Quantification of land-based nutrient loading discharging into a coastal lagoon in western Denmark using SWAT+

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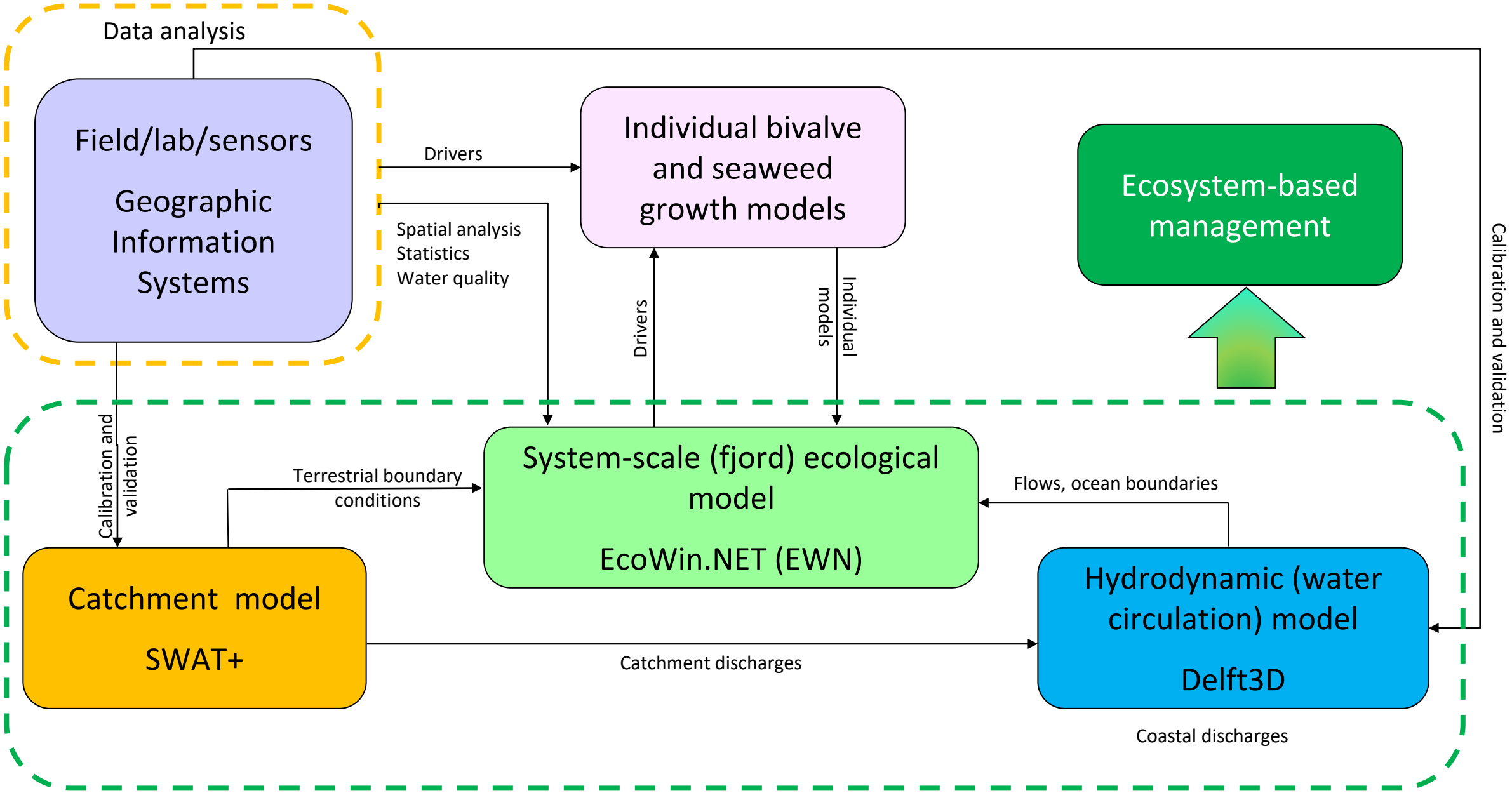
2023 Aarhus SWAT conference – 29/06/2023

Water quality in Ringkøbing Fjord

- Shallow lagoon located in western Denmark (300 km^2) controlled by a sluice
- Water Framework Directive (WFD) classification:
  - Heavily Modified Water Body (HMWB)
  - Ecological potential value: *Poor* (target: at least *Good*)
- The classification results from complex interactions between pressure from land, connection with the sea, physical characteristics, environmental drivers and biota.
- **Objective 1**: Provide a thorough understanding of the interactions between the catchment, the fjord, and the sluice
- **Objective 2:** Offer insights into how the stakeholders can work together effectively to achieve the targets set by the WFD
- **Objective 3:** Support policy makers in achieving these targets, ensuring both social and environmental sustainability

A review of the classification criteria and indicative measures required to move Ringkøbing Fjord from *Poor* to *Good* is critical.



