Multiple drivers of change in coastal water quality and ecosystem status:

From participatory mental mapping to systems modelling

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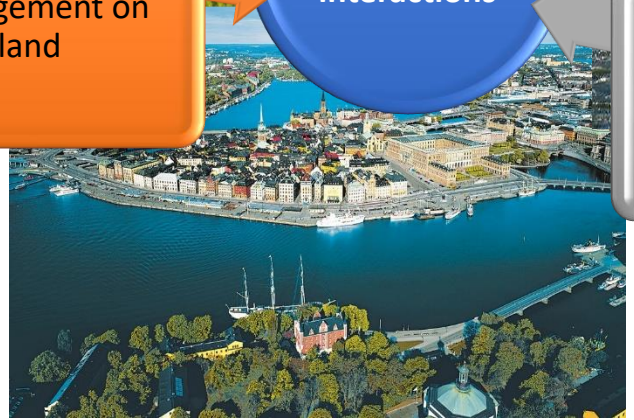
Some **result-conclusion exemplification**

Climate change

Human activities / management on land

Coastal pressures & interactions

Human activities / management at sea



Multi-approach combination to **coastal system** understanding & issue resolutions-solutions

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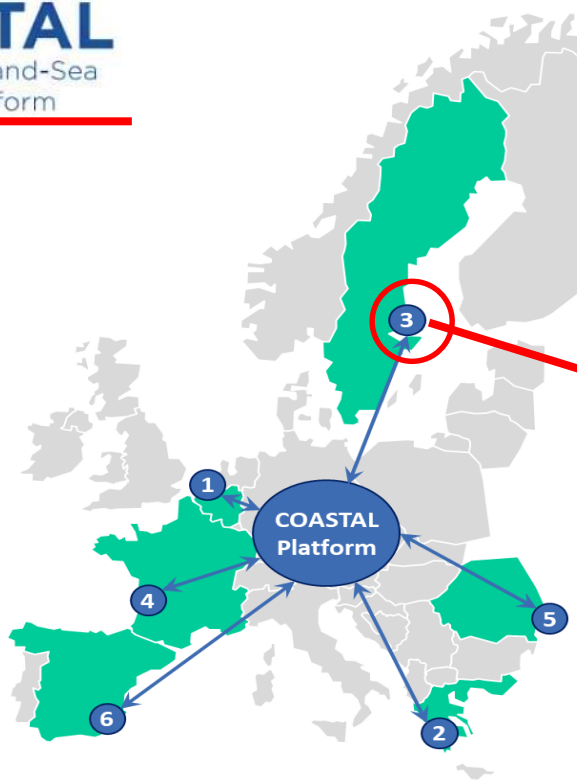
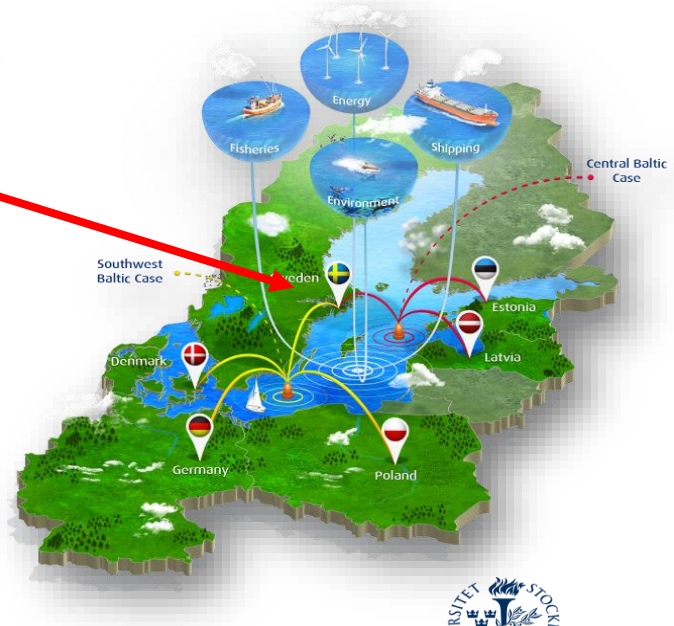
Collaborative Land-Sea Integration Platform

European Commission

Multi-Actor Labs

1. Belgian Coastal Zone
2. South-West Messinia
3. **Norrström/Baltic Sea**
4. Charante River Basin
5. Danube Mouth
6. Mar Menor Lagoon





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Multi-Actor Lab (MAL) 3. Norrström/Baltic Sea

