NORDBALT ECOSAFE

NEW Harmonica

Bring in complementary knowledge and expertise, skills and networks to meet the goal of reducing nutrient loads within safe ecological boundaries

from source to NAPSEA

JOINT POLICY BRIEF

30-09-2025

JOINT POLICY BRIEF

Introduction

Eutrophication has emerged as one of the most persistent and widespread environmental challenges affecting aquatic ecosystems across Northwestern Europe over the past century. Driven primarily by excessive nutrient inputs—particularly nitrogen and phosphorus—from agriculture, wastewater, and industrial sources, eutrophication has severely impacted marine, coastal and freshwater systems. These nutrient overloads have led to algal blooms, oxygen depletion, biodiversity loss, and the degradation of water quality, threatening both ecological integrity and socio-economic activities such as fisheries, tourism, and drinking water supply. Despite decades of policy interventions and technological improvements, the problem remains deeply entrenched, highlighting the need for coordinated, cross-sectoral strategies that address both legacy pollution, current nutrient management and emerging pressures, including climate change.

In support of its Zero Pollution Action Plan, the EU supported three projects (NAPSEA, NORDBALT-ECOSAFE and NEW-HARMONICA) with the objectives to develop and demonstrate methodologies to:

- Identify safe ecological boundaries for nitrogen and phosphorus and load reduction targets.
- Quantify sources and pathways of nitrogen and phosphorus from source to sea.
- Quantify the impact of climate change on these sources and pathways from source to sea.
- Develop more effective governance approaches.

These projects differed in geographical scope (spatial domains shown in Figure 1) and scientific approach. This policy brief summarizes the results of the three projects on the objectives above.

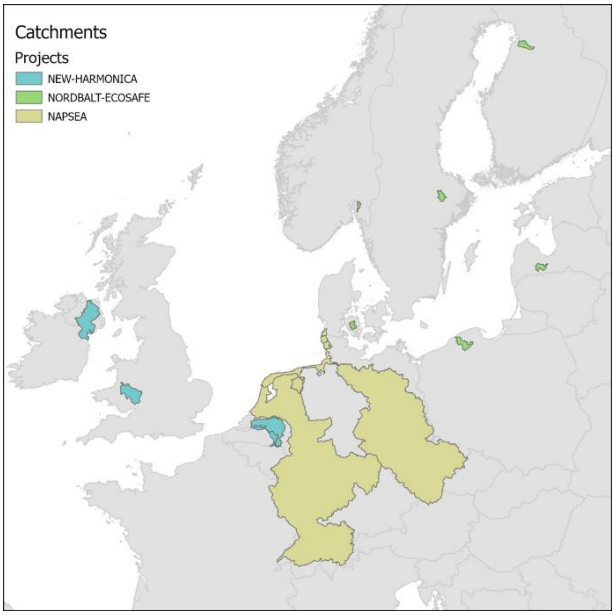


Figure 1. The various catchments that the three sister projects (defined by colour) worked on throughout the last three years.

Key messages

1. Harmonise nutrient threshold standards across Northwest Europe to unify restoration goals.

2. Invest in harmonized and enhanced nutrient and hydrological monitoring.

3. Use national Load Reduction Target (LRT) models to quantify sector-specific contributions, assign responsibilities, and ensure compliance.

4. Integrate climate change considerations into nutrient management policies by addressing local-scale approaches.

5. Support the implementation of site-specific nutrient management strategies to enhance efficiency, reduce environmental impact, and tailor solutions to local conditions.

6. Enable inclusive, multi-stakeholder catchment governance platforms to lead local restoration efforts, supported by coherent top-down frameworks that integrate regulation, incentives, and advisory services to drive behavioural and systemic change.

