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Strategies for water and nutrient retention in agricultural catchments linking modelling and optimization

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Abstract: The increasing frequency of droughts and heavy rainfall is intensifying conflicts between agricultural water use and other human and environmental demands. Natural/Small Water Retention Measures (NSWRMs) can help to mitigate these conflicts by enhancing water quality, improving agricultural resilience, and contributing to sustainable development goals (Magnier et al., 2024). However, there are knowledge gaps about the effectiveness of these measures across different regions, scales, and climate conditions.

The EU Horizon 2020 project "OPTAIN - OPtimal strategies to retAIN and re-use water and nutrients in small agricultural catchments across different soil-climatic regions in Europe" (https://www.optain.eu) aims to address these challenges in 14 European case studies. The project involves local stakeholders through Multi-Actor Reference Groups, which have identified and documented 235 potential NSWRMs, of which 66 from 29 categories have been selected for further evaluation. These measures are catalogued in collaboration with the WOCAT – World Overview of Conservation Approaches and Technologies (https://wocat.net) and NWRM.eu databases. To assess the impact of these NSWRMs at field and catchment scales, OPTAIN applies the SWAT+ model (a completely revised version of the widely used Soil and Water Assessment Tool; (https://swat.tamu.edu/), with a fully distributed routing scheme. Further field-scale simulations are conducted using the Soil Water Atmosphere Plant model (SWAP; https://www.swap.alterra.nl/) in areas of high data availability. OPTAIN has developed protocols and R scripts to standardize data preparation, model calibration, and evaluation across case studies (Plunge et al., 2024a, 2024b), thereby ensuring consistent analysis. Initial simulations in the German case study demonstrate the positive effects of NSWRMs, such as low tillage and grassed waterways, in reducing peak water flows, increasing low flows, and enhancing nutrient and sediment retention. Furthermore, the project has linked SWAT+ with an economic model using the CoMOLA platform (Strauch et al., 2019) to optimize NSWRM allocations based on environmental and economic criteria. To facilitate an in-depth, cross-sectoral discussion about preferred NSWRM implementation plans, the tool

ParetoPick-R was developed (Wittekind et al., 2025). It helps to develop a common understanding of the potential of NSWRMs and to explore trade-offs among the optimization objectives, such as water/nutrient retention, crop production, and cost. Stakeholders can then select their preferred implementation plans based on weights they assign to each objective and filter options applied to the solution space.

Policy analysis is another important component of OPTAIN, with local and regional policies being reviewed to identify gaps and opportunities for harmonizing water and agricultural policies across Europe. Interim findings, shared through policy briefs, emphasize the need for better integration of agro-environmental policies, increased intersectoral collaboration, and awareness-raising among stakeholders. OPTAIN's overarching goal is to improve the acceptance and implementation of NSWRMs by harmonizing data, methods, and policies across the 14 case studies. While there are significant differences between countries, which pose challenges for comparative studies, the project is working to address these through data standardization and model improvements. The R scripts developed by the project will assist future SWAT+ users worldwide in setting up and calibrating models to evaluate the effectiveness of NSWRMs in water and nutrient retention. Ultimately, OPTAIN aims to optimize the spatial allocation and combination of NSWRMs, ensuring they are both environmentally and economically sustainable, while also promoting policy alignment at local, national, and EU levels.

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