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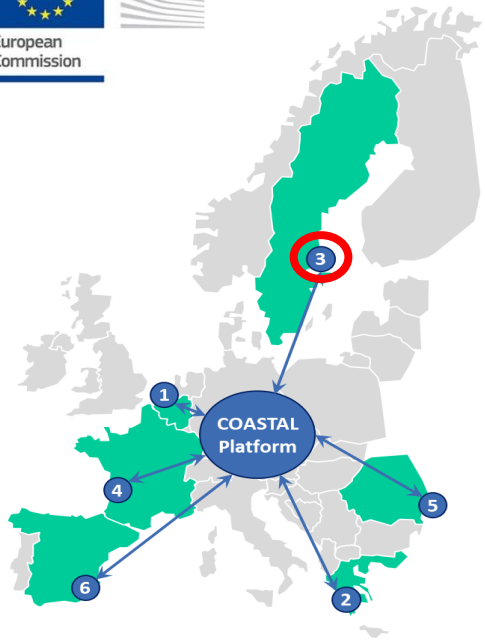

Platform for Land-Sea **Integration**

Many water-related issues

Water quantity

- Agriculture, forestry – main quantity problem: too much water – also, no irrigation preparedness for meeting droughts
- Urban runoff – storm water handling
- Hydro-climatic change

Water quality (land, coastal-marine)

- Severe coastal-marine eutrophication, pollution – largely waterborne loads
- Policies, regulations for mitigation in place since long – no clear mitigation progress
- Coastal tourism, recreation – wells, unconnected to municipal water supply/wastewater treatment - sea water intrusion risk

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Multi-approach combination

- **Mechanistic coastal-system simulations** of water quality and ecosystem status responses to various climate and land-sea eutrophication management scenarios

- **Participatory multi-stakeholder co-creation of Causal Loop Diagrams** of main issues and land-sea interactions affecting coastal systems

- **Unified Fuzzy Cognitive Map** development and stakeholder validation

- **Stock-flow Systems Dynamics modelling** of key quantifiable interaction components

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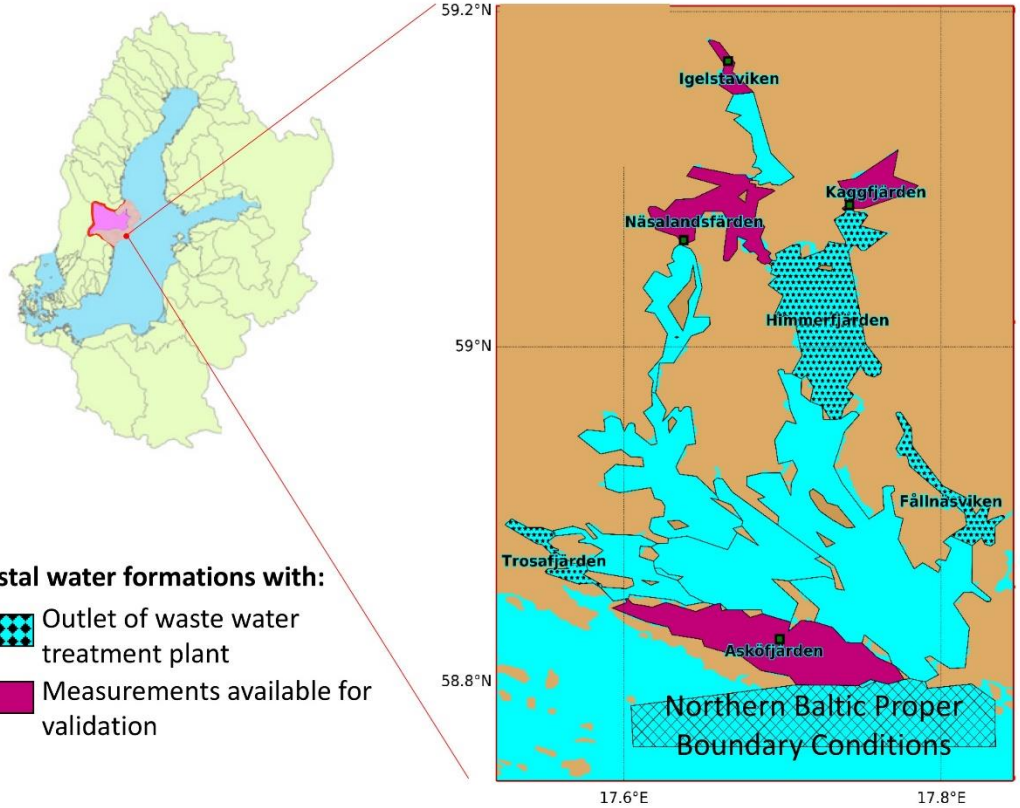
Mechanistic coastal-system simulations - Himmerfjärden Bay Case