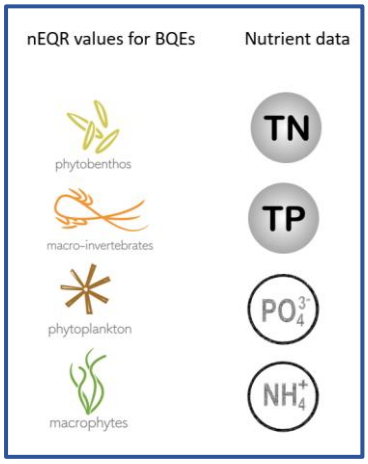
1. Harmonise nutrient threshold standards across Northwest Europe to unify restoration goals

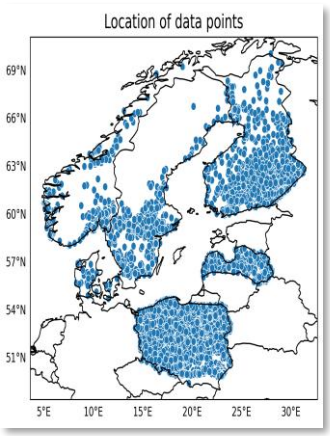
Main findings in projects:

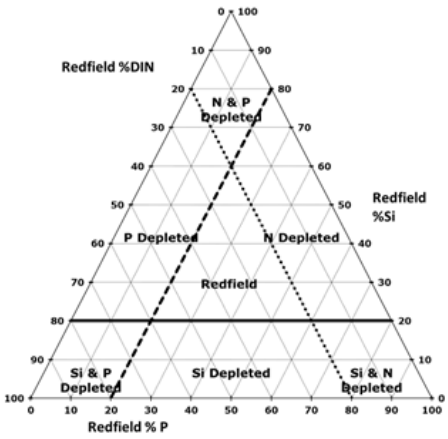
NAPSEA:
The analysis of nutrient threshold standards in River Rhine and Elbe showed that there was a missing link between marine and freshwater nutrient standards (Enserink et al., 2024). There is a need for including nutrient stoichiometry as both phosphorus and nitrogen (and silica) and their ratios are relevant for ecological impacts (van Beusekom et al., 2025a,b). In policies this is often not yet fully considered. Separate standards are needed to achieve good ecological status locally and downstream. The latter should be expressed as nutrient load targets and load reduction targets.

NORDBALT-ECOSAFE:
An analysis of Ecological Quality Ratio's (EQRs) for several biological indicators for lowland river and lake types in the Nordic and Central Baltic region showed that present nutrient threshold standards for total phosphorus and total nitrogen in some countries may not support Good Ecological Status (GES) (Solheim et al., 2024; Thrane et al., 2025). Understanding coupled element cycles is key to:

i) N:P:C - assessing trade-offs between nutrient retention and greenhouse gas production in individual wetlands;
ii) N:P:Si - targeted reductions in terrestrial nutrient loads to mitigate marine eutrophication







New-Harmonica:
An analysis of the River Meuse catchment for the Flemish and Dutch regions and comparison to the Neagh-Bann and Wye catchments in the UK and Ireland revealed that there are different nutrient standard thresholds for cross-border rivers and canals across NW Europe. The objectives for canals are also not well-coordinated with the numerous streams that take in large quantities of water from the canals in summers.

Policy recommendations

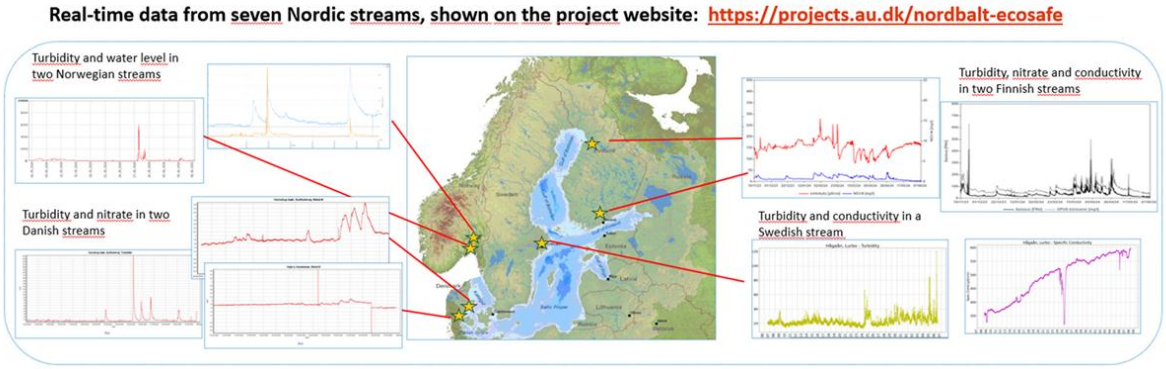
- Support cross-border cooperation initiatives to establish a common science base to underpin ecologically safe nutrient thresholds (N and P) that guide consistent waterbody restoration under the Water Framework Directive (WFD) as well as the Marine Strategy Framework Directive (MSFD).
- Promote frameworks and catchment-scale indicators that enable comparability of environmental performance across jurisdictions and facilitate integration of regional nutrient reduction measures.
- Support the inclusion of stoichiometry in protection of freshwater and marine waters.