SUCCESS framework – models for integrated management

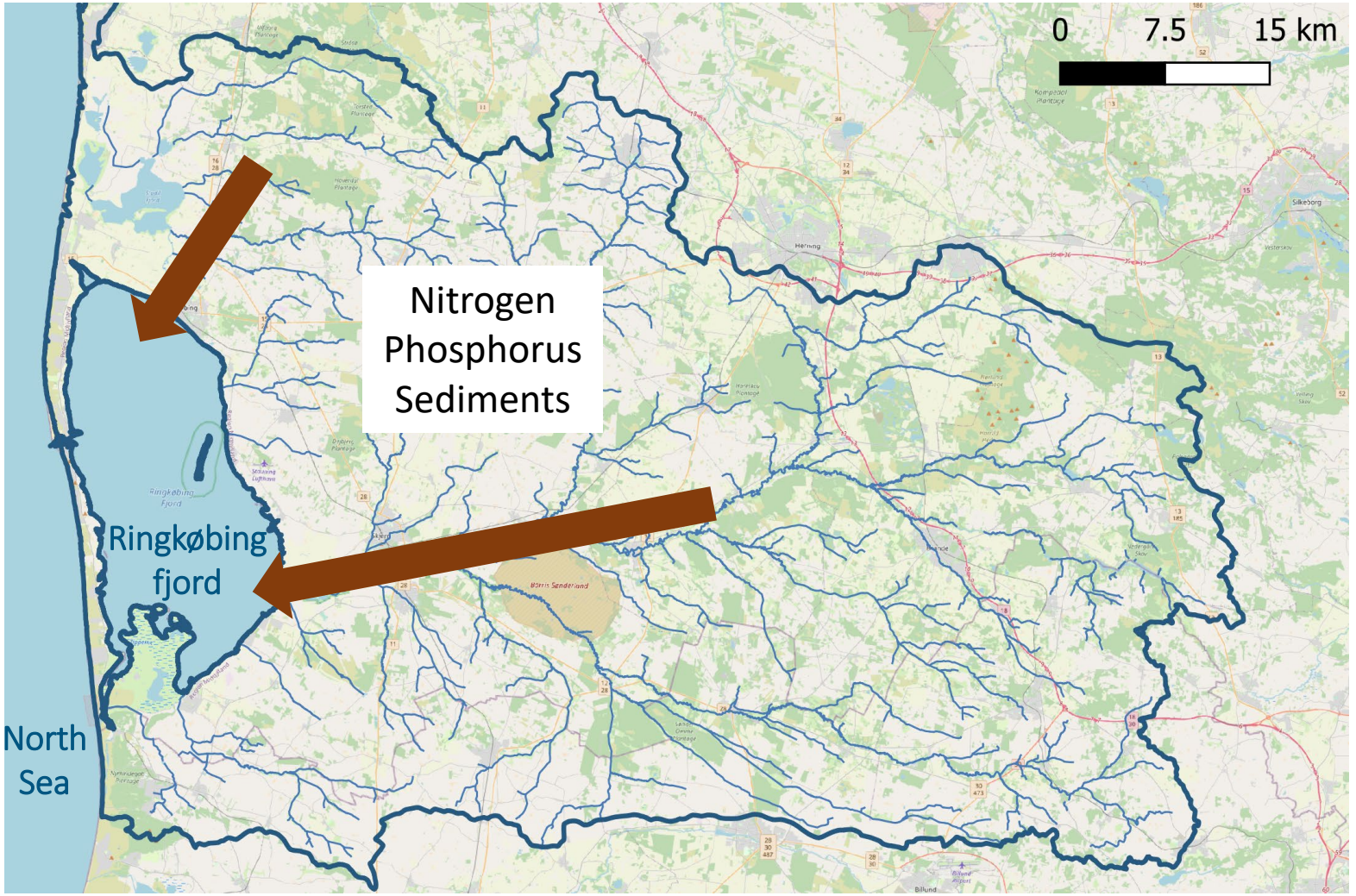
Catchment modelling objectives

Simulate loads entering Ringkøbing Fjord :

- Water
- Sediments
- Nutrients (Nitrogen and Phosphorus)

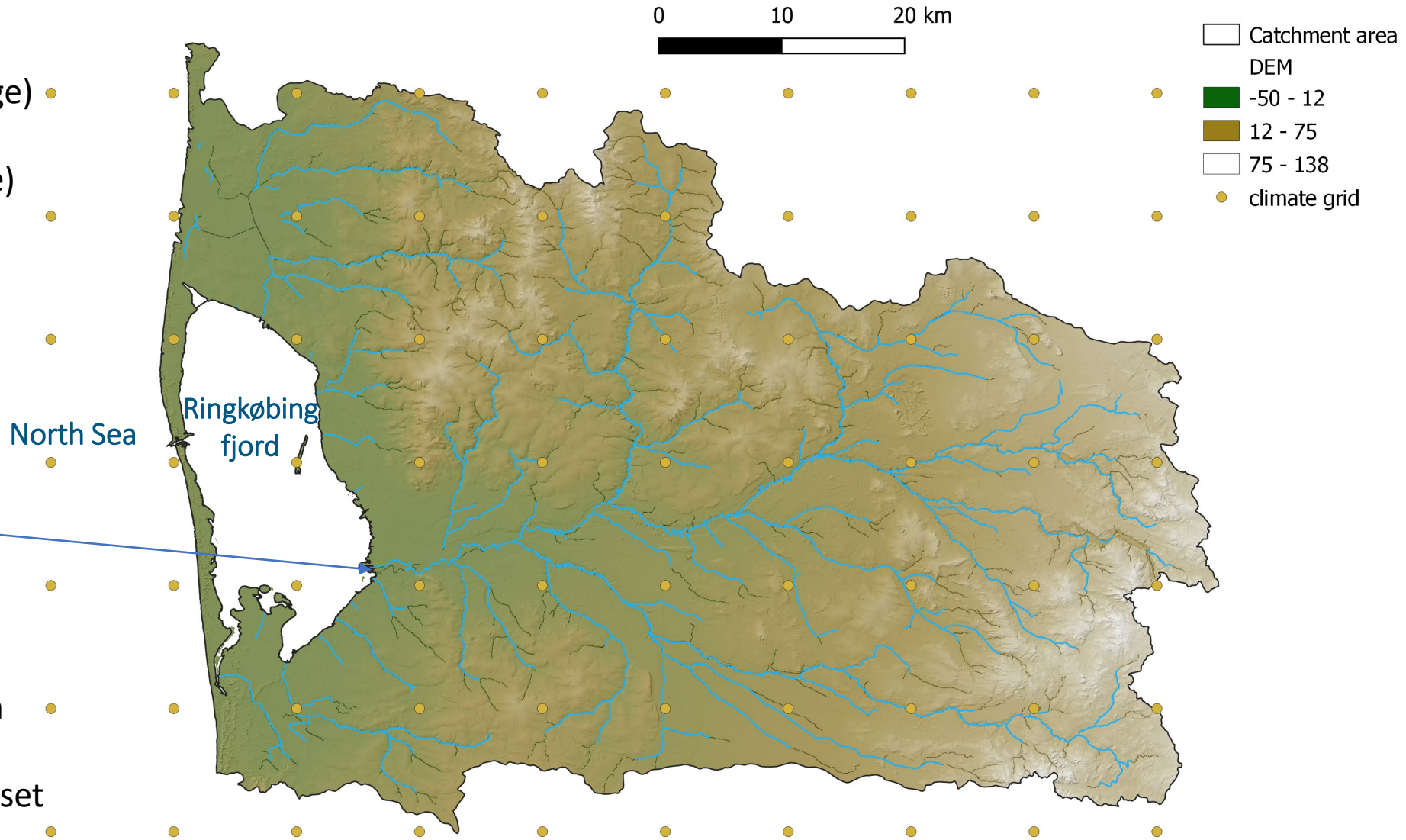
SWAT+
SOIL & WATER ASSESSMENT TOOL

- Delineation of floodplain units
- Flexible spatial connections
- Potential for scenario simulation



