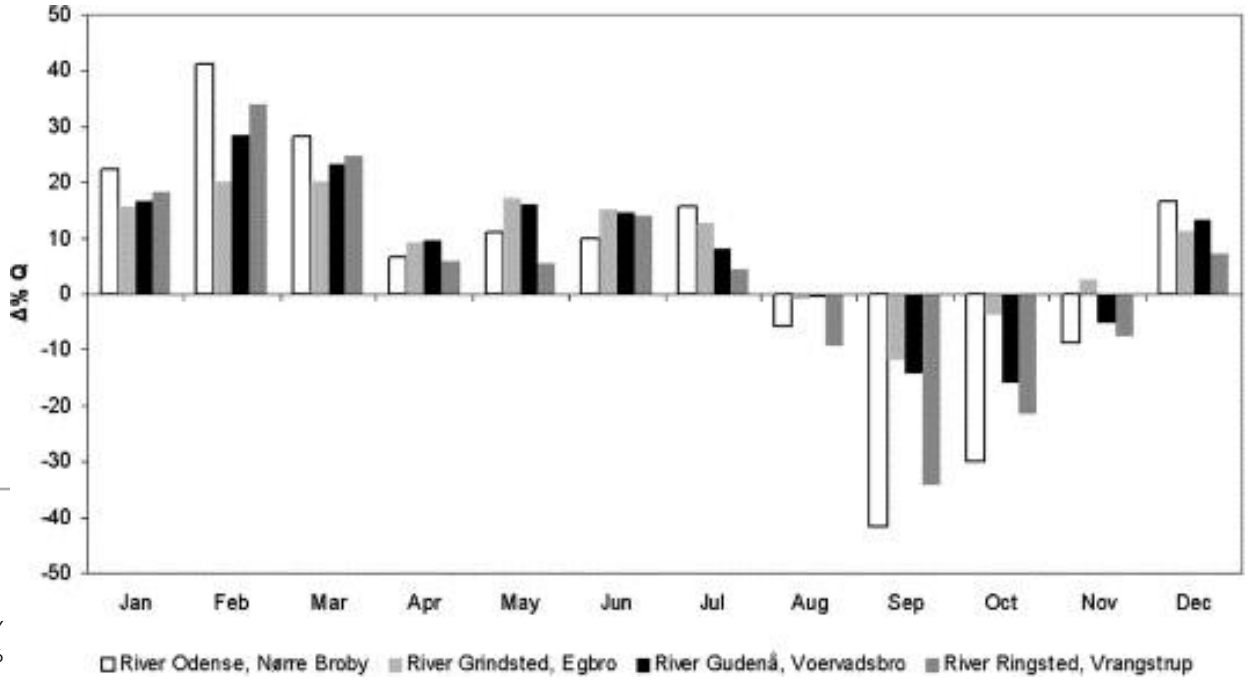
Figure 7. River discharges at Egbro River Grindsted (River Varde) for the scenario period (2071–2100). Straight line is the 30 year trend showing a slightly decreasing tendency, grey line is a 2 year moving average.



GEOGRAPHICAL VARIATION

The geographical variation projected by climate model with increases in stream flow in the west and the north - and no/little development in the central and eastern part is a continuation of the trends seen over the past 35 years and to some degree during the past 125 years.

STUDIES ON EFFECTS OF CHANGES IN STREAM FLOW

Next steps were to study the effects of altered stream flow on other things:

