Scaini A, Vigouroux G, Destouni G (2022).
H2020 773782- COASTAL MAL03 Flipbook -
Norrström, Baltic Sea: Workflow, issues and
future needs, Zenodo Repository.
https://doi.org/10.5281/zenodo.7102196

Supplementary Material to:

Destouni G (2025). Social perception and
prioritization data for integrated big-picture
science of water environmental change and
sustainability. Abstract EGU25-19884

CONTENT

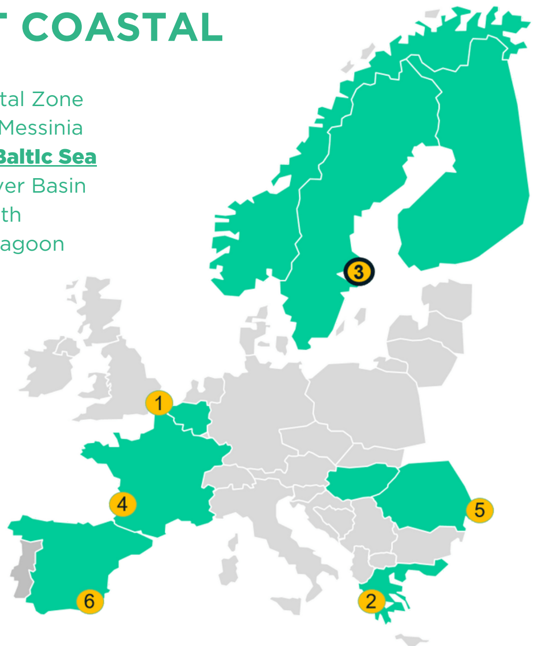
Source: State of the Baltic Sea – First version – HELCOM, 2017.

Dear reader,

In the following pages you will discover how we worked in the COllaborative lAnd Sea inTegrAtion pLatform (COASTAL) project to translate thoughts, issues and future needs for the development of the Baltic coastal region, with particular focus on the Norrström catchment and surrounding coastal areas.

ABOUT COASTAL

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



COASTAL aims to contribute to sustainable development through integrated coastal-rural planning based on coastal-rural synergies in the different case studies.

In the COASTAL project stakeholders from different sectors are involved to jointly develop and evaluate sustainable practices through coastal-rural collaboration. COASTAL combines local and scientific knowledge in order to generate coastal-rural synergies.

The project is organized around 6 multi-actor platforms located in 6 different countries across the EU.

NORRSTRÖM/BALTIC SEA

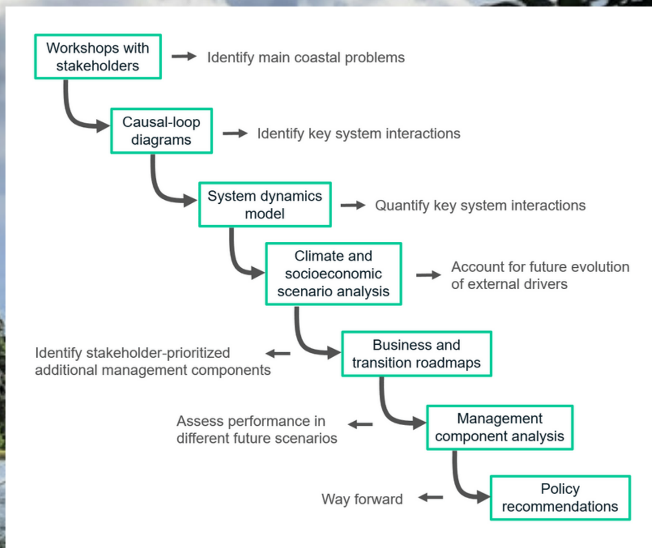
The Norrström catchment and its surrounding coastal zones in Sweden are a hotspot of issues related to water quality and quantity. Issues include agricultural, urban, and industrial activities, the increasing population density, coastal tourism, ongoing and future climate change, and their combined effects on the nutrient loads feeding coastal eutrophication.

For this reason, during the project we organized a series of workshops with local partners and stakeholders from land, coastal and maritime sectors. Based on their inputs, we have developed a model and scenarios of future development. Here, we briefly present you with the problems considered, show the main results and provide the basis for a way forward.

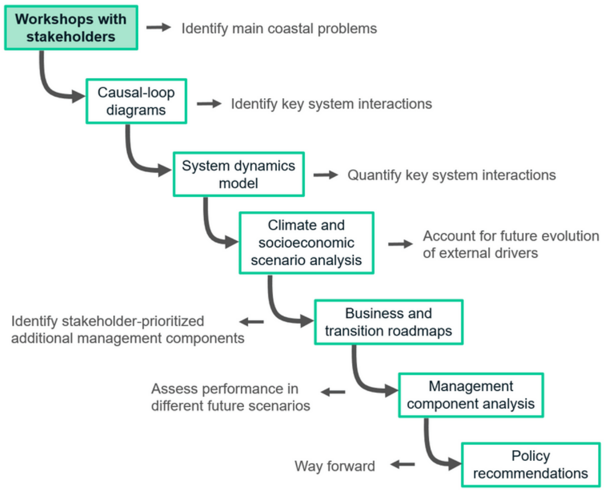
THE WORKFLOW

The steps followed in the projects are here summarized into a workflow diagram.