2. Invest in harmonized and enhanced nutrient and hydrological monitoring.

Main findings in projects

NAPSEA:
Monitoring observations (time and space) of discharge and concentrations are often not measured at the same time/location which is crucial for achieving reliable temporally and spatially distributed nutrient load estimates for the WFD and the MSFD (Ebeling et al., 2022).

NORDBALT-ECOSAFE:
Introduction of high-frequency sensor technology for monitoring of nutrient concentrations can give more precise and unbiased mean concentration and load estimates and is better suited to capture extremes related to climate change (Rozemeijer et al., 2025; van't Veen et al., 2025a,b; Skarbøvik et al., 2023).



New-Harmonica:
The project highlighted the low frequency, inconsistency and gaps in the current monitoring programmes across NW Europe to deliver and track achievement of safe ecological boundaries, Chemical parameters included in Nitrate Directive (ND) and WFD monitoring might differ between countries such as for phosphorus speciation in surface waters.

Policy recommendations

- Assure that nutrient concentrations and discharge is monitored at the same sampling stations in river basins, especially for monitoring stations situated near the outlets of the catchments and rivers.
- Allocate funding to develop high frequency sensor technology for nutrient monitoring at key monitoring sites in river basins to achieve precise and unbiased mean concentrations and load estimates.
- Ensure monitoring captures seasonal variability of discharges and concentrations and climate-driven extremes to improve source apportionment model calibration and validation for Load Reduction Targets (LRTs) that are derived from these models.
- Introduce and support more widespread monitoring of nutrient use by sectors within catchments to help determine their fair-share responsibilities and actions to mitigate the N and P pollution threat.
- Harmonise methods used for water quality monitoring and mandate data transparency and open access to monitoring results to support evidence-based decision-making.

3. Use national Load Reduction Target (LRT) models to quantify sector-specific contributions, assign responsibilities, and ensure compliance

Main findings in projects

NAPSEA:
In the NAPSEA project, the effectiveness of currently planned measures from different sectors were evaluated with catchment models (example for nitrogen in the Rhine in Figure 2; Musolff et al., 2025; van Beusekom et al., 2025a,b). It was estimated that the reduction of nutrient loads due to currently planned measures would be largely insufficient to achieve nutrient concentrations within safe ecological boundaries in the whole catchment of the Wadden Sea. Different approaches for more effective measures were evaluated and only the most drastic set of measures was able to comply with the safe ecological boundaries defined in the project.