Examples on

- sediment transport

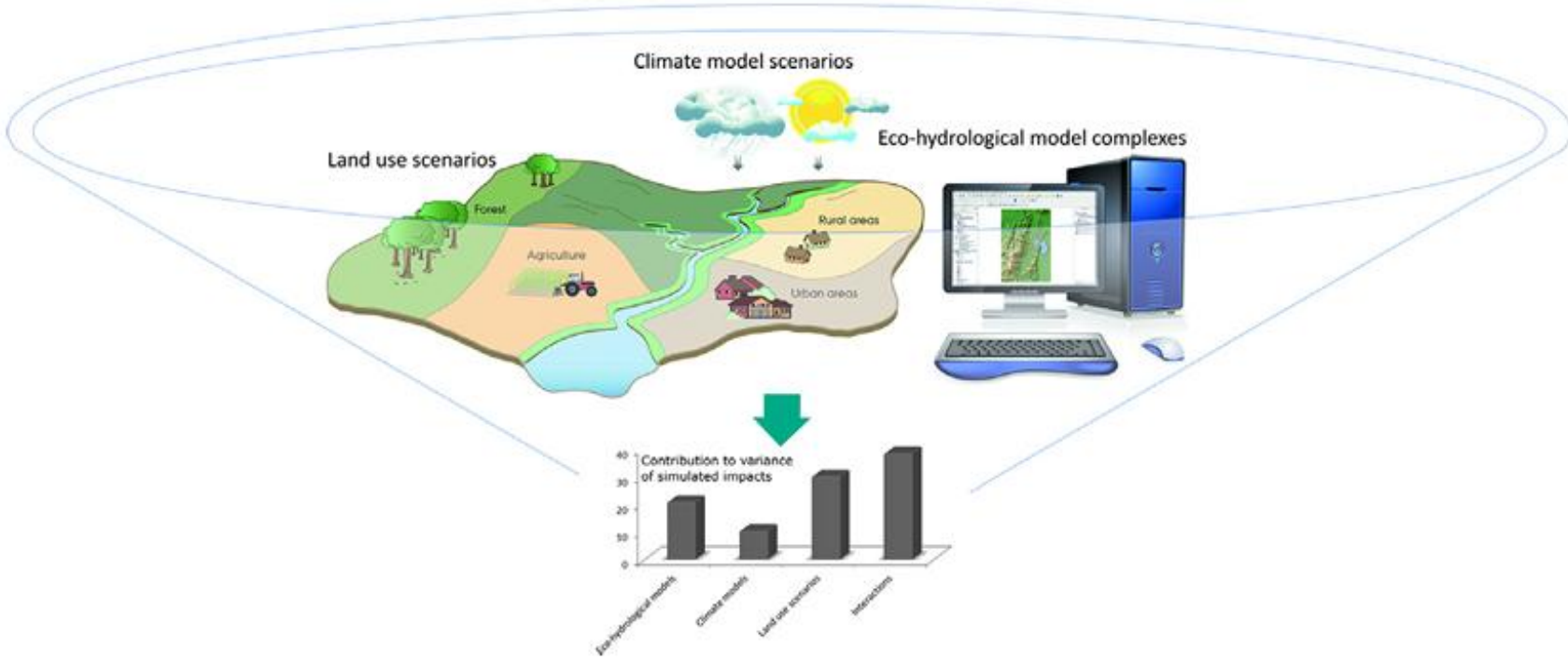
- effect on flooding and in the case below the effects of changed flooding on habitats in the river valley

NUTRIENTS

COMBINE CLIMATE CHANGE SCENARIOS WITH OTHER CHANGES

The next step was to combine climate change effects on the hydrological system with other changes

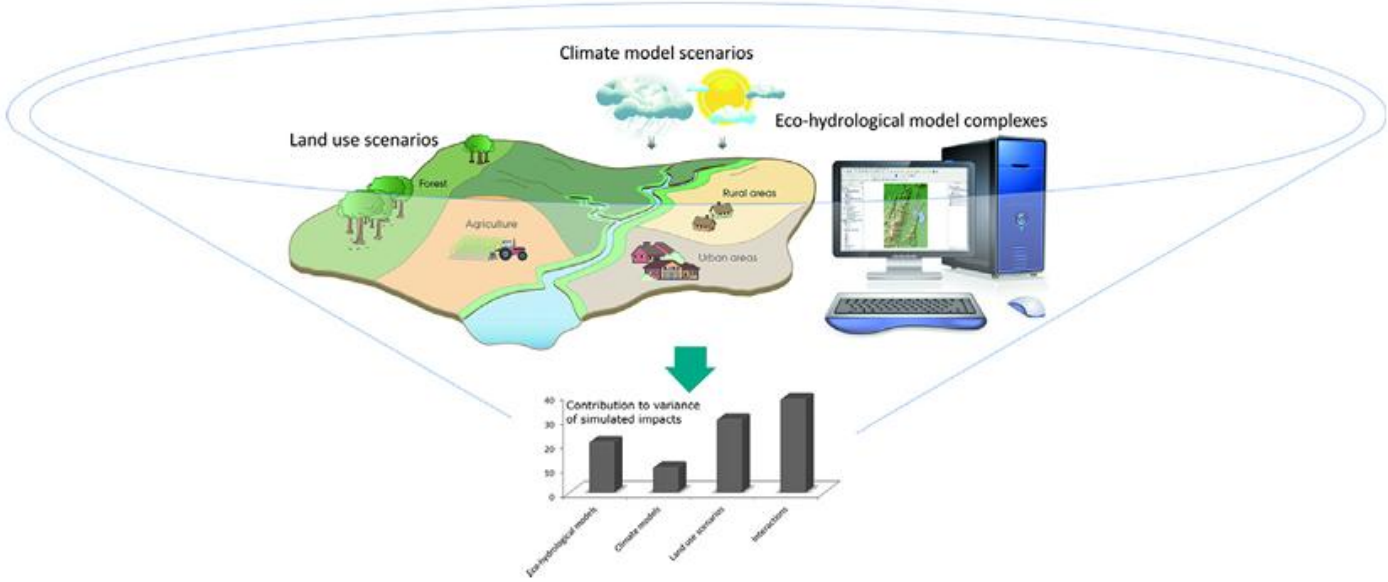
- for example changes in land use/land cover and agriculture to model the combined effects on nutrient transport and effect on marine and lake ecology