Catchment overview

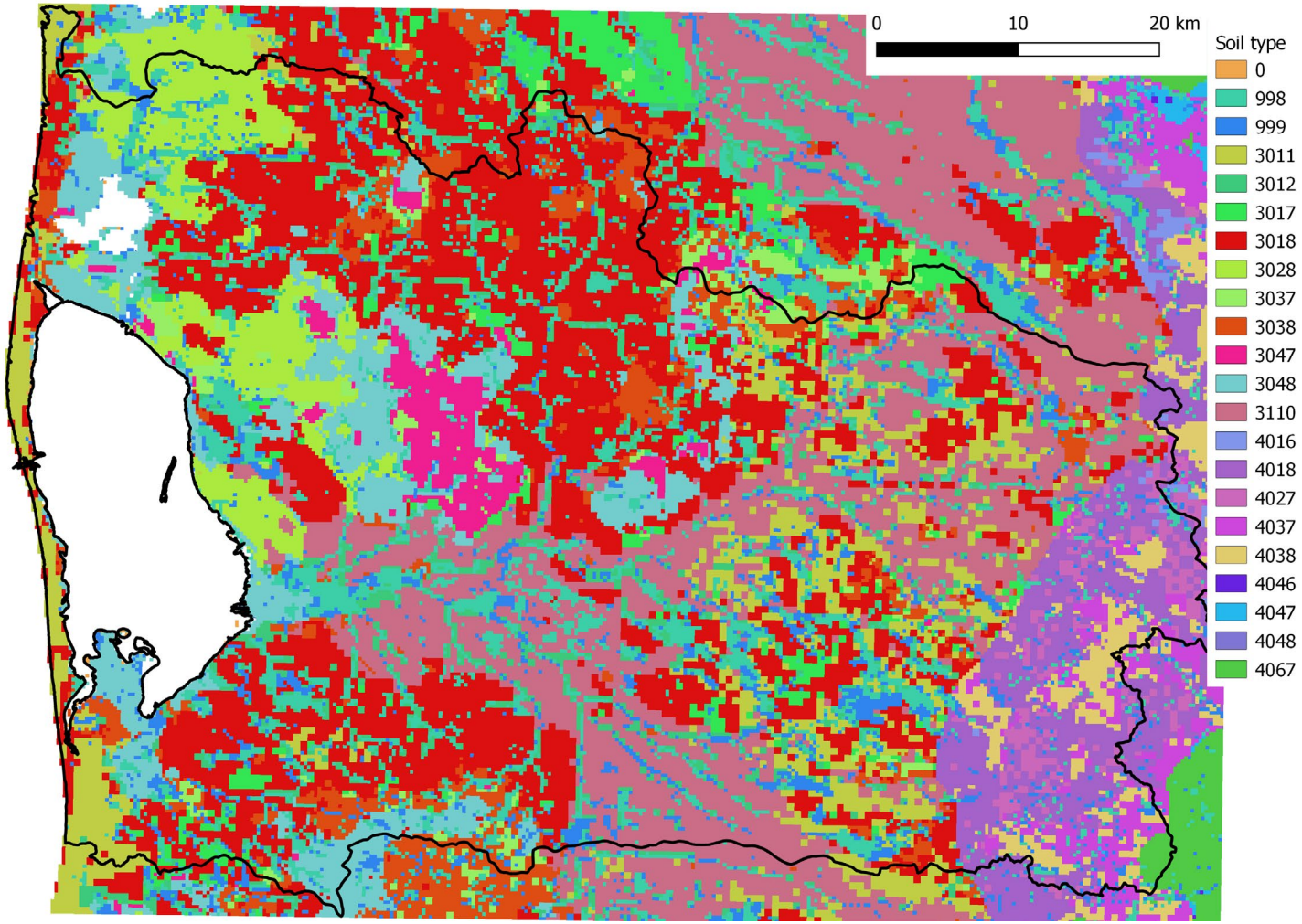
- Catchment area: 3372 km^2
- Lowland area (39 m in average)
- Skjern river: largest river in Denmark (in terms of volume)



Data:

- Elevation: National DEM 25m
- Climate data: 10 km Danish Meteorological Institute dataset