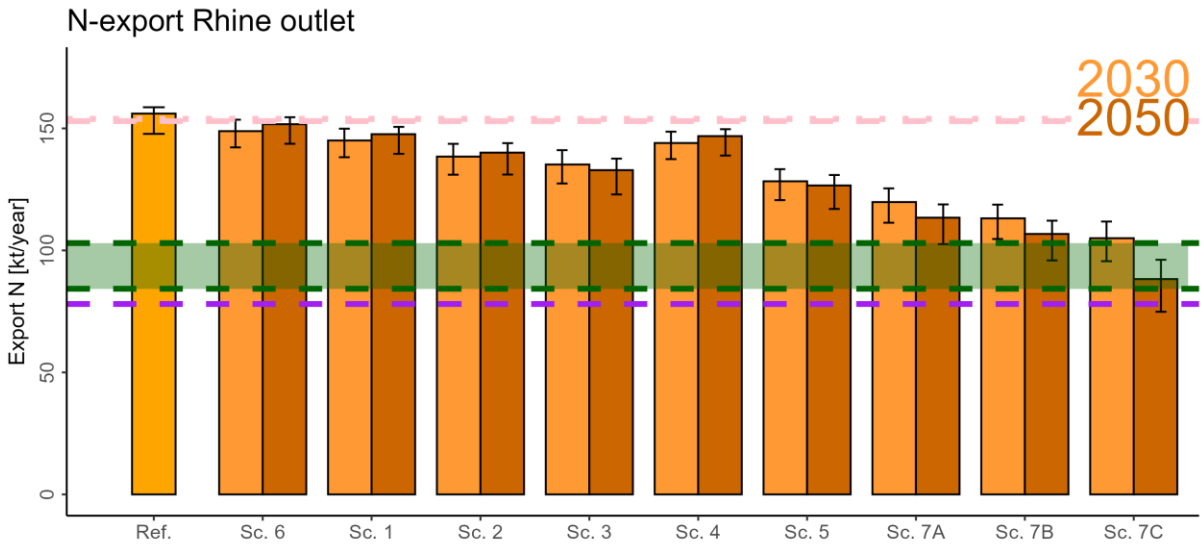


Figure 2. Nitrogen loads from the Rhine at Lobith for all model scenarios. The dashed horizontal lines show the reduction targets for: seagrass recovery in the Wadden Sea (green) natural nitrogen to silicate ratios preventing blooms of non-silicifying phytoplankton in the Wadden Sea (purple) and WFD threshold for which modelled discharges where used for the reference (dashed pink) year as well as 2030 and 2050 (dotted pink; overlaps with dashed line). Ref: reference period 2010–2020, lighter colours in scenarios: average 2028–2032, darker colours: average 2046–2050, whiskers: 5–95% confidence interval (100 model realizations). More details in van Beusekom et al., 2025b.

NORDBALT-ECOSAFE:
In the NORDBALT-ECOSAFE project the application of SWAT+ on six river basins with one in each of the participating countries was tested and compared to national models and methods. The SWAT+ calibration and validation for the six river basins which represented huge differences in climate, geology, soil type and land use showed generally a good performance for water and nitrogen with less good performance in general for phosphorus. Future scenarios simulations to identify suitable measures to close the gap between current conditions and nutrient threshold standards for achieving good ecological conditions in rivers were run after discussion with local stakeholders. The outcome is shared as project deliverables and scientific articles are currently in preparation (Marttila et al., 2025; Bieger et al., 2025 a,b).

New-Harmonica:
The potential impact of Best-Management Practice (BMP) scenarios on meeting nutrient LRT's in each New Harmonica catchment was assessed using a suite of models (MFA, CRAFT, SLAM, NEMO, INITIATOR-SWAP-ANIMO). Scenarios were modelled under the assumption of both current and future climate conditions, where possible. LRT's have been calculated according to the method as defined by the policy makers in each partner country. The differences between the methods have been identified and evaluated. Overall, modelling indicates that combinations of many measures will be needed to achieve targets now and in future and must address sources and pathways in unison

and across sectors. Both regulations and voluntary measures offered to stakeholders must facilitate a multi-stranded approach. Stakeholders consistently rated input reduction BMPs to control nutrient stocks in soil as the most effective measures (but most difficult to implement) across all areas. Wastewater treatment measures and the expansion of the sewer network in rural areas were also highly rated.

Results have been discussed with regional stakeholders and within the Policy Science Working Group nutrients of NW-Europe. It's important to notice that LRT is not enshrined in current policy legislation for protecting waterbodies.

Policy recommendations

- Recognize needs to develop improved water quality modelling in EU to close the gap between current conditions and nutrient threshold standards
- 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 and to integrate land use and water quality planning more holistically
- To improve support for LRT, harmonize source apportionment methods to distinguish the natural part of nutrient loadings to water Adopt an integrated source-to-sea approach for selecting and implementing nutrient reduction measures across the entire catchments areas, including all countries for the transboundary river basins involved. Support improved access to and exchange of data (monitoring and model outputs) between the neighbouring countries for this.
- Apply LRT to evaluate policy scenarios for the implementation of the Nitrate Directive and WFD. It also gives useful insight in upstream-downstream issues, for example consequences of conflicting thresholds in cross-border water bodies.
- Elaborate guidelines to apply LRT methods using the Polluter Pays Principle (PPP) to achieve WFD-targets for water quality, and to strengthen the integration of the PPP into the implementation of the WFD.