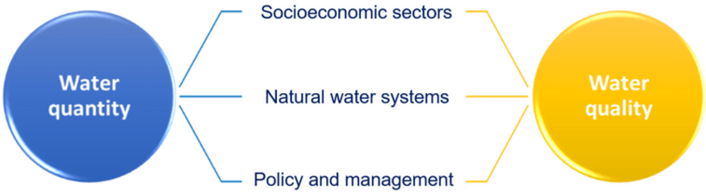
In the next pages, we will go through each step of the way.



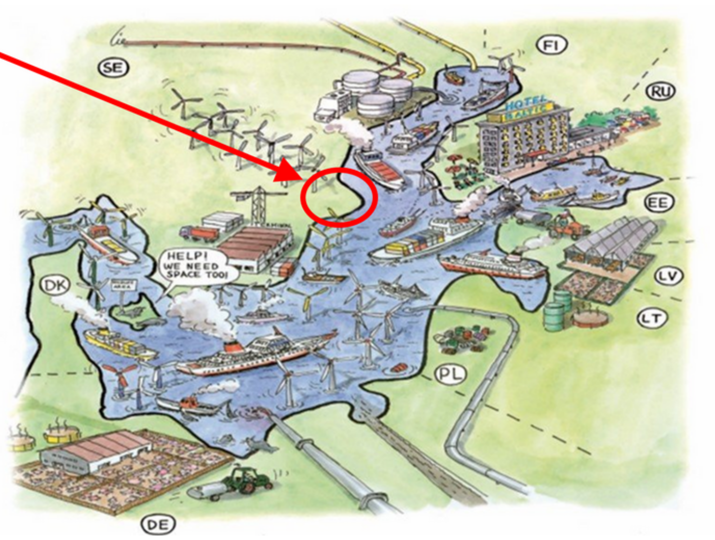
WORKSHOPS WITH STAKEHOLDERS



IDENTIFIED MAIN PROBLEMS IN THIS COASTAL CASE

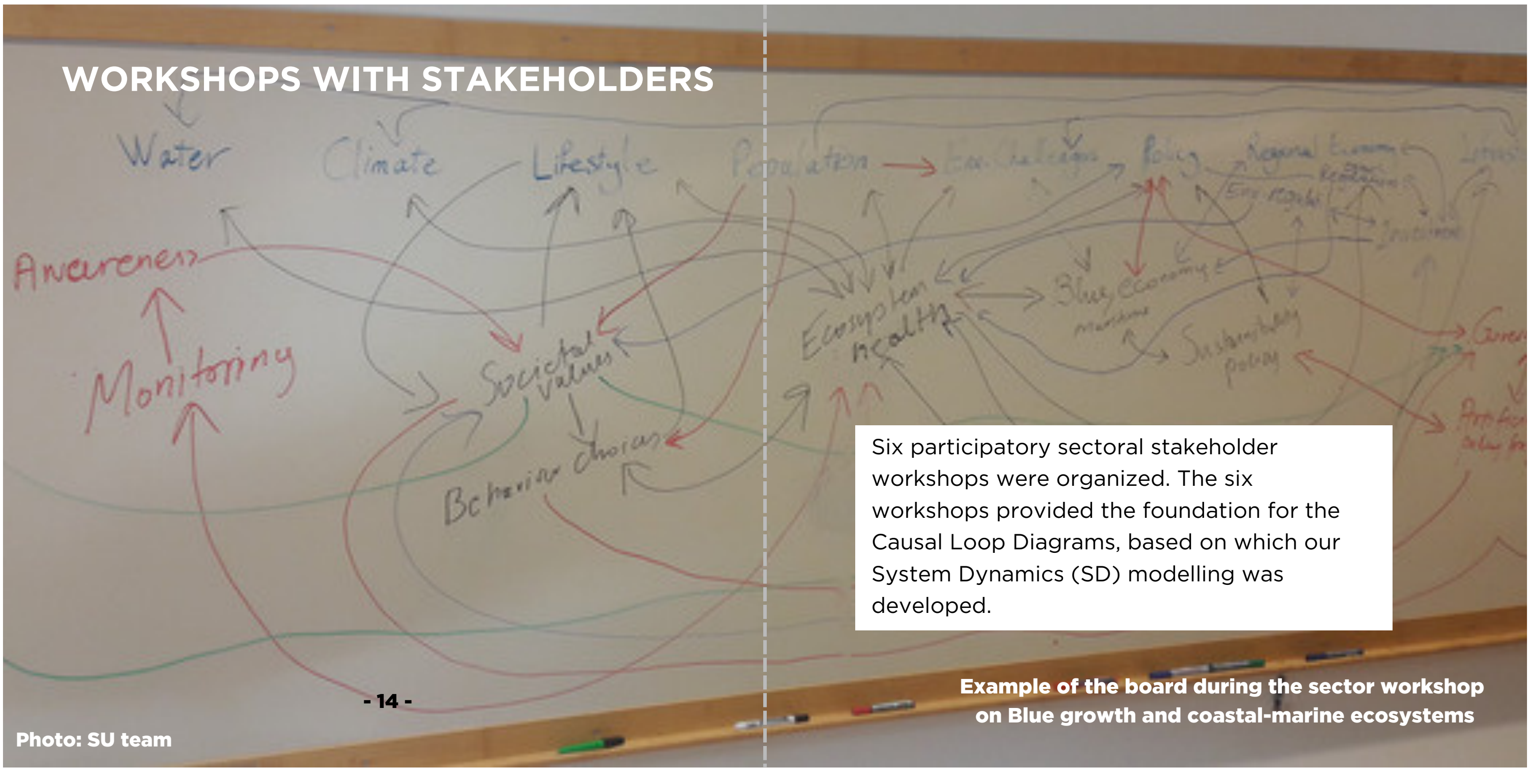


The issues considered involve the whole water cycle and combine inland, coastal and sea waters and their interactions with each other and with socio-economic sectors and policy and management.