Model implementation: soil type

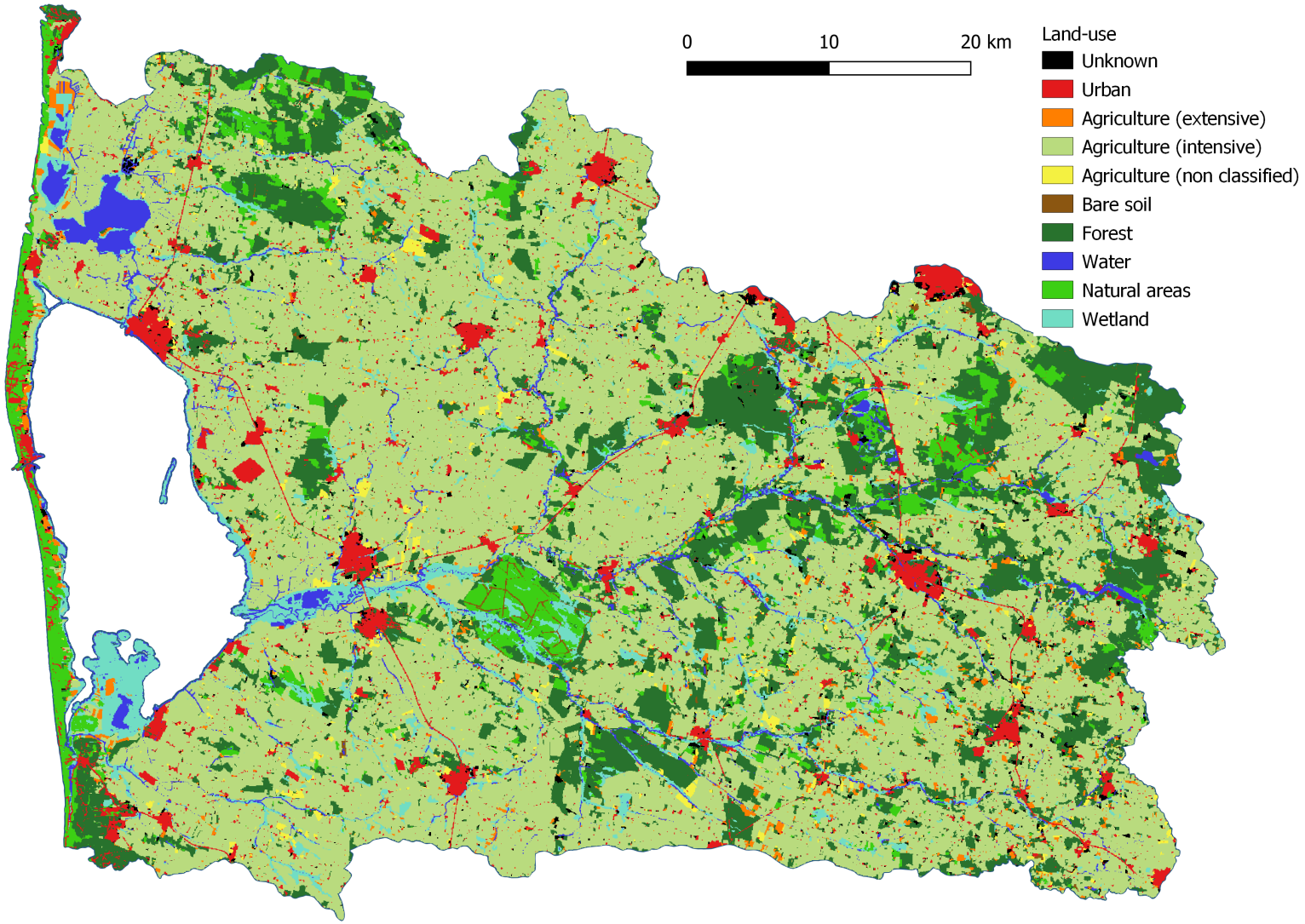


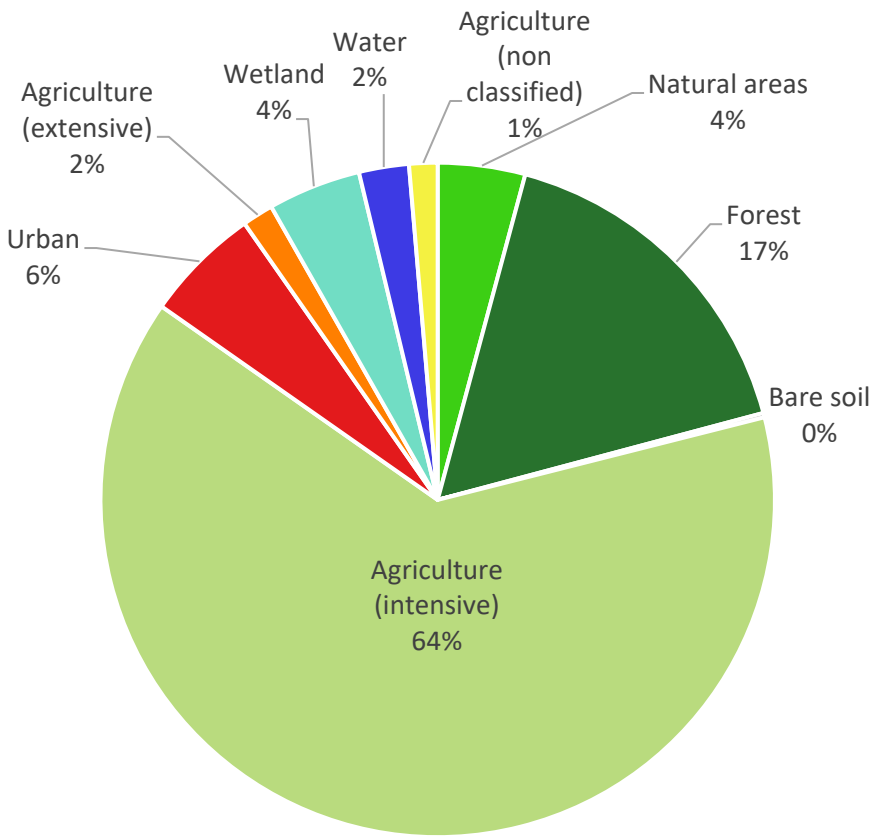
- 250 m resolution map based on the national topsoil texture map
- Derived from about 45,000 soil samples, that were interpolated using ordinary kriging (Greve et al., 2007)

DK3018	27%	Sandy	72%
DK3110	16%		
DK999	15%	Wetland soils	
DK3048	7%	Sandy-clay	
DK3011	7%	Sandy	

15 soil types dominated by sandy soils (A type)

Model implementation: land use





Total area: 324642 ha (3246 km^2)

Landuse VP3

Model implementation: crop rotation

The agricultural area has been divided into 11 farm types and 20 crop rotations

- Includes organic and conventional farming
- Detailed information on management practices