4. Integrate climate change considerations into nutrient management policies by addressing local-scale approaches, preparing for extreme weather events (e.g. droughts, heatwaves, heavy rainfall), and supporting adaptive agricultural practices such as crop diversification and rotation

Main findings in projects

NAPSEA:
Loads are calculated as concentration times discharges. If precipitation patterns change due to climate change this is bound to affect the dilution, residence times and total loads of nutrients from catchments (van Beusekom et al., 2025a,b).

In the NAPSEA project, the impact of climate change on nutrient loads from the Elbe and Rhine was evaluated with models for a moderate climate scenario RCP4.5 (Musolff et al., 2025). The modelled outcome clarified that the nutrient loads in the Elbe and Rhine react differently towards 2050 to climate change (see climate scenario (Sc. 6) in Figure 3), with loads increasing largely in the Elbe compared to the Rhine (between 2030 and 2050).

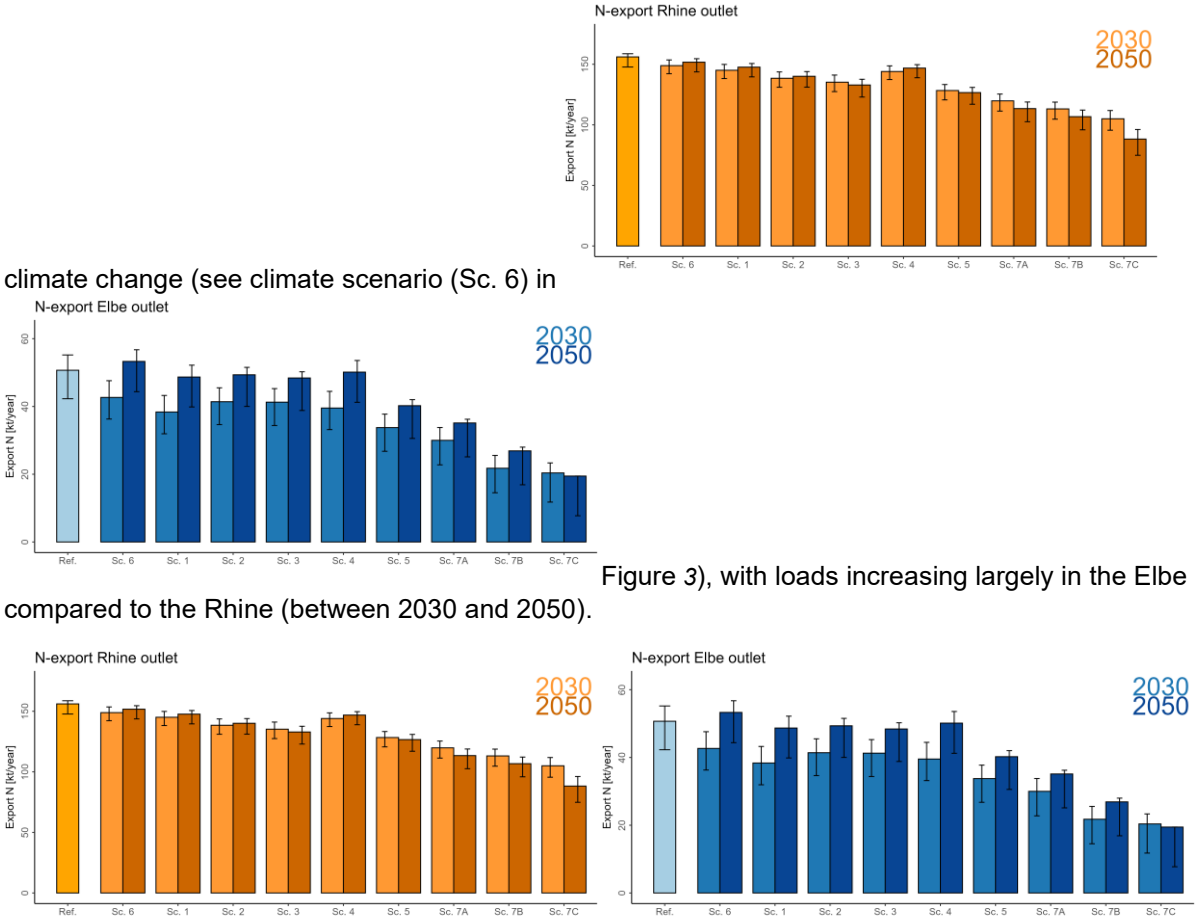


Figure 3. Nitrogen loads from the Rhine at Lobith (left) and the Elbe outlet (right) for all model scenarios. Ref – reference period 2010–2020, lighter colours in scenarios – average 2028–2032, darker colours – average 2046–2050, whiskers – 5–95% confidence interval of the best performing 100 model realizations.

NORDBALT-ECOSAFE:
The project has analysed the importance of climate change (temperature and precipitation) for the ecological boundary conditions for nutrients (nitrogen and phosphorus) to support achieving good ecological quality for different biological indicators in stream, river and lake types in the Nordic-Baltic region (Lyche Solheim et al., 2024). The main results show that the nutrient threshold boundaries seem to be adequate in streams but need to be more stringent in many lake types in a future warmer climate (Thrane et al., 2025).

New-Harmonica:
The project simulated the potential impacts of climate change on source and pathway control

measures for improving water quality in the catchments. For phosphorus, wetter winters will increase risk of losses in runoff and limit the effectiveness of buffering/interception measures so this should be considered in their design going forward. Source control measures in the catchments were only minimally impacted and remained effective. For nitrogen, drier summers may increase residual nitrate in autumn/winter through reduction in both plant uptake and denitrification. Reduced base flows are likely to lower the carrying capacity of rivers for contaminants.

Policy recommendations

- Take climate change impacts into account when designing nutrient reduction measures.