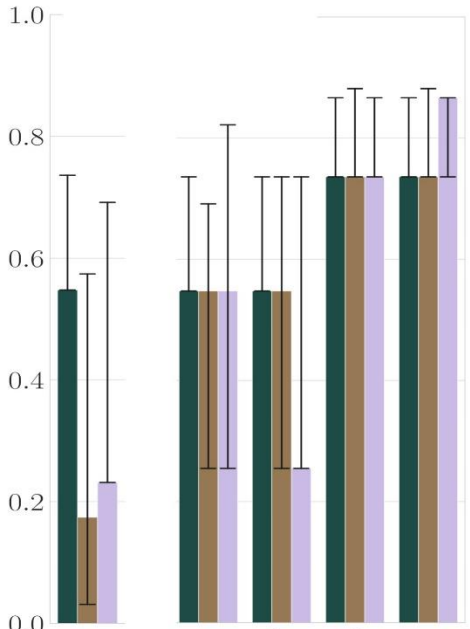
Water quality and **ecosystem status** responses to various **climate** and **land-sea management scenarios**

Vigouroux et al. (2020, in review) based on:
A scalable dynamic characterisation approach for water quality management in semi-enclosed seas and archipelagos
(Vigouroux et al., Marine Pollution Bulletin, 2019)



Compliance with Good Component Status (according to WFD) under various hydroclimatic & management scenarios

Coastal area fraction with **good status** for Chl a



Climate scenarios:

- Dry-cold
- Dry-warm
- Wet-warm

Management scenarios 0-4:

0. Base case
No new measures

1. 50% reduction of nutrient loads from land

2. Aerobic coast – no internal P loading

3. Good sea status

4. Combined land & sea measures (1+3)

Vigouroux et al. (2020, in review)

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Some conclusions from mechanistic coastal-system simulations - Himmerfjärden Bay Case

- Hydroclimatic conditions important for efficiency of eutrophication management measures
  - Wetter-warmer conditions shift efficiency level

- Not unidirectional (land)source-to-sea effect pathways
  - both land-based and sea-based measures affect the coastal system
  - differently for different status components

- Internal loading of phosphorus - not main driver of coastal eutrophication, but adds complexity to its management

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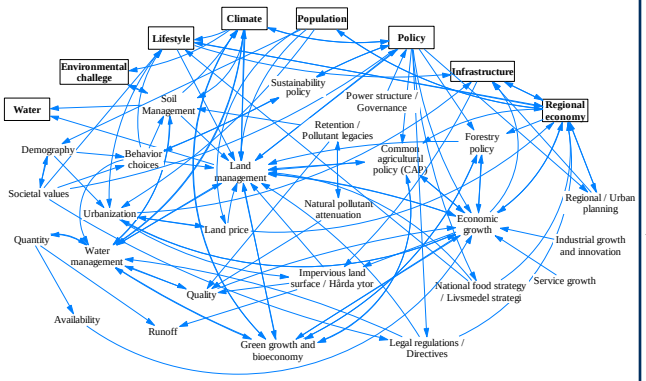
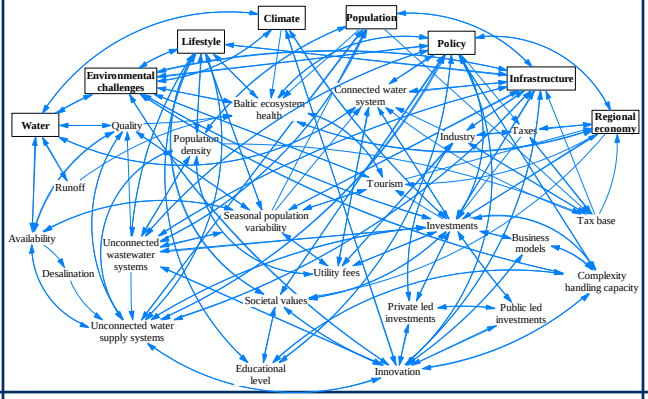
Participatory Multi-Stakeholder Causal Loop Diagrams - 6 sector workshops

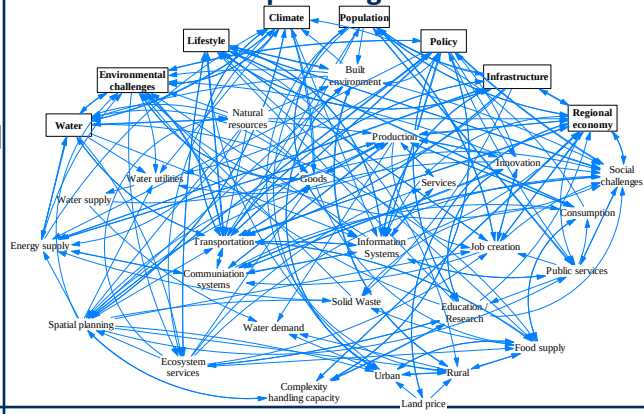
SW1.Green growth , terrestrial-freshwater ecosystems