Source: WWF Germany, Frankfurt (2010), BaltSeaPlan project

WORKSHOPS WITH STAKEHOLDERS

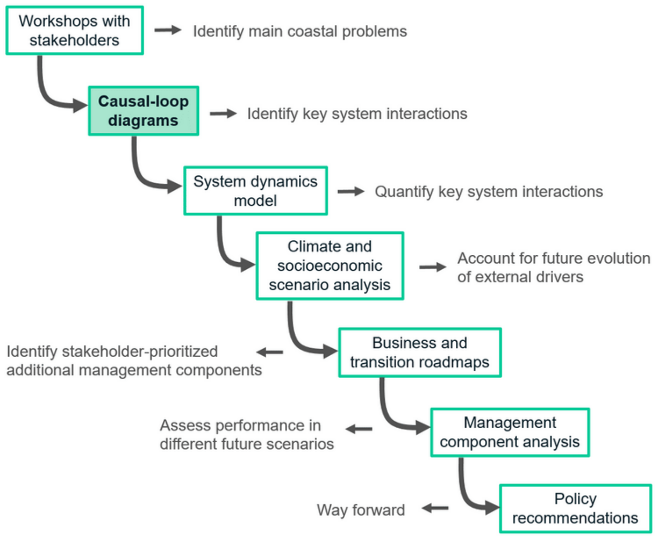


Six participatory sectoral stakeholder workshops were organized. The six workshops provided the foundation for the Causal Loop Diagrams, based on which our System Dynamics (SD) modelling was developed.

Example of the board during the sector workshop on Blue growth and coastal-marine ecosystems

Photo: SU team

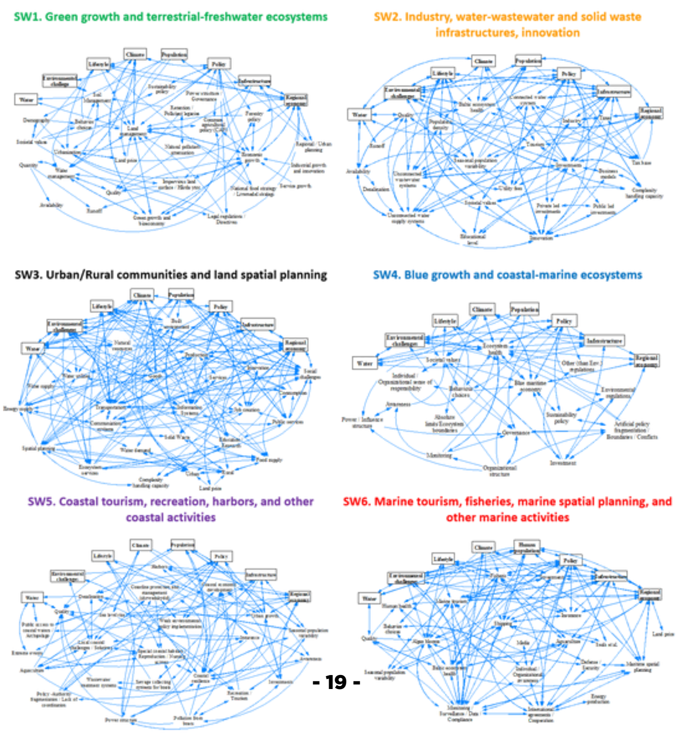
CAUSAL LOOP DIAGRAMS



CAUSAL LOOP DIAGRAMS

The figure panels to the right show the Causal Loop Diagrams created in the sector workshops (SW) on:

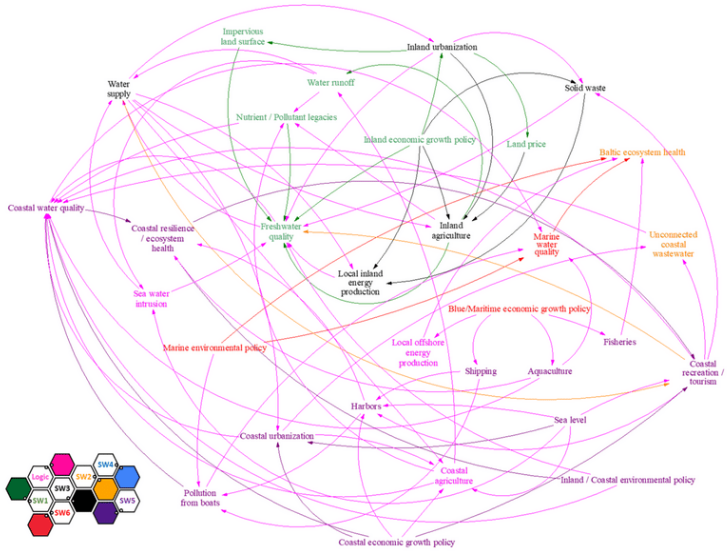
- SW1-Green growth and terrestrial-freshwater ecosystems;
- SW2-Industry, water-wastewater and solid waste infrastructure, and innovation;
- SW3-Urban-rural communities and land spatial planning;
- SW4-Blue growth and coastal-marine ecosystems;
- SW5-Coastal tourism, recreation, harbors, and other coastal activities;
- SW6-Marine tourism, fisheries, marine spatial planning and other marine activities.



