



Abstract

Climate change is expected to profoundly impact catchment nutrient dynamics worldwide. Many European aquatic ecosystems already face serious threats from nutrient pollution and eutrophication. In Europe, the drivers of excess nutrient pollution vary regionally due to differences in climate and human activities, emphasizing the need for better cross-boundary nutrient management. Effective management can enhance ecosystem services, including:

- Provisioning (water supply and food/drink),
- Regulating (contaminant removal),
- Supporting (nutrient cycling), and
- Cultural (recreation).

ENGAGE aims to implement a novel approach to reduce nutrient export and improve ecosystem services in national and international river basins across Europe. The project combines stakeholder engagement with advanced computational hydrology and interactive decision-support (DS) tools. These tools integrate remote sensing, socio-economic factors, governance frameworks, and societal change considerations. This use-inspired approach prioritizes practical needs to ensure application beyond the project, moving beyond the traditional «loading dock» model, where researchers apply existing prediction tools in the hope that they will be useful. Instead, ENGAGE customizes environmental predictions to meet the specific needs of collaborative nutrient management across regional, national, and international levels.

Environmental predictions, defined as quantitative statements about the future of terrestrial and freshwater systems, help communities manage variability and pollution in water resources. Such predictions are crucial as climate change increasingly affects the economy, public health, and ecosystems.

ENGAGE will establish regional stakeholder boards (SBs) comprising local, regional, and national authorities to identify nutrient pollution problems, co-design strategies for nutrient export reduction, and co-identify important elements that should be included in the DS tool to ensure informed decisions. This transdisciplinary approach aims to extend beyond hydrology and soil science by incorporating insights from stakeholder interactions and a regionally integrated perspective.

In parallel, an EU-level stakeholder network (SB-network) will be formed to assess which regional strategies and decision-support tool requirements are scalable and replicable across EU member states. The strategies, modeling needs, and remote sensing techniques will be implemented in three European river basins:

- Guadiana River Basin (Portugal and Spain)
- Gauja-Koiva River Basin (Latvia and Estonia)
- Hobølélva River Basin (Norway)

To ensure the long-term impact and broader adoption of the project's tools and strategies, ENGAGE follows an iterative research plan based on annual cycles. Lessons learned from each cycle will inform subsequent phases, improving process design and implementation. This iterative approach, in collaboration with the SB-network, will guide the co-design of policy recommendations and guidelines for enhanced large-scale nutrient management across Europe.

By integrating scientific innovation with stakeholder-driven insights, ENGAGE seeks to advance sustainable nutrient management, promote cross-boundary collaboration, and provide practical tools and policies to address nutrient pollution in European aquatic ecosystems.



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- INSTITUTO POLITÉCNICO DE BEJA - ESCOLA SUPERIOR AGRÁRIA - PORTUGAL
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KEYWORDS