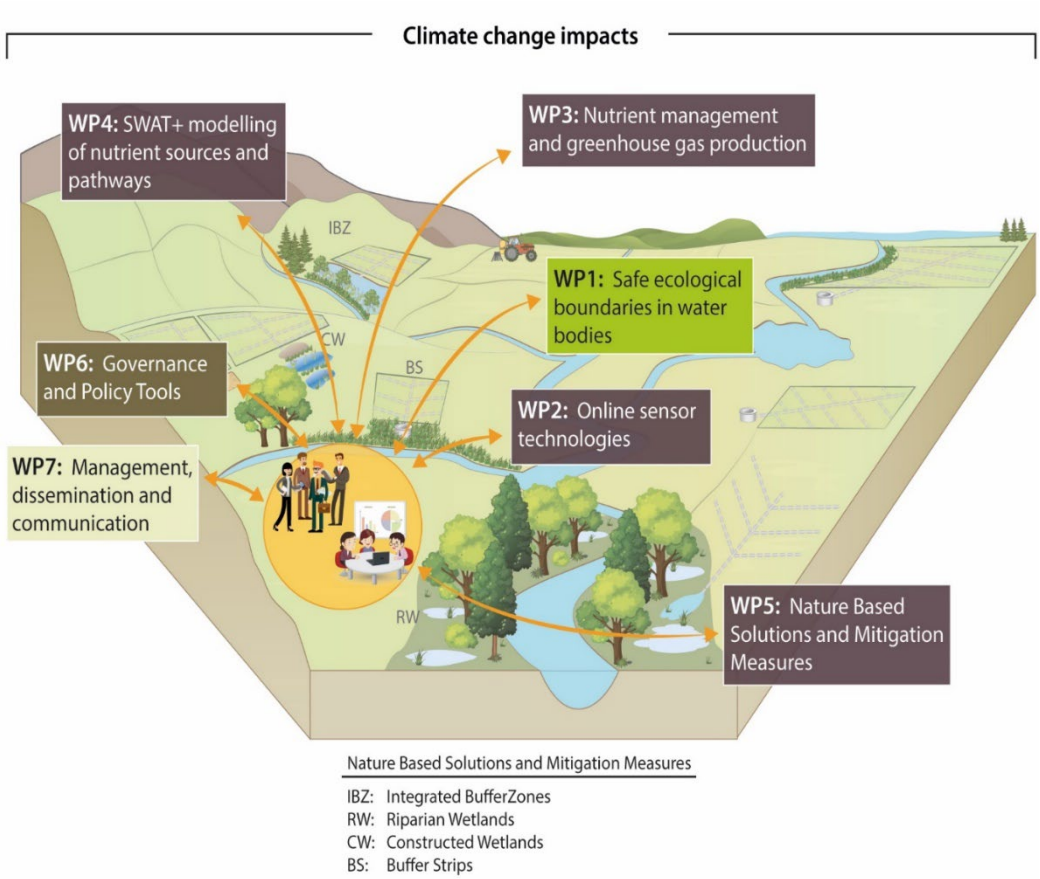

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Nitrogen and phosphorus load reduction approach within safe ecological boundaries for the Nordic-Baltic region
https://projects.au.dk/nordbalt-ecosafe

POLICY BRIEF NO. 6

NORDBALT ECOSAFE


Material bank: University of Oulu

Developing catchment scale water quality modelling is important for water resource management, climate change adaptation, and sustainable land use planning

Recommendations

- **Recognize needs to develop improved water quality modelling in EU to close the gap between current conditions and boundary conditions**
- **Catchment models can help to integrate land use and water quality planning more holistically**
- **Continue to improve modelling and management collaboration within EU**
- **Key policy actions are needed to effectively implement catchment modelling as a tool for stakeholder engagement**

Efficient water resource management is vital for sustainable development and risk assessment. Catchment scale hydrological models help assess water availability and quality, predict flood risks, optimize water storage, and design water-climate -resilient policies. This policy brief aims to remind about the importance to develop water quality modelling approaches nationally but with international collaboration. European Union (EU) countries have a long tradition of hydrological and water quality modelling. Modelling together with monitoring supports several societal critical functions and goals in EU joint agreements. The Water Framework Directive (WFD), the Restoration Act, the Nitrates Directive among other targets needs new tools and approaches for planning, managing and especially predicting measures and actions done in land use and water protection.