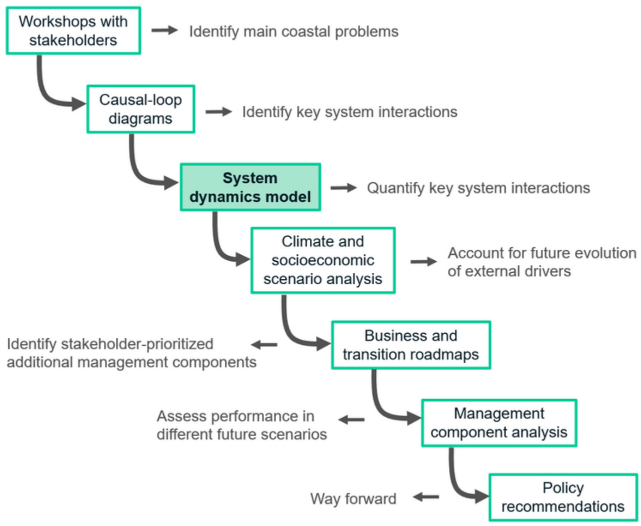
SIMPLIFIED AND UNIFIED REGIONAL CAUSAL LOOP DIAGRAM

After the workshops, the sectoral Causal Loop Diagrams were harmonised and merged into one regional Coastal Loop Diagram containing the main interactions taken up by the stakeholders, and introducing main interaction directions and weights. The key quantifiable interactions among these were further included in our development of a fully quantitative System Dynamics (SD) model.

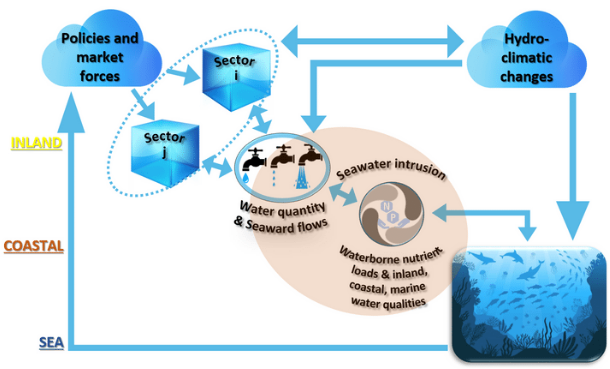
Read more at https://h2020-coastal.eu/assets/content/Deliverables/773782-COASTAL-WP1-D04.pdf or [10.5281/zenodo.6860726](https://doi.org/10.5281/zenodo.6860726)



SYSTEM DYNAMICS MODEL



SYSTEM DYNAMICS MODEL

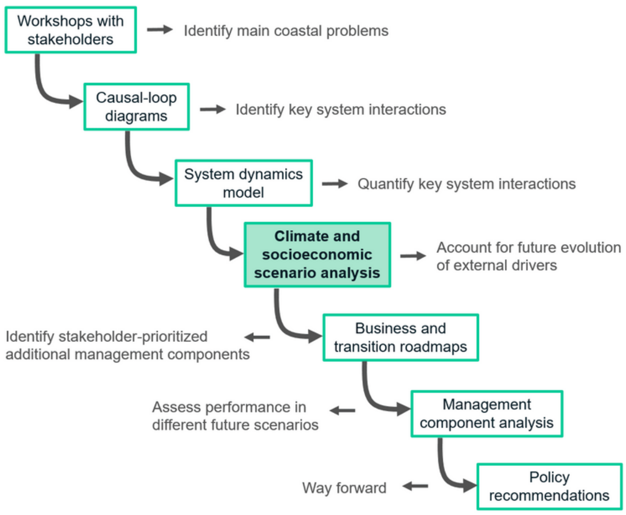


The system dynamics (SD) model represents the main quantifiable interactions in the unified regional Causal Loop Diagram.

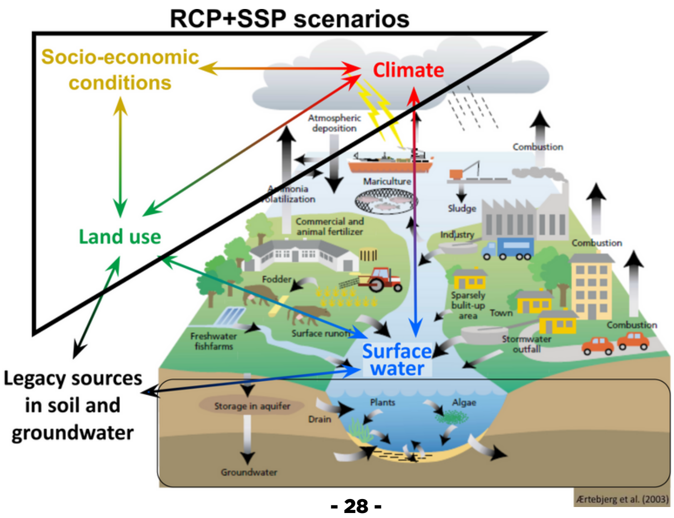
The SD model addresses problems of water availability and quality, and their interactions with and implications for key inland and coastal sectors, with water as a land-sea and sector interaction and impact tracer. The SD model quantifies key policy indicators for water quantity (water availability for socio-economic sectors, water availability for natural sub-systems and proxy of seawater intrusion risk) and water quality (Nitrogen (N) and Phosphorous (P) inputs to and loads from socio-economic sectors, N and P inputs to and loads from natural water systems, policy and management indicators for water quality).