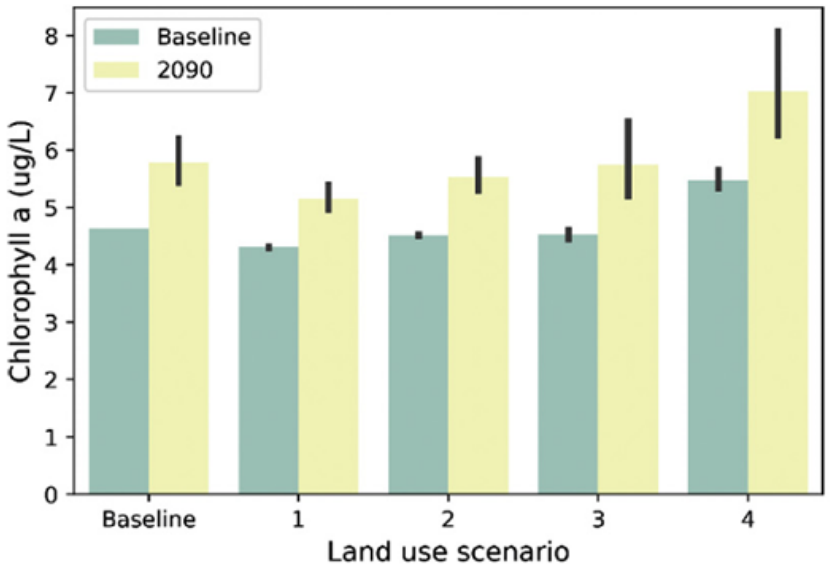


CC & OTHER CHANGES COMBINED

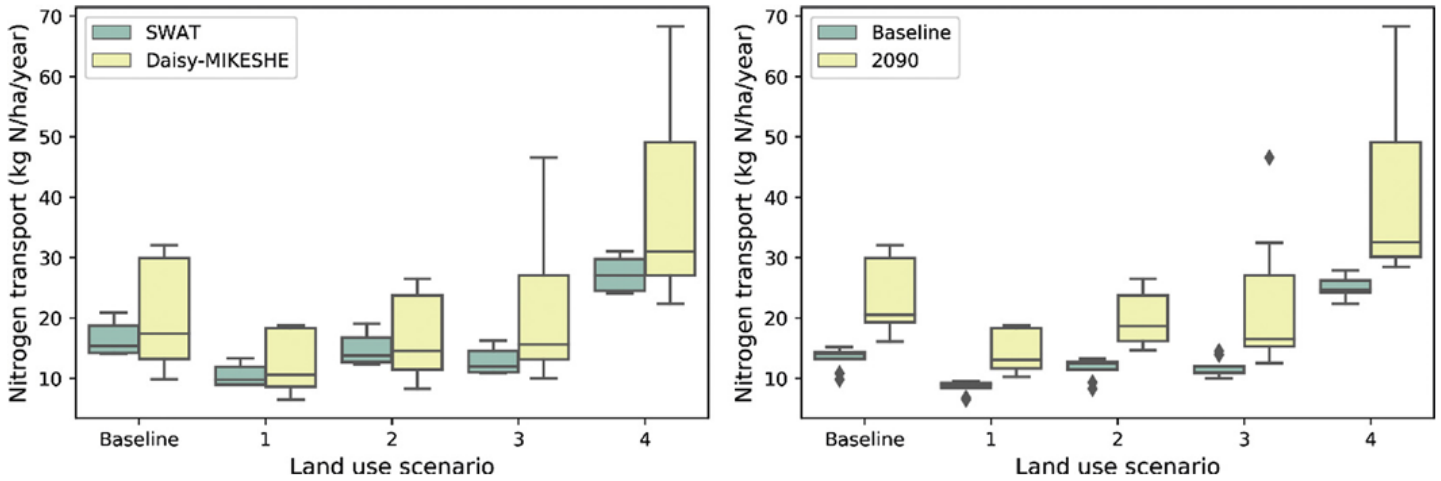
Study in the Odense fjord catchment

-CC scenario + 4 agricultural landuse scenarios => nitrogen transport => clorophyll a in Odense fjord





D. Trolle et al. / Science of the Total Environment 657 (2019) 627–633



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