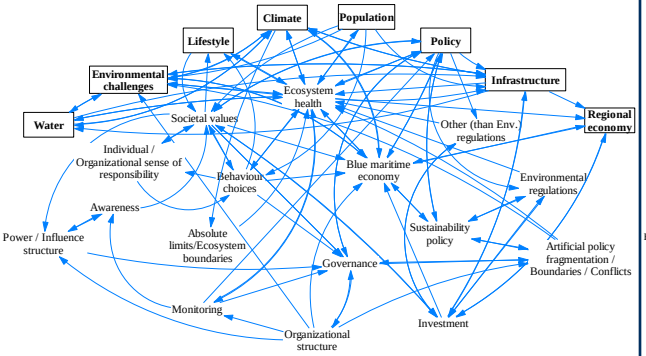
SW2. Industry, water-wastewater and solid waste infrastructure, innovation



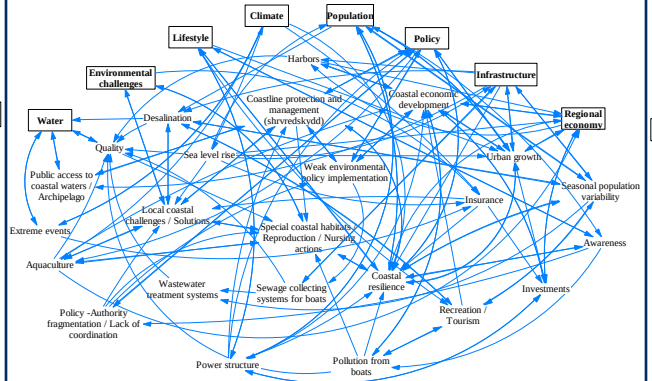
SW3. Urban-rural communities, land spatial planning



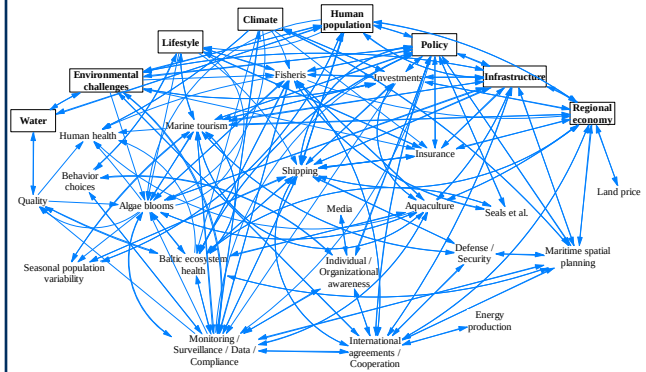
SW4. Blue growth, coastal-marine ecosystems