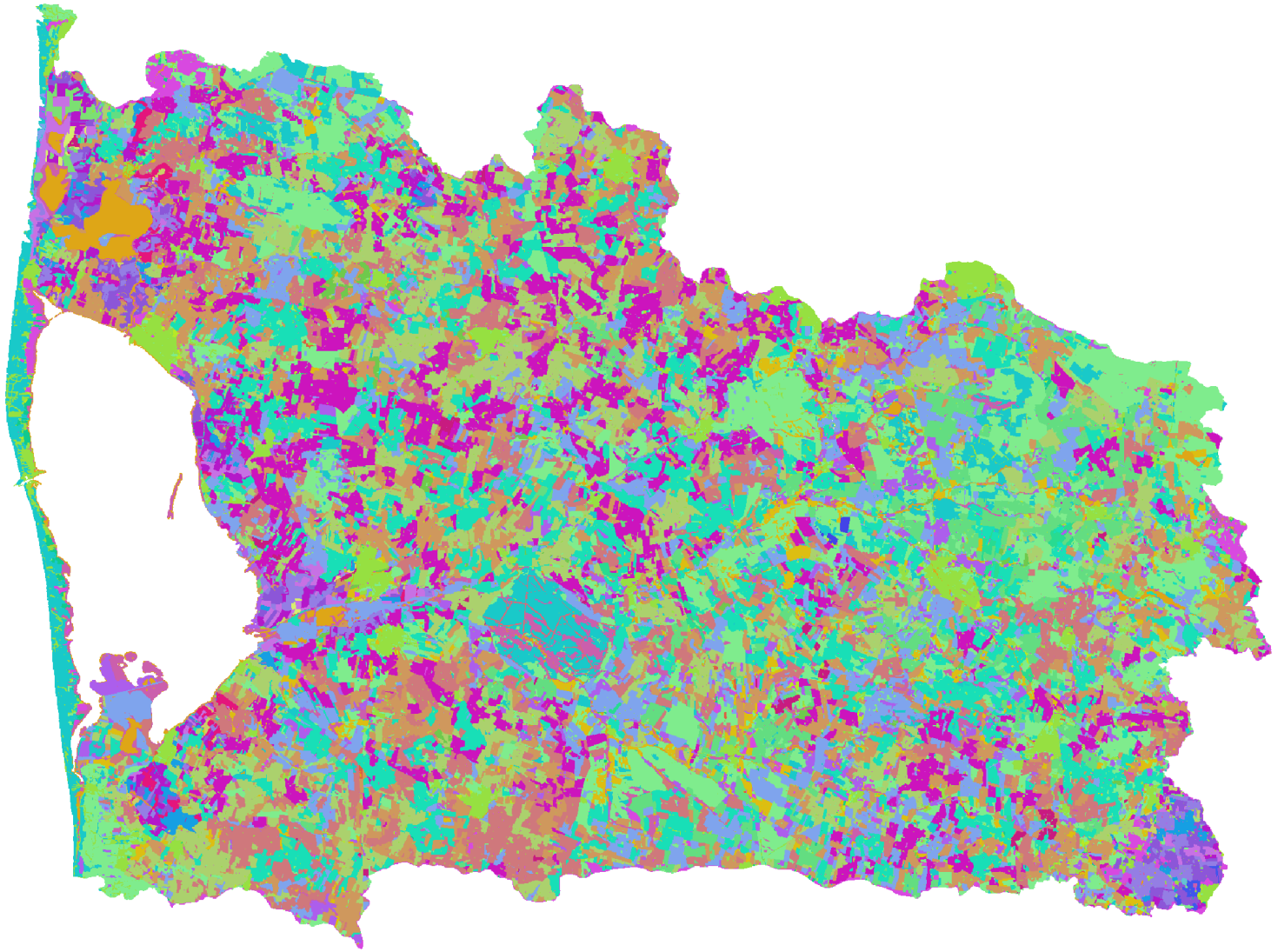
Farm type	Number of rotation
Plant farm	4
Cattlefarm with less than 20% wholecrop for fodder	2
Pig farm with more than 80 kg N pr ha fertilizer	4
Cattlefarm with more than 20% wholecrop for fodder	2
Other crop production	1
Cattle > 170 kg N	1
Potato farm	1
Nitrogen quota 50%	1
Pig farm with less than 80 kg N pr ha fertilizer	1
Seed production	1
Vegetables	1

Crop rotation 1 (Plant farm)	Main crop	Catch crop	Animal manure (kg N/ha)	Mineral fertilizer (kg N/ha)
Crop 1	Spring barley		76	59
Crop 2	Winter barley		113	87
Crop 3	Winter rape		125	96
Crop 4	Winter wheat		103	80
Crop 5	Spring barley	Oil radish	76	59
Crop 6	Spring barley	Oil radish	76	59

	plowing	sowing1	sowing2	harvest1	fertilizer1	fertilizer2
Crop 1	01-Apr	02-Apr	02-Apr	10-Aug	13-Apr	
Crop 2	19-Sep	20-Sep	10-Aug	01-Aug	01-Mar	01-Apr
Crop 3	19-Sep	20-Sep		01-Aug	01-Mar	15-Apr
Crop 4	19-Sep	20-Sep		20-Aug	01-Mar	01-Apr
Crop 5	01-Apr	02-Apr	02-Apr	10-Aug	13-Apr	
Crop 6	01-Apr	02-Apr	02-Apr	10-Aug	13-Apr	

Implementation through Management Schedule Operations

Model implementation: land use units



Combination of:

- Land use base map
- Drainage area maps
- Farm type map

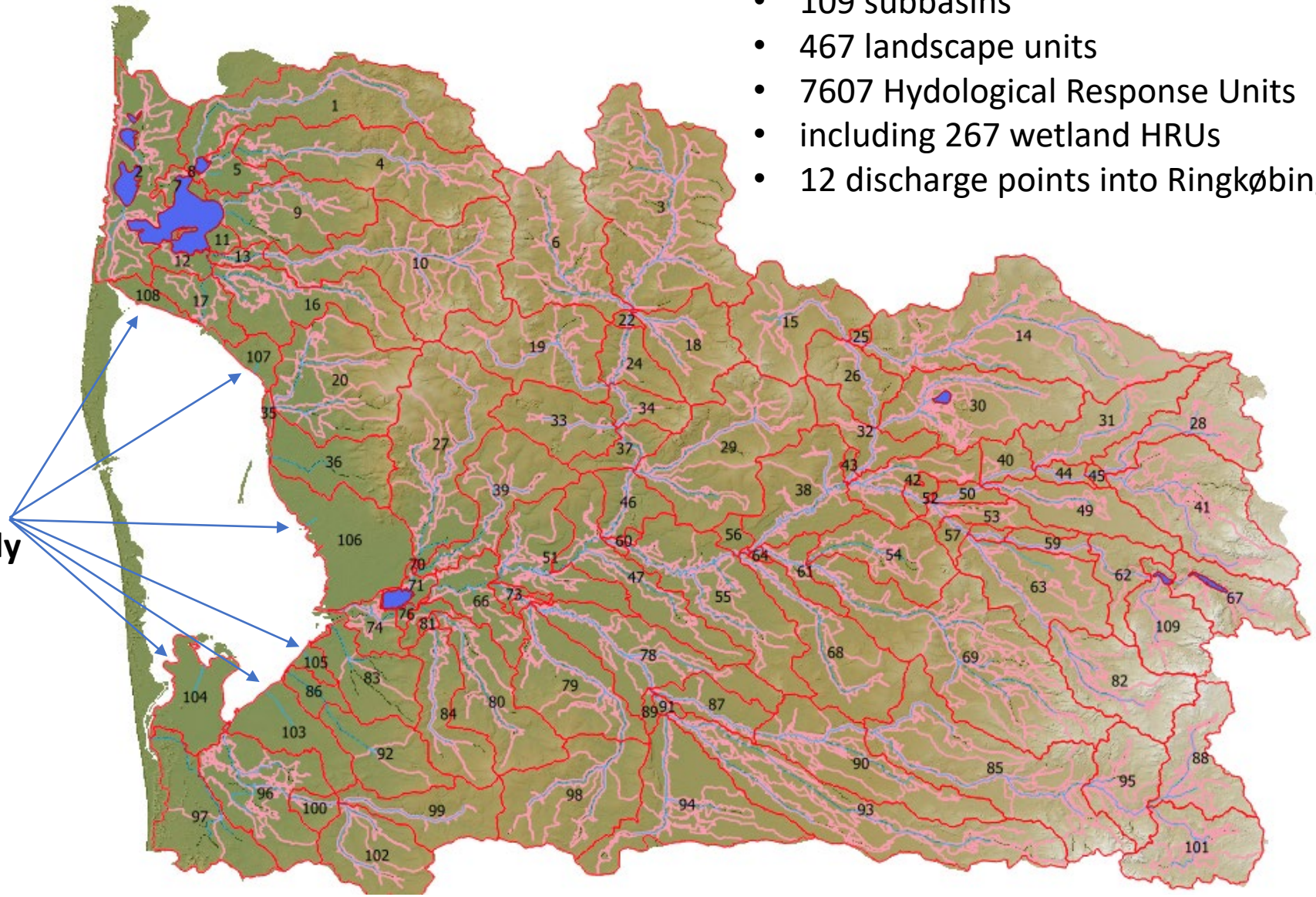
Gives a total of 27 land use classes

Watershed delineation

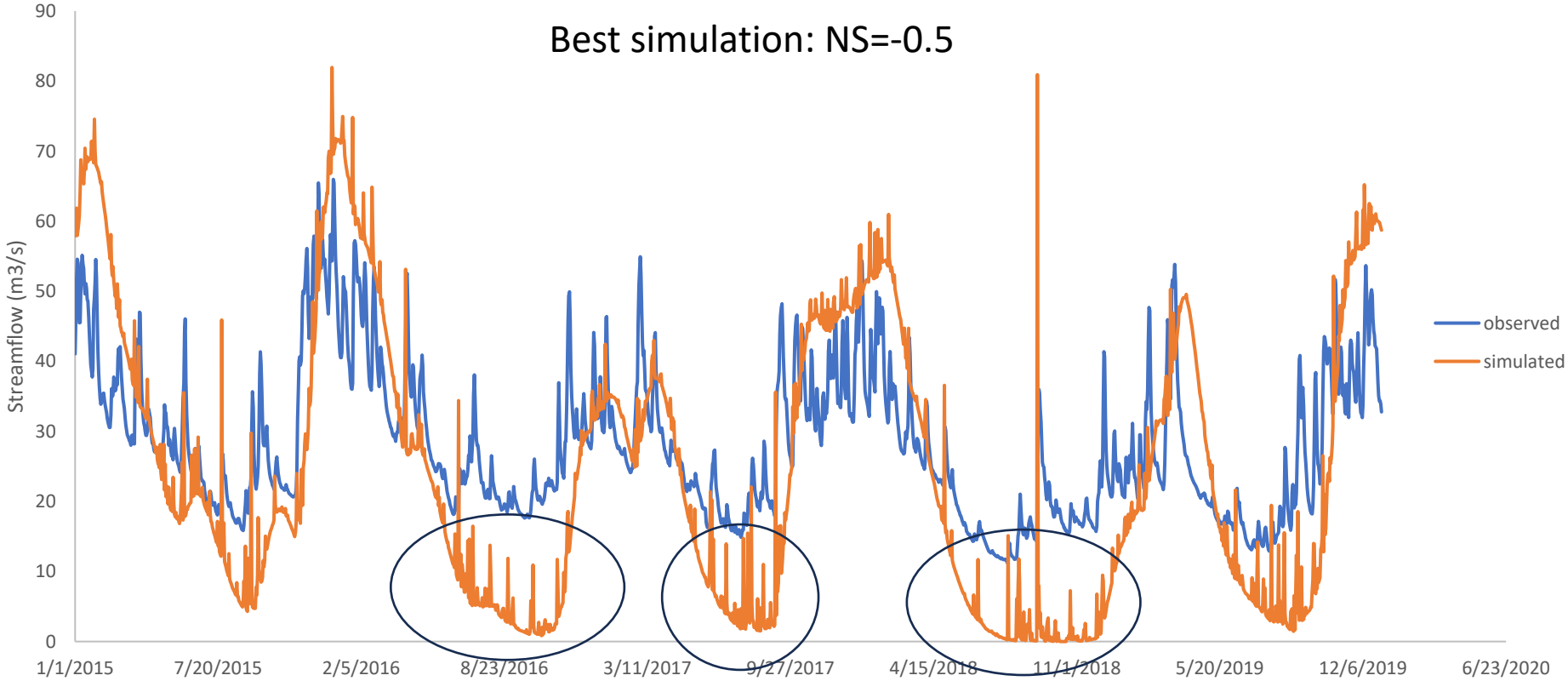
Watershed delineation characteristics:

- 9 lakes
- 109 subbasins
- 467 landscape units
- 7607 Hydological Response Units
- including 267 wetland HRUs
- 12 discharge points into Ringkøbing Fjord

6 coastal subbasins implemented manually

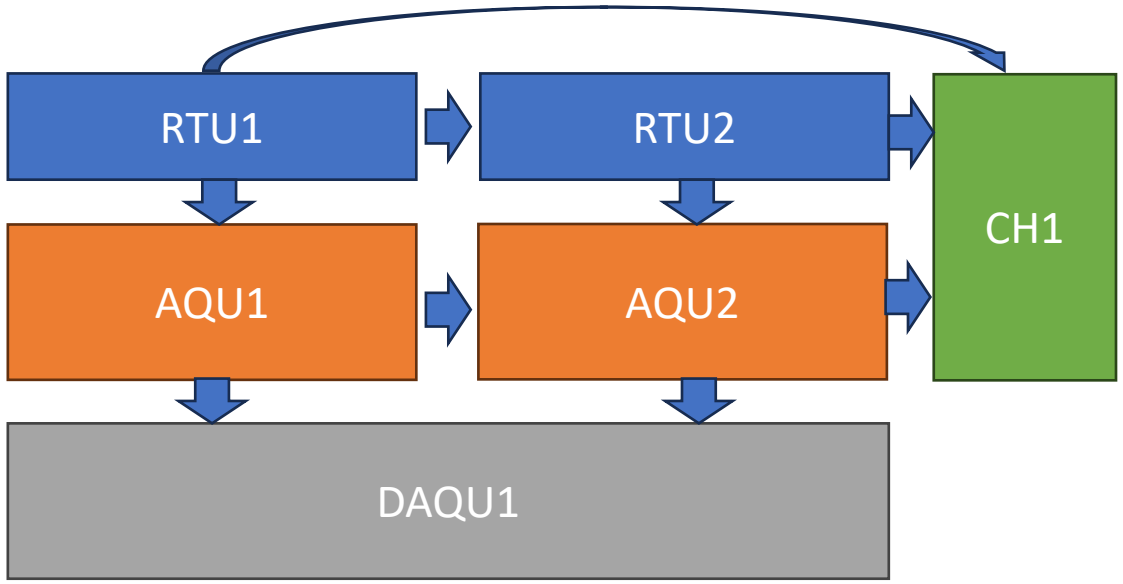


Calibration challenge: lowland hydrology

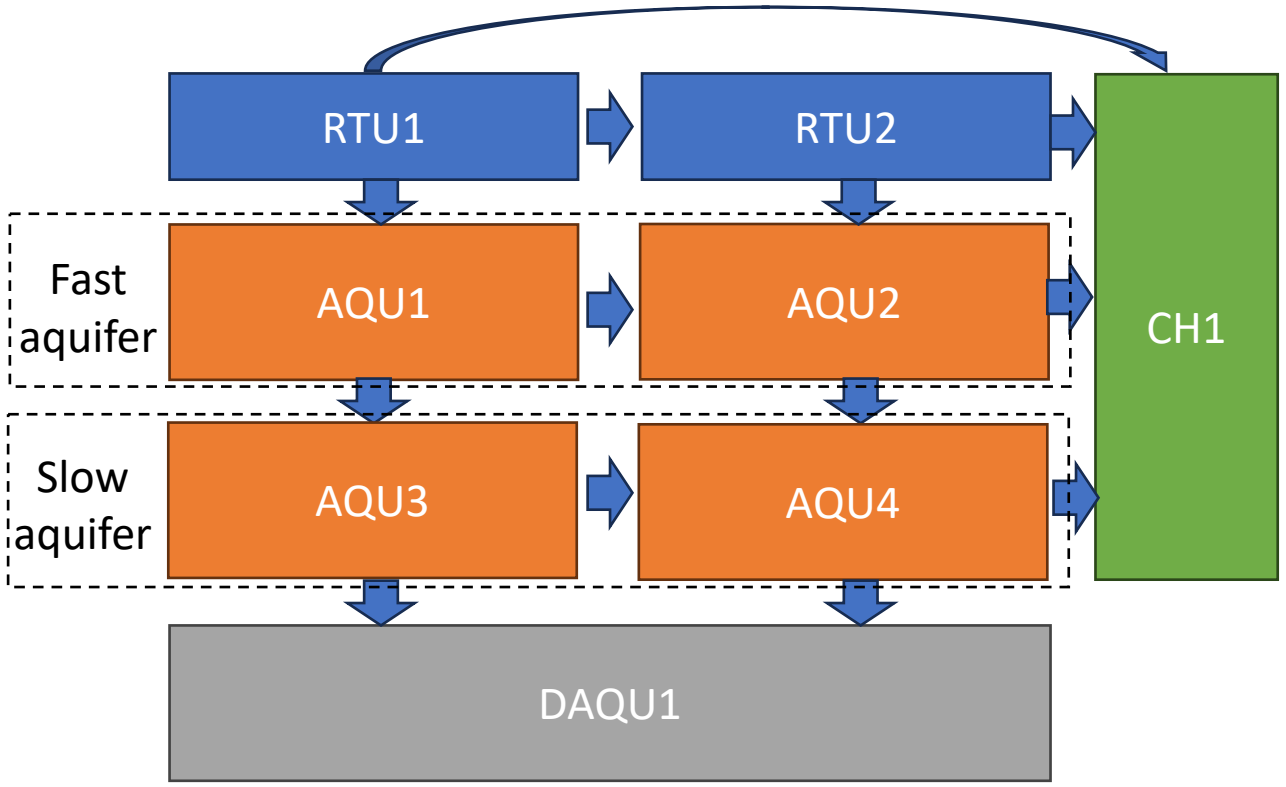


The model underestimates summer baseflow.