Read more at: 10.5281/zenodo.6976851

CLIMATE AND SOCIOECONOMIC SCENARIO ANALYSIS



ANALYSIS OF FUTURE CLIMATE AND SOCIOECONOMIC SCENARIOS



The scenarios were developed based on projected climate and socio-economic changes, combining relevant climatic representative concentration pathways (RCPs) and shared socioeconomic pathways (SSPs) downscaled and interpreted for the region.

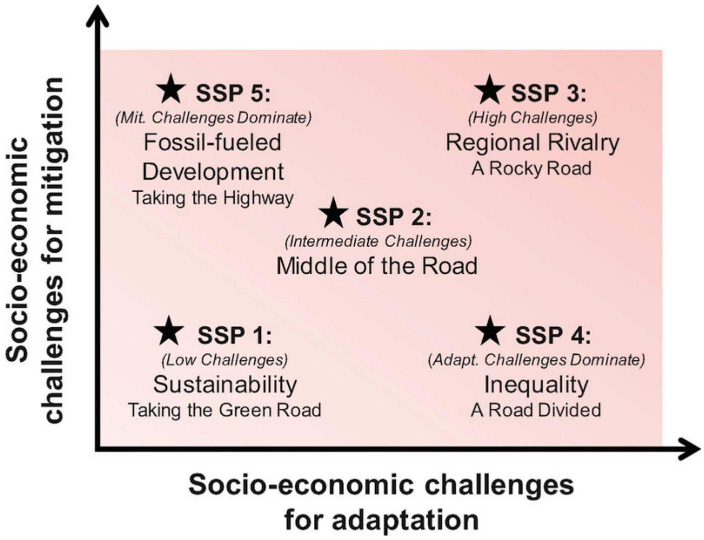
ANALYSIS OF FUTURE CLIMATE AND SOCIOECONOMIC SCENARIOS

Combined SSP and RCP scenarios considered in our regional scenario analysis:

- Current conditions: long-term average hydro-climate and land use conditions continued into the future
- Sustainability: SSP1+RCP 4.5
- Middle of the road: SSP2+RCP 4.5
- Inequality: SSP4+RCP 4.5
- Fossil-fueled development: SSP5+RCP 4.5

First, these scenarios are tested with current water and nutrient management conditions.

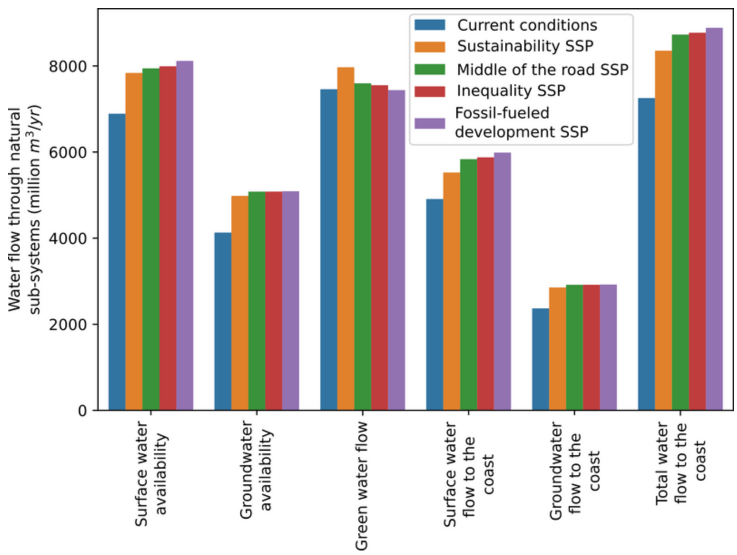
Read more at: [10.5281/zenodo.6854490](https://doi.org/10.5281/zenodo.6854490)



O'Neill et al., 2017

WATER AVAILABILITY

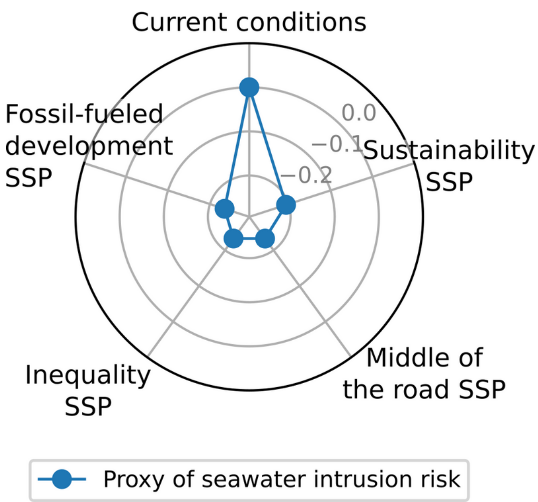
Changes in water availability



Changes in water availability under current management conditions and different climate and socioeconomic scenarios.