SW5. Coastal tourism, recreation, harbors, other coastal activities

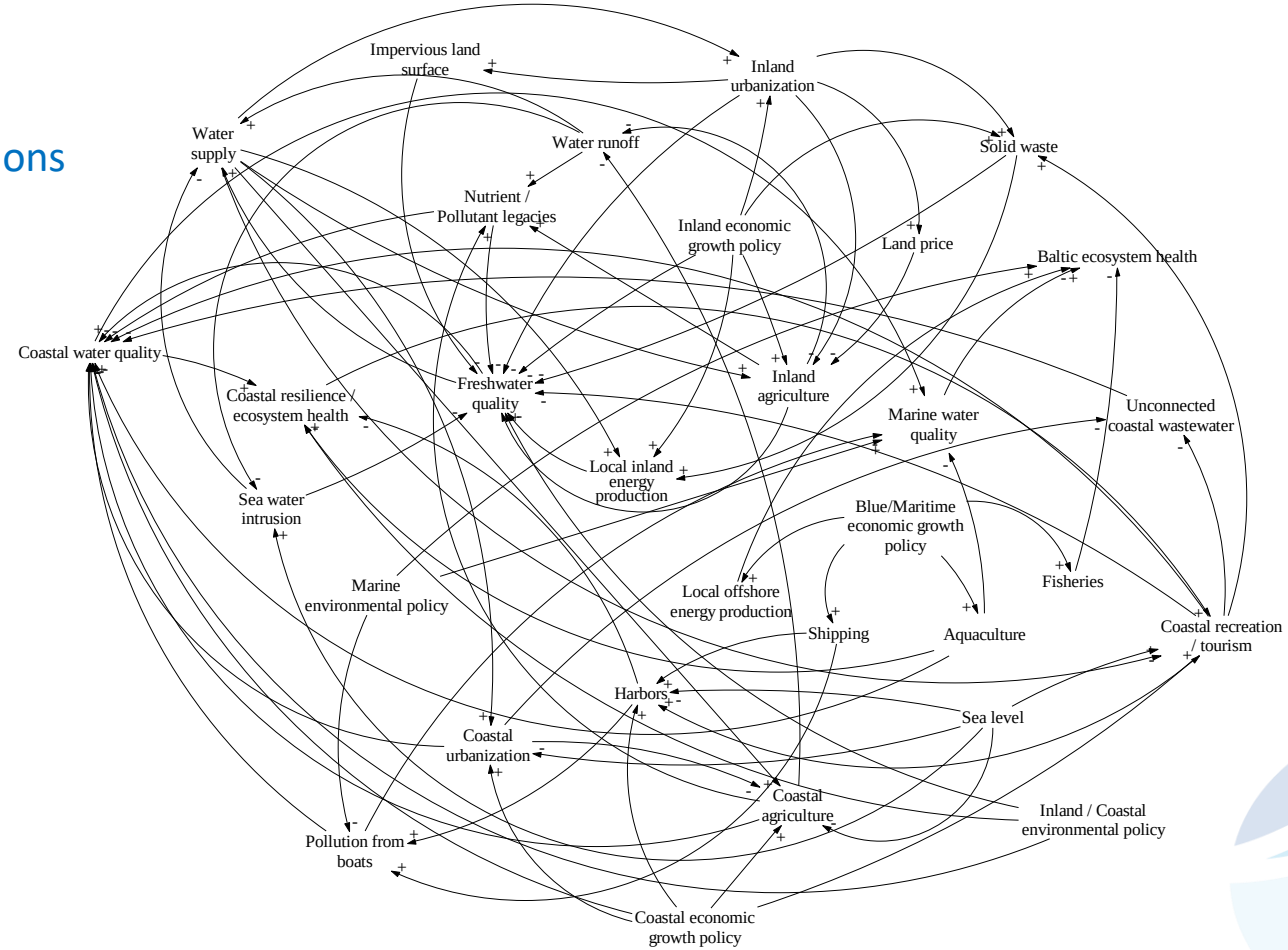


SW6. Marine tourism, fisheries, marine spatial planning, other marine activities

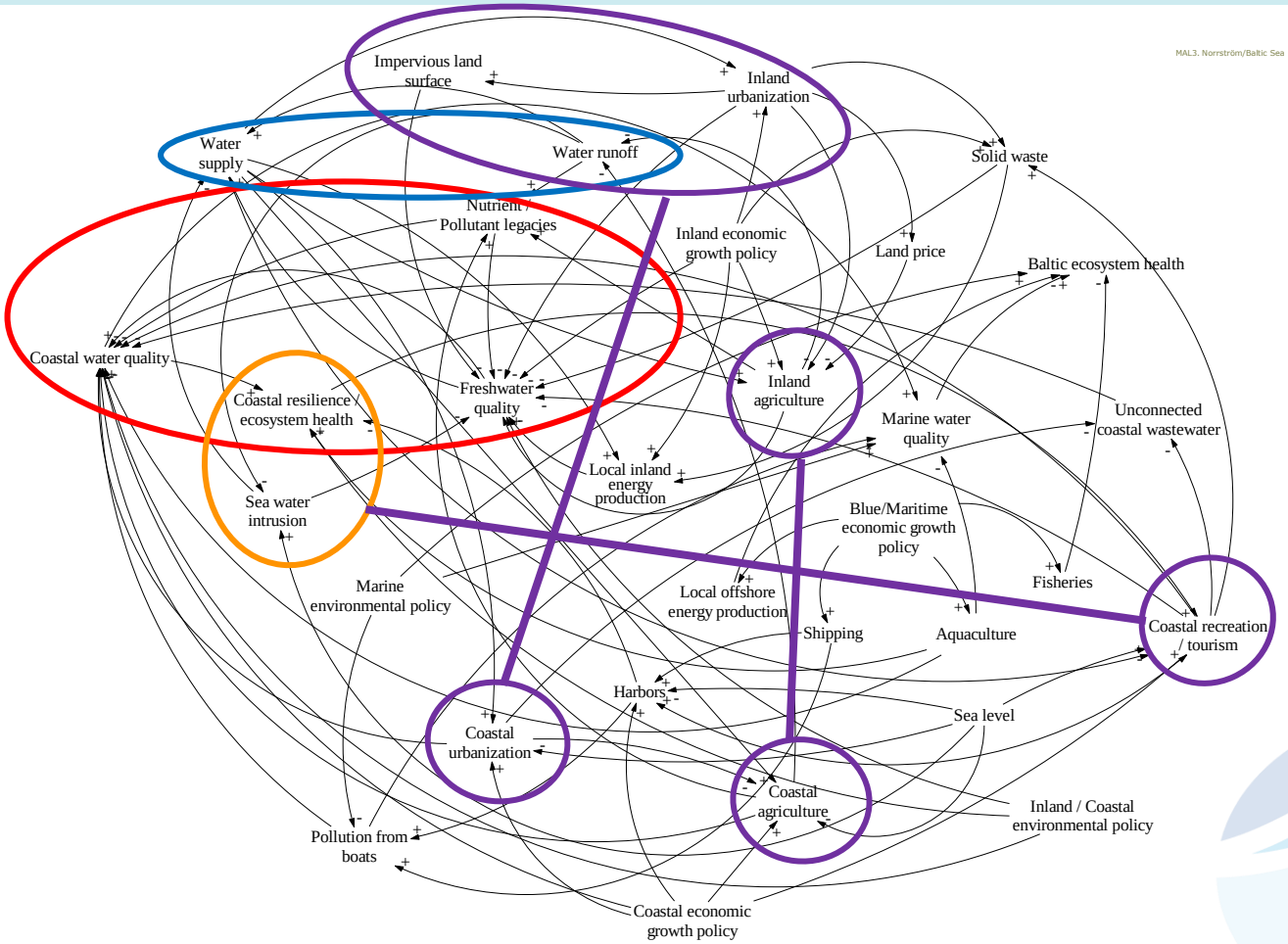