- Estimate the combined impacts of nutrients and climate on biological quality elements in rivers, lakes and coastal waters.
- Gain more support for nutrient reduction measures by collaborating with other policies aiming at climate adaptation and terrestrial biodiversity

5. Support the implementation of site-specific nutrient management strategies to enhance efficiency, reduce environmental impact, and tailor solutions to local conditions.

Main findings in projects

NAPSEA:
In the Hunze catchment, a detailed SWAT model enabled the evaluation of 13 locally tailored scenarios—ranging from land use changes to nature-based solutions—developed in collaboration with the Water Board Hunze and Aa's (Musolff et al., 2025). These scenarios assessed the effectiveness of planned and potential interventions under both moderate and extreme climate projections. Notably, measures such as improved wastewater treatment, reduced agricultural runoff, and wetland expansion demonstrated promising results in meeting ecological targets. This case highlights the value of site-specific nutrient management strategies that enhance efficiency, reduce environmental impact, and are responsive to local conditions and stakeholder input.

NORDBALT-ECOSAFE:
The project has developed a classification framework for the implementation of mitigation measures and nature-based solutions in catchments (Bieger et al., 2024). The aim of the classification framework is to support catchment managers in choosing the most suitable options when trying to reduce nutrient pollution from mainly diffuse sources. Similarly, the project has developed a Catchment Management Support System (CatchManSS) with the aim of supporting SWAT+ modellers to conduct scenarios for stakeholders and catchment managers for reducing nutrient emissions and transport in catchments.

New-Harmonica:
Stakeholder opinions within the project highlighted the need for region- and catchment-specific measures, and the need to ensure source and pathway mitigations were cohesively implemented. Specific impacts will vary in response to a multitude of antagonistic and synergistic processes and be dependent on local conditions, including the physical landscape, land use and drainage. Strong policy and financial support to farmers will be needed to overcome barriers to implement source reduction measures such as slurry export or destocking. Scepticism about Climate change and/or models that are used to evaluate environmental policy may cause difficulties in getting uptake of voluntary measures in some regions. Upgrades of sewer systems can also make significant strides towards reducing nutrient loading in some NW European countries.