Overall, water flows and water availabilities are expected to increase on average in the future.

RISK OF SEAWATER INTRUSION IN FRESH COASTAL GROUNDWATER



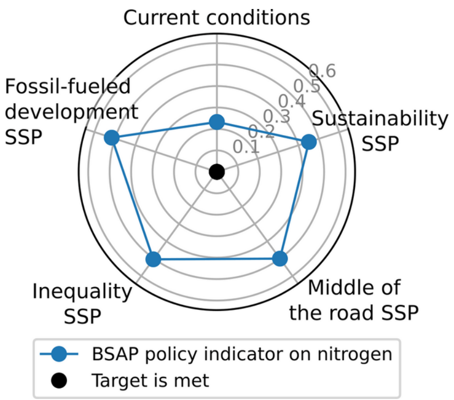
Lower proxy value means decreased risk

The risk of seawater intrusion into fresh groundwater is one of the most pressing management issues for coastal freshwater availability.

Overall, future scenarios are expected to decrease the risk of seawater intrusion because they increase the freshwater flows toward the sea.

WATER QUALITY

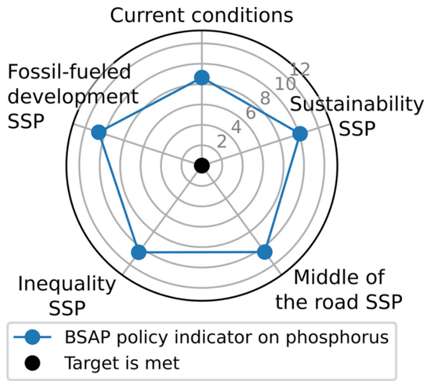
NITROGEN



The results (blue circles) show ability to reach the nutrient load reduction targets of the Baltic Sea Action Plan (BSAP) for nitrogen and phosphorous under current management in different future evolution scenarios.

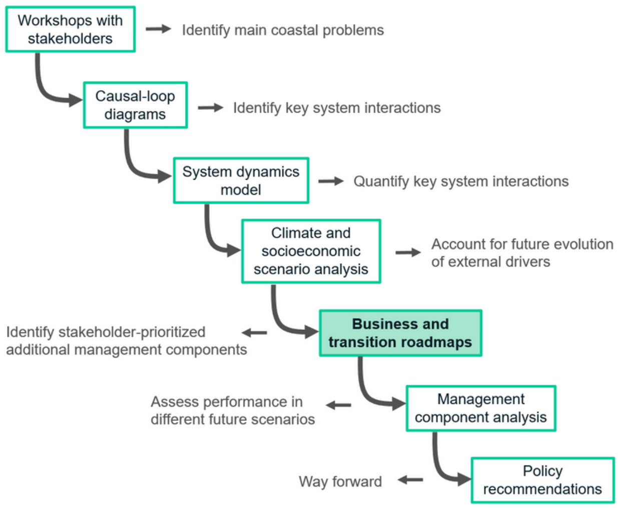
Result = 0 means target is met
Result > 0 means target is not met

PHOSPHOROUS



Overall, the future scenarios imply greater difficulty in meeting the BSAP load reduction targets because they increase the water flows that carry the nutrients.

BUSINESS AND TRANSITION ROADMAP



BUSINESS AND TRANSITION ROADMAP

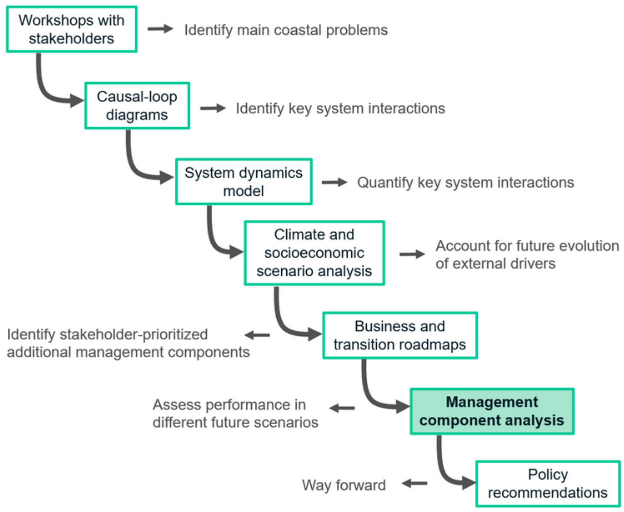
A business and transition roadmap was developed with management components prioritized by stakeholders to be added on top of current management practices in order to promote rural-coastal synergies and environmental sustainability, with focus here on water quality with regard to nutrient loads to inland and coastal-marine waters.

Four solution components for decreasing nutrient loads were prioritized by the stakeholders.