Unified-Simplified Fuzzy Cognitive Map – used for semi-quantitative scenario analysis & multi-stakeholder validation

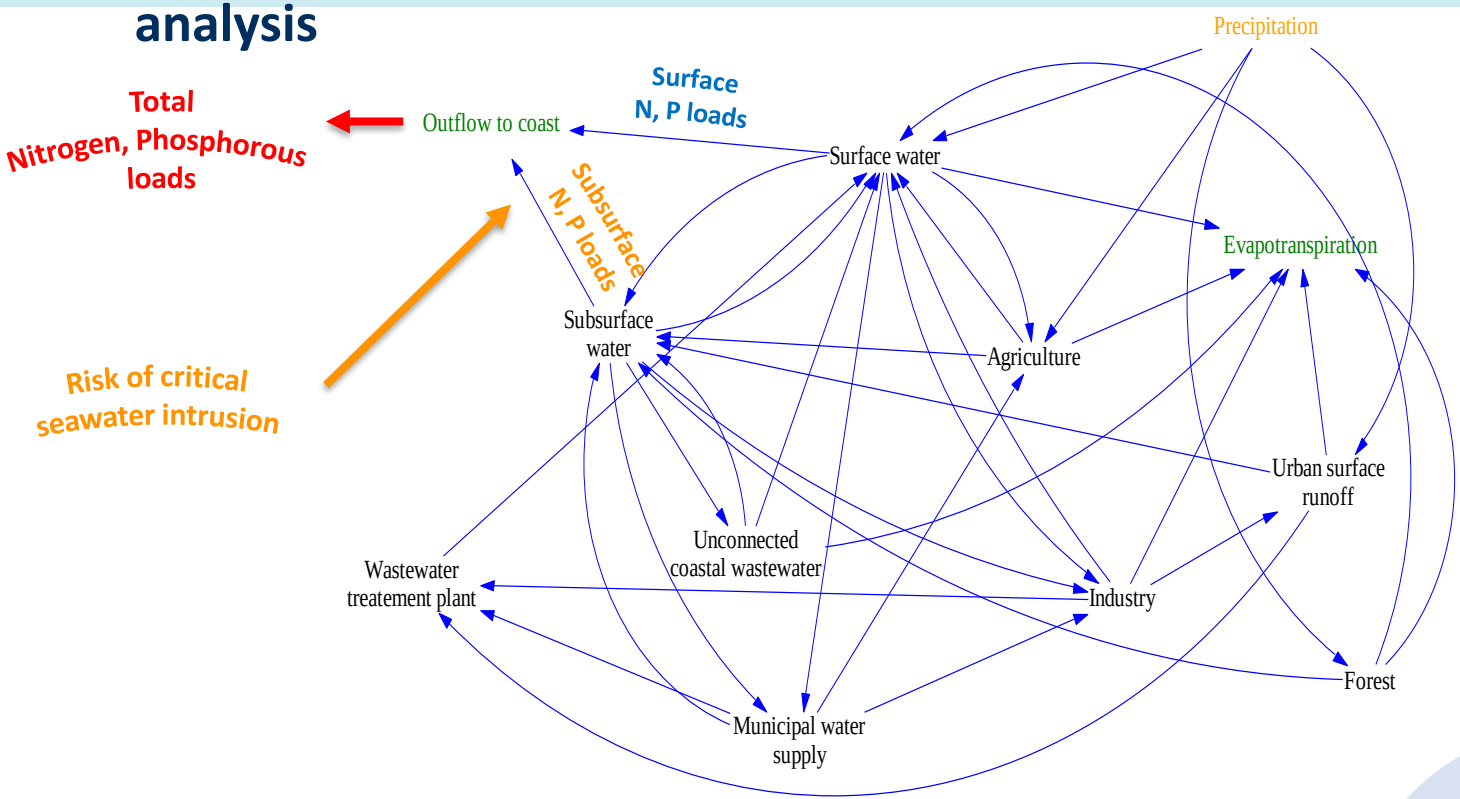
31 variables
160 connections
567 loops



Key interactions further included in **fully quantitative System Dynamics modelling**