Policy recommendations

- Support locally tailored, model-informed strategies that combine stakeholder input with model scenario analysis to reduce nutrient pollution.

- Promote nature-based solutions such as wetland expansion and improved wastewater treatment as effective, climate-resilient interventions.
- Adopt decision-support tools (e.g. CatchManSS) and classification frameworks to guide catchment managers in selecting and evaluating mitigation measures.
- Embed these tools and approaches into regional and national water policies to ensure consistent, evidence-based nutrient management across diverse catchments.
- The selection of measures should be more aligned with farmers motivation to pick up measures, such as planning security and low bureaucratic burden.

6. Enable inclusive, multi-stakeholder catchment governance platforms to lead local restoration efforts, supported by coherent top-down frameworks that integrate regulation, incentives, and advisory services to drive behavioural and systemic change

Main findings in projects

NAPSEA:
The effectiveness of the current governance framework and social acceptability of measures were evaluated, alongside an analysis of the policy framework as implemented in the Netherlands and Germany, focusing on instruments such as EU directives, national strategies and regional plans (Dworak et al., 2025). The analysis revealed that the policy provisions were mostly consistent within the freshwater domain and within the marine domain, but between the freshwater and marine domain indicator and targets are inconsistent. Also, the approaches used for target setting differ between the Netherlands and Germany for the WFD waterbodies.

Based on the study on social acceptance of nutrient reduction measures in the Rhine basin, through an online survey with citizens and interviews with farmers, we concluded that fairness, transparency and fit-for-purposeness are important criteria for acceptable measures (Geidel et al., 2025). The latter criteria require a more intensive dialogue on appropriate measures at farm-scale.

NORDBALT-ECOSAFE:
This project analysed the content and the effectiveness of European Union and national regulations and policies for lowering nutrient emissions. Regulations and policies were discussed with farmers and other stakeholders in national workshops. Different countries favour different mitigation measures and nature-based solutions, based on national experience and expertise. There are promising examples such as the catch crop program in Denmark where strict regulations have improved water quality. Regulations and policies in many countries suffer from a lack of consistency and predictability: rules may be created and then removed or exempted, and subsidies may be available one year and then withdrawn the next. Bureaucracy may make it impossible for authorities to reward the most effective measures. With subsidies, the application process may be heavier than the reward for landowners.

New-Harmonica:
Institutional arrangements pertaining to land use and water management in the Dutch Meuse, Flemish Meuse, Neagh-Bann and Wye catchments were analysed to assess the effectiveness of nutrient governance and management. In all four cases, responsibility for nutrients is shared among a wide range of government departments and public agencies operating at the national, regional and local levels. Consequently, many different types of nutrient policies, plans and strategies are currently in use, but typically in a fragmented and sectoral fashion. In addition, there are numerous private sector organisations, associations, partnerships and campaign groups with competing interests in food production, water supply and wastewater treatment, and environmental protection.

Due to organisational overlaps and different priorities, beliefs and attitudes among stakeholders, there are significant co-ordination challenges and other related institutional barriers which impede efforts to reduce nutrients and restore water environments. A more harmonised approach to decision making is required both within and across key policy, planning and management processes and procedures pertaining to land and water.

To facilitate this and bring about the required environmental improvements, catchment-scale governance arrangements should be developed. The arrangements should include multi-stakeholder platforms to bring key agencies with authority and stakeholders together. Through such collaborative processes, common visions for the future of land and water in each catchment area should be agreed, joint strategies to limit nutrients should be developed. Clear lines of authority and responsibility for operation, regulation, planning, monitoring, enforcement and reporting should be established to improve prospects for successful implementation and affirmative action.