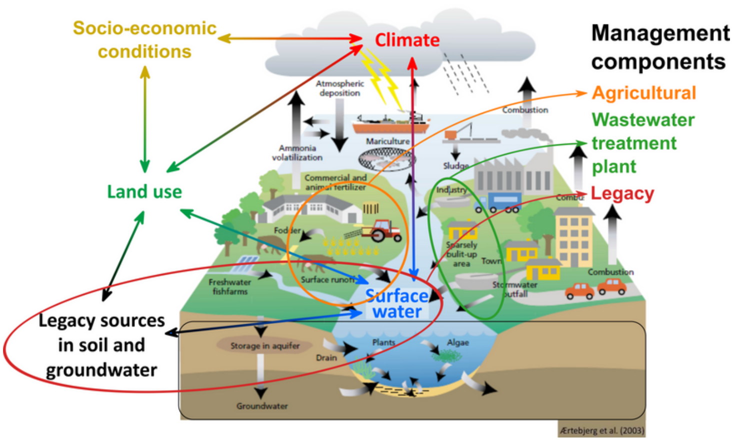
Key stakeholder-prioritized solution components in business road map

- Improved knowledge transfer between sectors
- Integrated risk assessment of nutrient losses from agricultural soil to surface water
- Nutrient recovery in wastewater treatment plants
- Smart water and sanitation systems

MANAGEMENT COMPONENT ANALYSIS



MANAGEMENT COMPONENT ANALYSIS



Based on the stakeholder-prioritized solution components, we developed three comparable quantifiable management components to test with the SD modelling:

Agricultural measures
25% reduction in nutrient concentrations leaching from agricultural soils (e.g., by reduced and better optimized fertilizer application…).

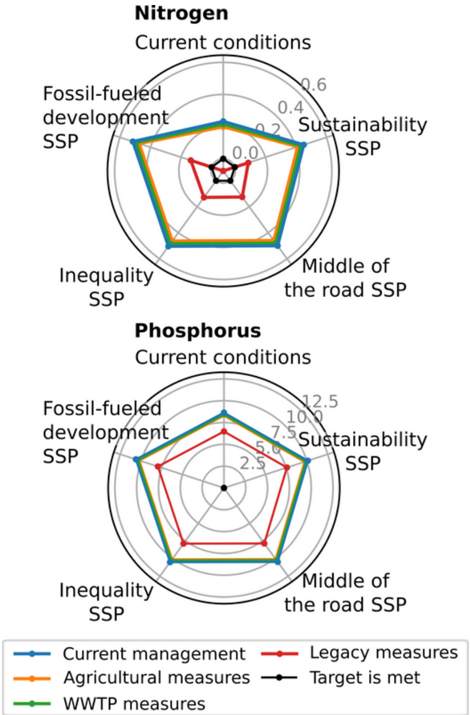
Wastewater treatment plant (WWTP) measures
25% reduction in nutrient concentrations discharged from WWTPs and unconnected wastewater to the natural water systems (surface, subsurface and coastal waters).

Legacy measures
25% reduction in nutrient concentrations released from legacy sources in soil, groundwater and sediments (e.g., by enhanced retention in downstream constructed wetlands and reactive barriers).

Current management continued to the future is compared to the above.

Read more at: 10.5281/zenodo.6855356

MANAGEMENT COMPONENTS IN DIFFERENT FUTURE SCENARIOS



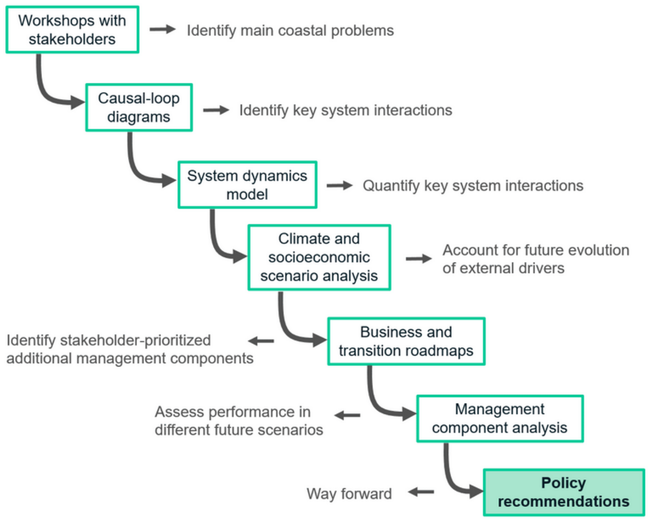
Baltic Sea Action Plan (BSAP) load reduction targets are not met under current management conditions.

Even considerable decrease of currently active agricultural and WWTP nutrient sources is insufficient for meeting BSAP nitrogen and phosphorous load reduction targets.

Only reduction of nutrient releases from legacy sources can considerably decrease current nutrient loads to the coast.

Even the legacy source reductions are insufficient for meeting BSAP targets under future scenarios, due to the increase of the water flows that carry the nutrient loads.

POLICY RECOMMENDATIONS/ WAY FORWARD



WAY FORWARD

Time frames of sustainability

Assessment of which additional measures and how much of them are needed to reach the nutrient load reduction targets of BSAP has to consider future evolution scenarios, since all scenarios tend to make it more difficult to meet the targets.