Figure 1. Nutrient leaching and erosion transport in Örsundaån agricultural catchment in Sweden

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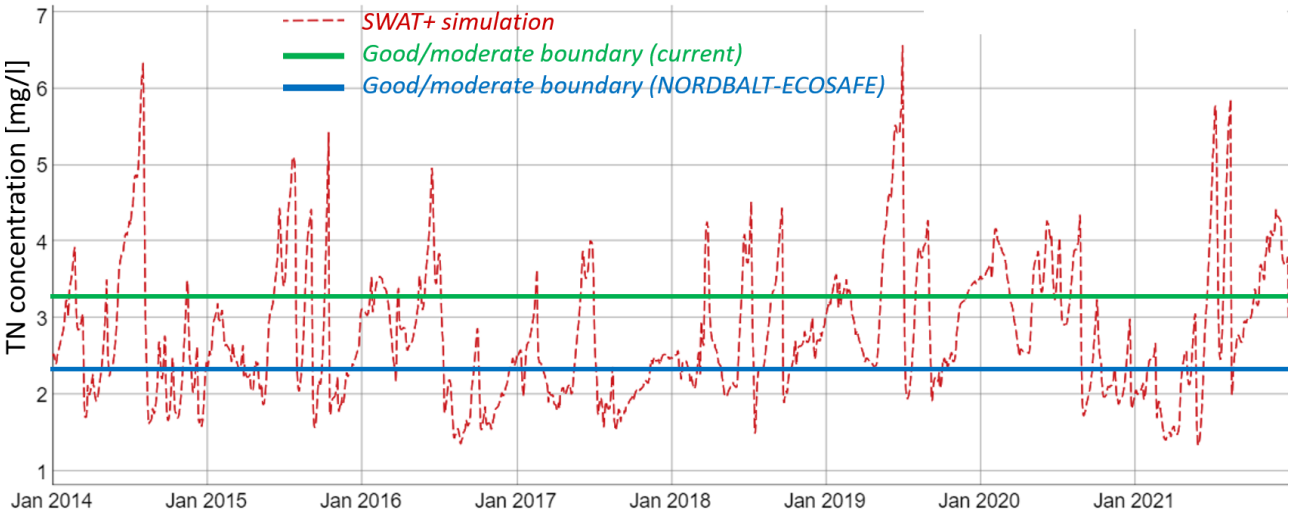

Figure 2. Simulated daily TN concentrations using SWAT+ versus good/moderate ecological status boundaries for one of the tributaries of the Słupia river, Poland.

Land use, land use changes and the forestry (LULUCF) sector plays a key role in achieving the EU's goal of zero net emissions by 2050. At the same time, LULUCF sector has a notable impact on local and regional water quality and ecological status. We need new tools and approaches for accomplishing good/moderate ecological status and ecologically safe boundaries (Figure 2) in European river basins.

The NordBalt-Ecosafe project has tested the potential of applying the SWAT+ model to the Baltic sea region's agricultural land use challenges and scenarios. Developed by the USDA Agricultural Research Service, SWAT+ is a more advanced version of the widely used SWAT model. SWAT+ simulates hydrological processes at different scales, from small watersheds to large river basins, incorporating various physical, climatic, and anthropogenic factors. In six case study catchments in Denmark, Finland, Norway, Sweden, Poland and Latvia SWAT+ was tested in the Baltic Sea region for various agricultural land use and management conditions.

Using new key features related to integrated catchment management SWAT+ allows users to model complex systems involving land use, soil types, vegetation, climate, and human interventions.

Most important capabilities of SWAT+ are:

1) Detailed description of agricultural management practices: the effects of soil management systems and crop rotation strategies on water quantity and quality can be quantified.

2) Flexibility in implementing structural measures: the effects of structural measures and their placement in the catchment can be assessed.

3) Simulation of crop growth and yields: agricultural productivity can be considered when developing catchment management strategies, increasing acceptance among farmers.

The NORDBALT-ECOSAFE project aims to foster the implementation of innovative Nature-Based Solutions and mitigation measures in the Nordic-Baltic region of Europe to reduce diffuse nutrient losses from agriculture and forestry under current and future climate conditions. The partners in NORDBALT-ECOSAFE are from Denmark (lead), Norway, Sweden, Finland, Latvia, and Poland