Policy recommendations

- Recognise the right to a healthy environment of all humans and the property rights of coastal property owners as setting duties for states concerning aquatic ecosystems
- Set clear national targets that verify the binding targets of the Water Framework Directive
- Mandate and incentivise science-based, effective, sensible, location-specific and acceptable measures to lower emissions and to enhance water quality
- Farming: enact strict, clear and predictable legal rules on fertilizer use and manure
- Forestry: enact strict, clear and predictable legal rules on drainage and clear-cutting
- Offer consistent and sufficient financial support for farmers and foresters
- Look beyond landowners: regulate and incentivise investors, industries, traders, retailers, public procurement officers and consumers through sustainability criteria, taxes, and information remedies
- Take a systemic approach and vision just transition paths to sustainable land use, economic activity and consumption

Stakeholder Engagement

At the Land Use and Water Quality Conference 2025 in Aarhus, Denmark, the three sister projects jointly hosted a special session to present their main findings (LUWQ, 2025). The session attracted 64 participants from 14 countries, including scientists, policy makers, water managers, and consultants. The discussions focused on enhancing water quality and ecological outcomes through a more integrated, locally tailored, and science-based approach.

Stakeholders emphasized the need for a holistic and strategic vision, advocating for an integral source-to-sea approach that considers climate impacts and harmonizes goals across regions. Improved monitoring and data use were also highlighted, with recommendations to implement high-frequency sensor monitoring, enhance data resolution using cost-effective methods, align boundaries with ecological thresholds, and analyse the impacts of past plans.

Mitigation and planning strategies were discussed, with a strong push for multifunctional Nature-Based Solutions, improved land-use planning, and financial instruments that support implementation. Governance and policy improvements were deemed essential, including strengthening governance structures, ensuring political commitment, aligning with broader policies such as the Common Agricultural Policy (CAP), and simplifying procedures with clear, practical guidance.

Stakeholder engagement itself was recognized as a key factor, with calls to foster collaboration among scientists, farmers, and managers, promote public awareness, and support local partnerships in decision-making. Additionally, local adaptation and innovation were encouraged through customized plans, bottom-up approaches, and pilot catchments to demonstrate effectiveness.

To support this engagement, a questionnaire was developed around the key messages. Participants were asked to rank a combination of recommendations, resulting in the following priorities (Figure 4):

1. Improving monitoring to benefit policy, stakeholders, and scientists (closely linked to key message #2).
2. Adopting a source-to-sea approach with data on both concentration and loads (linked to key messages #2 and #3).
3. Establishing better governance structures from local to international levels (linked to key message #6).
4. Promoting multifunctionality in mitigation measures, including Nature-Based Solutions and trade-offs (linked to key message #5).

When asked to identify the most important steps for achieving good water and ecological quality, participants ranked the following actions (Figure 5):

1. Setting clear and feasible political targets (key message #1).
2. Enhancing monitoring systems (key message #2).
3. Developing improved governance models (key message #6).
4. Advancing catchment modelling (key message #3).
5. Considering the effects of climate change (key message #4).
6. Implementing novel mitigation measures (key message #5).

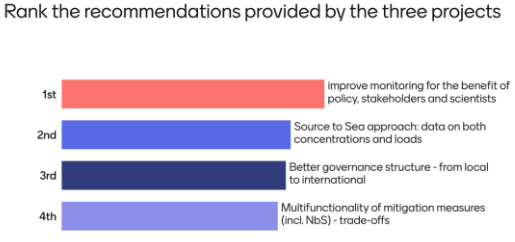


Figure 4. Results of ranking recommendations at special session hosted at LUWQ conference.

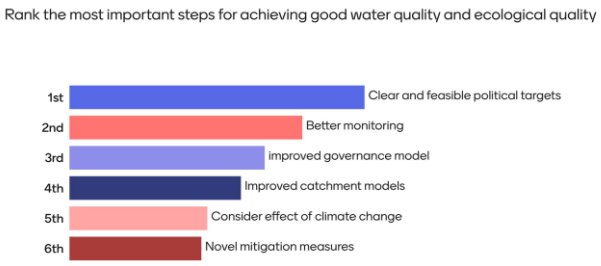


Figure 5. Results of ranking important steps at special session hosted at LUWQ conference.

More information

More information about the three projects can be found on the project websites:

NAPSEA: https://napsea.eu/

NORDBALT-ECOSAFE: https://projects.au.dk/nordbalt-ecosafe

NEW-HARMONICA: https://newharmonica.eu/

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