Systems Dynamics modelling – used for fully quantitative scenario analysis

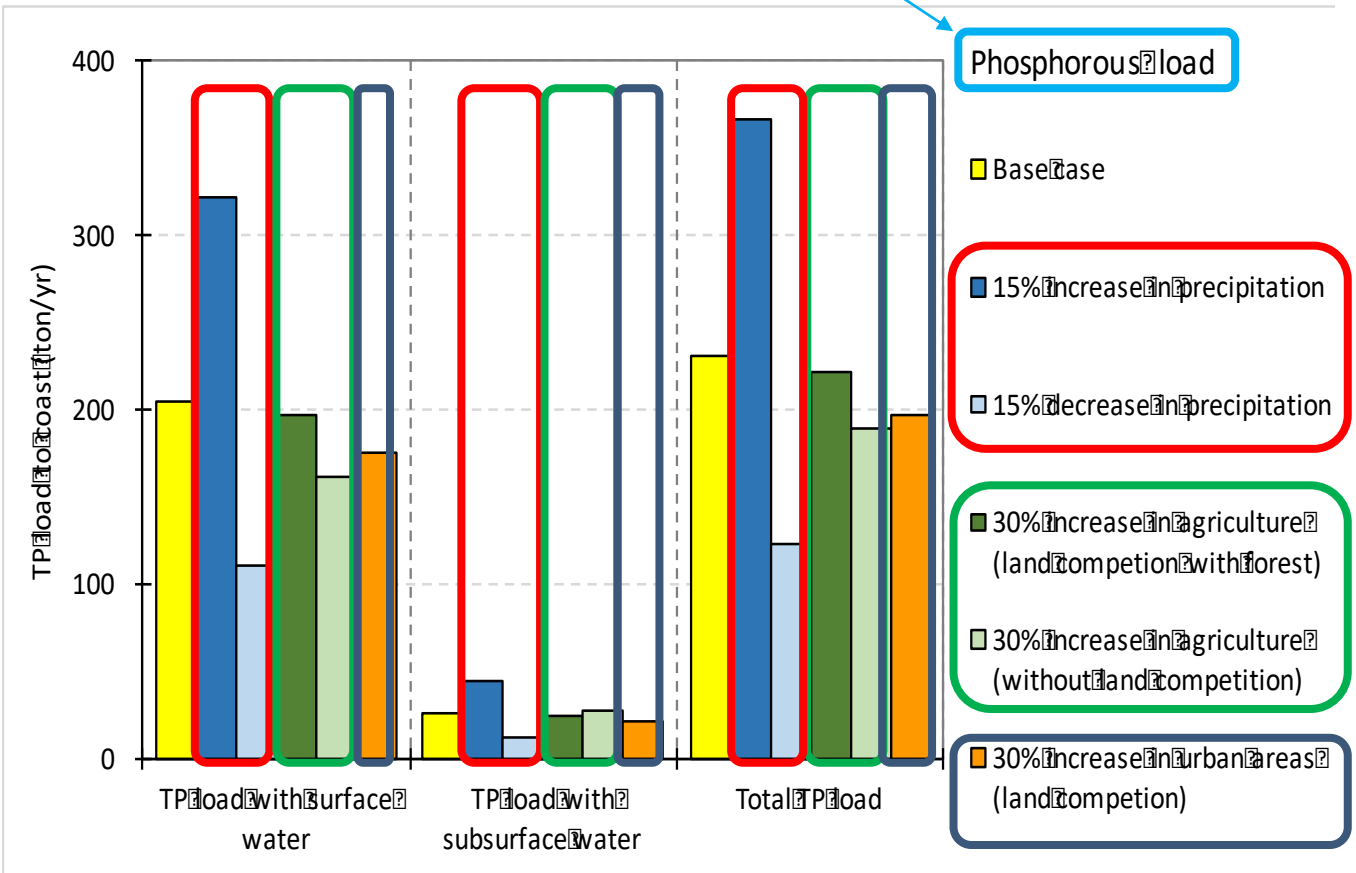


Water quantity

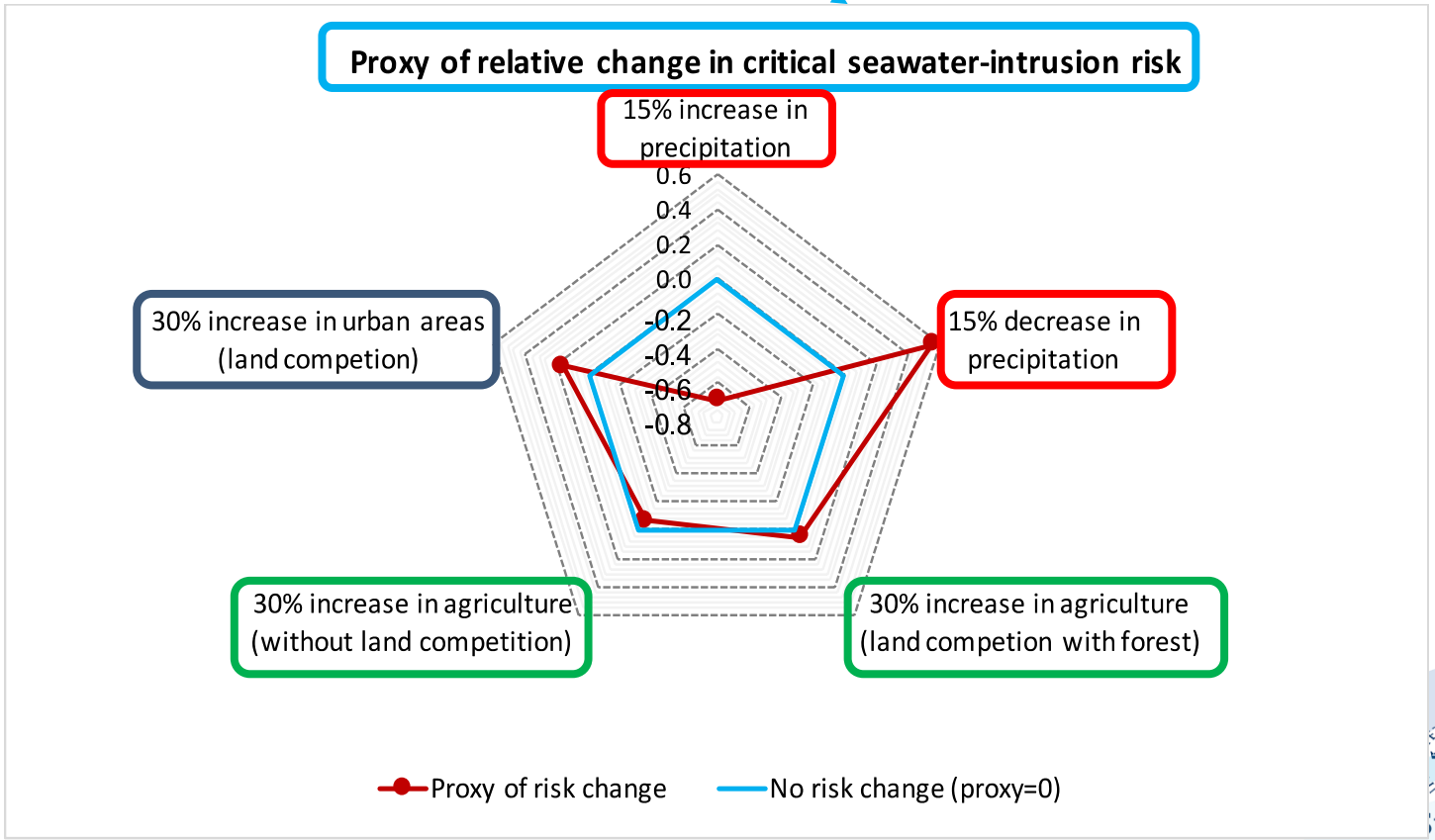
Water balance

Inter-sectoral flows

Scenario result example



Scenario result example



Recent work – data analysis and modeling regarding coastal solution trends and barriers

Nutrient loads from land to coast

- Destouni et al., **Water quality and ecosystem management: Data-driven reality check of effects in streams and lakes**, *Water Resources Research*, 2017.
- Destouni, Jarsjö, **Zones of untreatable water pollution call for better appreciation of mitigation limits and opportunities**, *WIREs Water*, 2018.

Physical land-coast-sea interactions

- Chen et al., **Dominant Hydro-Climatic Drivers of Water Temperature, Salinity, and Flow Variability for the Large-Scale System of the Baltic Coastal Wetlands**, *Water*, 2019a.
- Chen et al., **Scenarios of Nutrient-Related Solute Loading and Transport Fate from Different Land Catchments and Coasts into the Baltic Sea**, *Water*, 2019b.

Land-coast-sea model-coupling for coastal water quality

- Vigouroux et al., **A scalable dynamic characterisation approach for water quality management in semi-enclosed seas and archipelagos**, *Marine Pollution Bulletin*, 2019.

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THANK YOU FOR LISTENING!

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