- Targeting legacy sources (downstream capture/retention of their nutrient releases) → substantial and robust reduction of nutrient loads
- Addressing and mitigating the continuous nutrient releases from legacy sources → key to relatively fast achievement of good water quality in inland and coastal waters of MAL3, consistent with other reports
- Legacy measures must also be combined with additional agricultural and WWTP measures → needed to stop/reduce further legacy source build-up and releases for the future – key to long-term sustainability

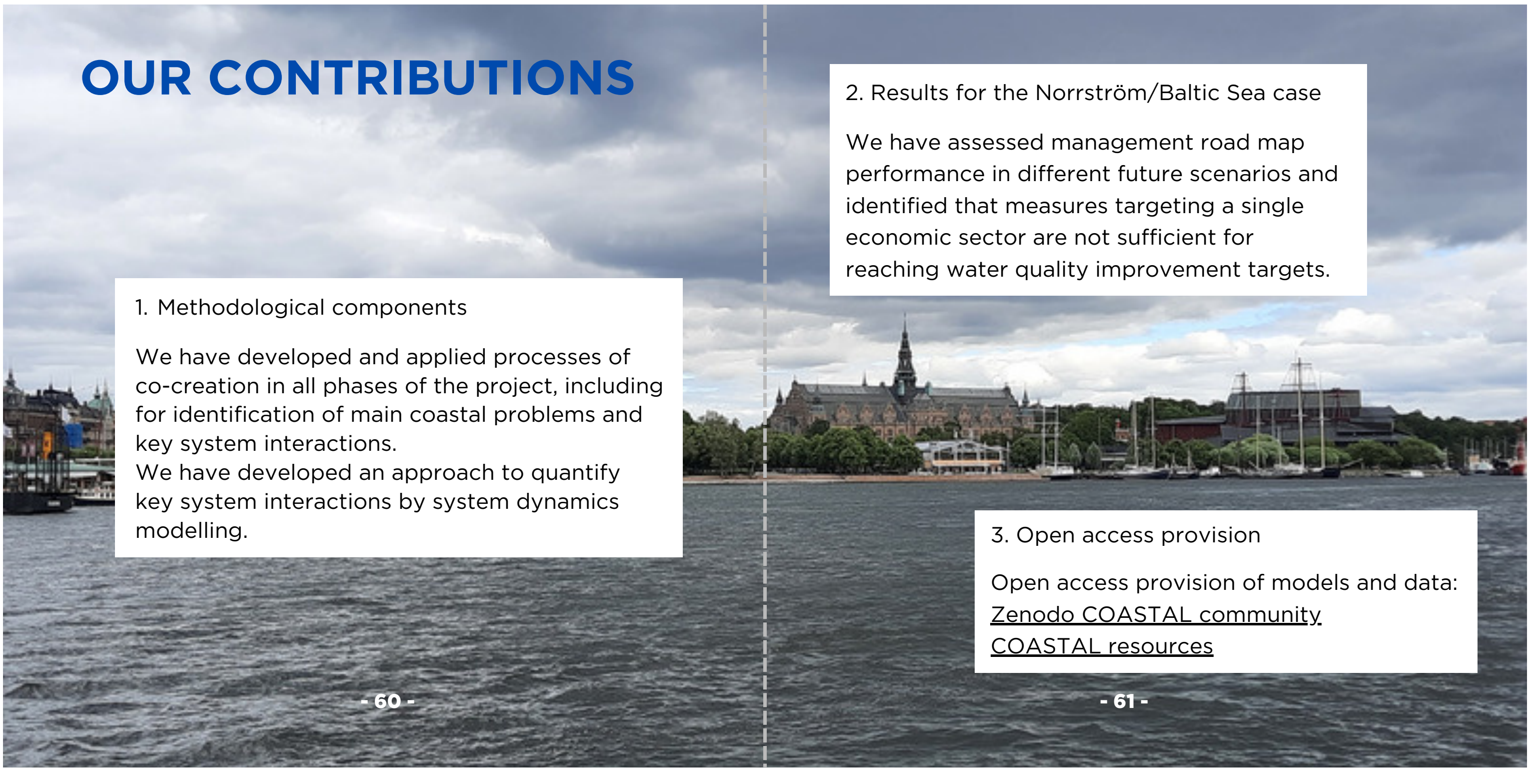
WAY FORWARD

Reductions needed

We need combined, synergistic strategies that focus on water quality, aiming at reduction of nutrient loads from both active and legacy sources.

Examples of measures for reaching the needed reductions:

- For legacy sources: enhancement of downstream retention/attenuation of their nutrient releases (e.g., by well-placed constructed/restored wetlands, reactive barriers with nano-particle injection for retention enhancement)
- Recycling and reuse of nutrients
- More adaptive nutrient management under uncertainty (considering future scenario, source and load evolutions, and their modelling)



OUR CONTRIBUTIONS

1. Methodological components

We have developed and applied processes of co-creation in all phases of the project, including for identification of main coastal problems and key system interactions.
We have developed an approach to quantify key system interactions by system dynamics modelling.

2. Results for the Norrström/Baltic Sea case

We have assessed management road map performance in different future scenarios and identified that measures targeting a single economic sector are not sufficient for reaching water quality improvement targets.

3. Open access provision

Open access provision of models and data:
Zenodo COASTAL community
COASTAL resources

MAL3 COASTAL PARTNERS

SWEDISH MAL COORDINATION: Stockholm University

LOCAL PARTNERS:

SEI Stockholm Environment Institute

NIRAS

CAMPUS ROSLAGEN

Luke NATURAL RESOURCES INSTITUTE FINLAND

GLOBAL UTMANING

Flipbook by Anna Scaini, Guillaume Vigouroux and Georgia Destouni, in collaboration with the partners Donatella Acquaviva, Joel Ahlgren, Karina Barquet, Sofia Bernett, Klas Sandström and Riikka Venesjärvi.

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https://coastal-xchange.eu/

Photo credits: Anna Scaini, Georgia Destouni

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