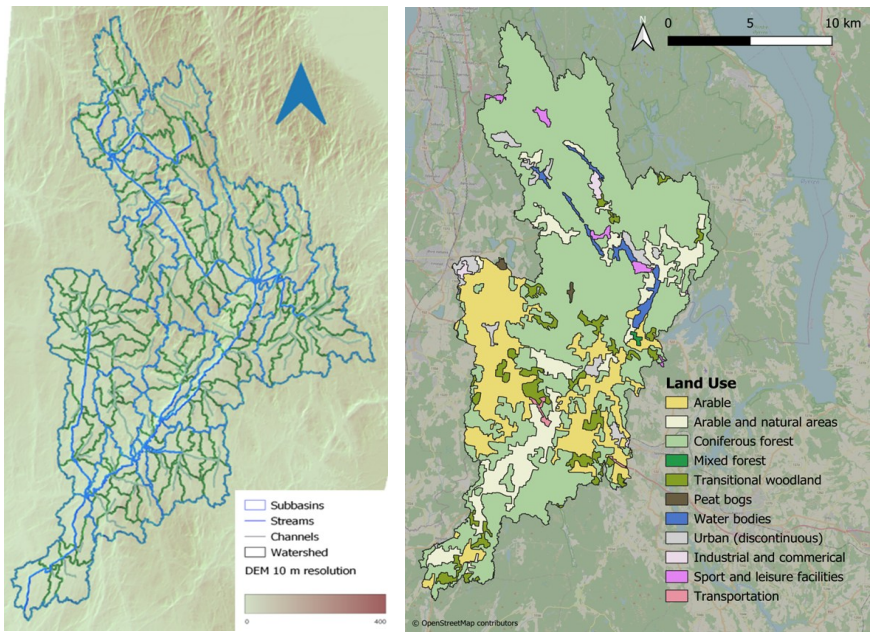

Figure 3. SWAT+ model structure for Hydrological Responce Units (HRUs) and Land Use map at Hobølelva Catchment in Norway.The national Teotil model in Norway calculates annual sediment, total nitrogen (N), and total phosphorus (P) loads. It incorporates results from the Agritil model, which specifically provides loads from agricultural areas. Based on NordBalt Ecosafe modelling results the SWAT+ model offers broader outputs compared to the national model, calculating runoff, nitrate loads, and the concentration of key nutrient components in streams at a finer, daily resolution.

Challenges and limitations with SWAT+:

1) High input data requirements, that is now always available from all sites

2) High level of expertise needed to create a reliable model

3) Further testing and developing are needed to Nordic land use conditions

Based on SWAT+ model validation in NordBalt Ecosafe project case studies the SWAT+ model offers broader outputs compared to the national models, calculating runoff, nitrate loads, and the concentration of key nutrient components in streams at a finer, daily resolution. However, large variations between countries were noted.

In general, the loads calculated by the SWAT+ model have matched the measured values similarly or even better for the study period compared to the outputs from the national models. In some cases national models performed better than SWAT+, probably due to earlier development and continuous use by authorities.

Advantages of using SWAT+ in combination with/instead of national models:

1) Consistent, transnational approach for the entire region

2) Detailed description of agricultural management and structural practices

3) Capability of the model to predict water quantity and quality under changing land use and climate conditions

Still today different member countries use various modelling approaches for operational hydrological purposes, land use management and water quality management. In some countries water quality modelling is even lacking at national scale. However, new state-of-the-art, physically-based models used to simulate hydrological processes, including surface and groundwater, erosion, sediment transport, water quality and ecology can provide a tool for improved consultations between stakeholders on how to close the gap between measured status and WFD boundaries for different water body types. In particular, new modelling approaches that advance in spatial and temporal resolution, data integration, and usability are recommended to use and apply to member countries using similar approaches.

Policy recommendations for strengthening and supporting EU level improvement in water quality modelling actions

1. **Testing and implementing new modelling approaches:** New models, their structure and capability to model and predict hydrology and water quality should be tested and implemented jointly at EU level on open access platforms.
2. **Incorporate Stakeholder Input in Policy Design:** Engage local communities, water user associations, and other stakeholders in the policy design process to ensure that hydrological models reflect diverse needs and concerns.
3. **Strengthen Data Infrastructure:** EU member states should invest in building robust data collection systems and improve access to high-quality meteorological, hydrological, and land use data. Support the development of open-access data platforms to facilitate model calibration and improve data sharing across sectors.
4. **Improve Model Calibration and Validation:** Emphasize the need for monitoring stations, environmental assessment and continuous data collection, which will enhance the accuracy of model development. Collaborate with universities and research institutions to conduct long-term data collection campaigns, which are essential for accurate model validation.
5. **Promote Cross-Sectoral Collaboration:** Encourage collaboration among government agencies, environmental organizations, and local communities to ensure that hydrological modeling efforts align with national water policies and development goals. Create multi-disciplinary teams to address complex water management challenges, leveraging expertise from agriculture, urban planning, and environmental science.
6. **Invest in Computational Resources:** EU member states should invest in high-performance computing infrastructure to support large-scale simulations at the national level. Collaborate with international organizations to access computational resources for national modeling efforts.

The NORDBALT-ECOSAFE consortium will develop and demonstrate innovative methods and establish best practices to improve current river basin management and governance by reaching the following major aims: i) setting ecologically safe nutrient boundaries in different types of water bodies; ii) improving monitoring of nutrient concentrations by comparing benefits of novel high-frequency online sensors with traditional monitoring; iii) establishing nutrient loading tipping points for carbon sequestration and emissions in water bodies; iv) establishing a harmonised river basin modelling tool for precise estimation of nutrient sources, pathways and transport; v) demonstrating novel Nature Based Solutions (NBSs) and Mitigation Measures (MMs) for reaching the required nutrient load reductions; and vi) developing advanced solutions supporting regional governance structures to implement the most suitable measures to meet the ecological nutrient boundaries. A conceptual diagramme is showing the links between different parts of the project and a ma shows our working platform consisting of six river basins and riverine monitoring points under HELCOM and OSPAR. https://projects.au.dk/nordbalt-ecosafe

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