Solution: dual aquifer implementation



QSWAT+/SWAT+ Editor default implementation

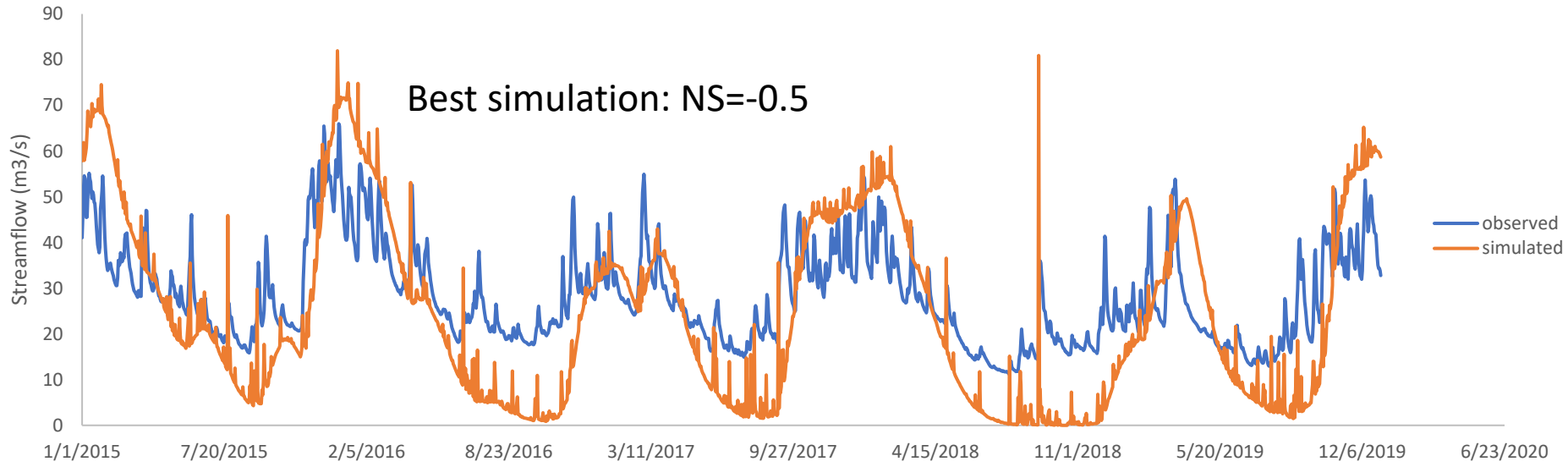


Dual aquifer implementation

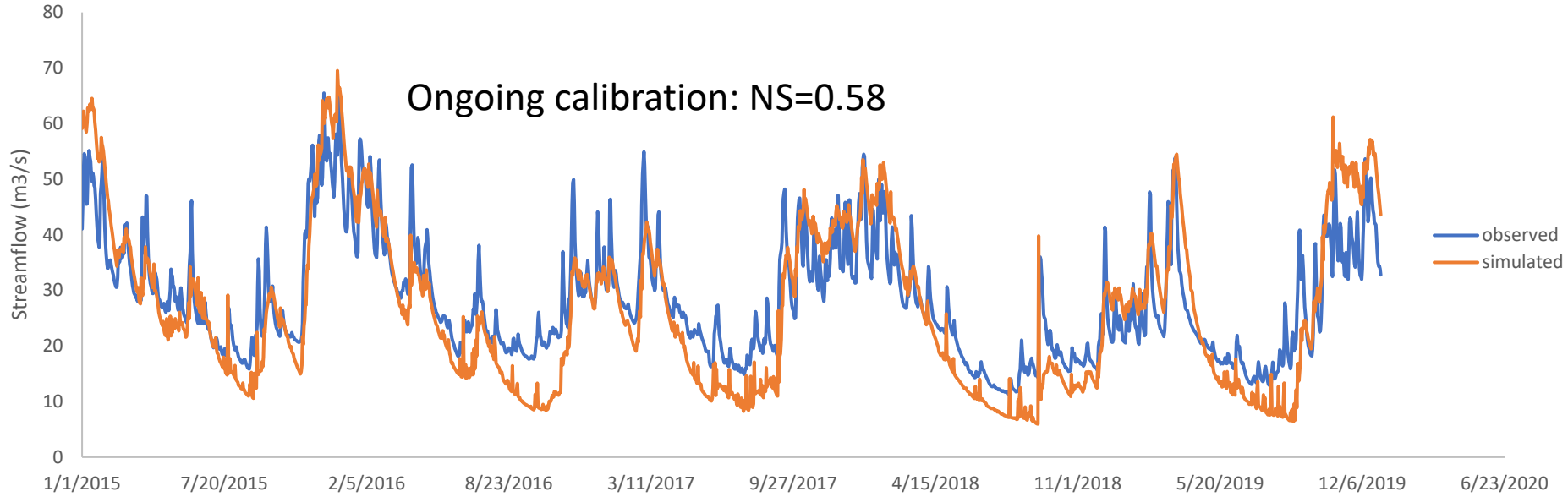
Wagner et al. (2022)

Model calibration: results

Default setup



Dual aquifer setup



Potential scenarios

- Land use change
  - Wetlands restoration
  - Land use conversion

- Agricultural practices
  - Crop rotation
  - Fertilizer inputs (timing, quantities, composition)
  - Irrigation

Scenarios have the potential to impact the water quality in the catchment and in the lagoon in different ways, and it is essential to study their effects to develop sustainable and resilient water management strategies.

Conclusions and next steps

- The catchment model is developed for the Ringkøbing fjord catchment in order to estimate nutrient loads entering the coastal lagoon.
- The dual aquifer configuration has proved useful for simulating the hydrology of this lowland catchment.
- The next step is to calibrate nutrient exports.
- The model takes into account detailed agricultural practices and will be used to estimate the impact of land management scenarios on the ecological status of Ringkøbing Fjord.