OPTAIN

Optimal Strategies to Retain Water and Nutrients

D4.1: Assessment of local conditions important for NSWRM implementation

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Project Consortium

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Summary

The OPTAIN project aims to identify efficient measures for the retention and reuse of water and nutrients (NSWRM - Natural/Small Water Retention Measures) in small agricultural catchments based on empirical data and scale-adapted integrated modelling approaches. Task 4.1 of the project focused on the analysis of local conditions that are important for model implementation of NSWRM and scenario design. This deliverable reports about the activities of task 4.1, which were completed in three steps: 1) issue identification, 2) possible measure selection and 3) analysis of the possibility of model implementation.

Each lead of an OPTAIN case study identified and analysed its major case-study specific issues, and determined the needs for water retention within the catchment based on a questionnaire, public European wide datasets as well as local national datasets (if available). Moreover, the need for water quality improvement has been summarized and the existing yield gap was analysed.

The leads of task 4.1 developed a detailed questionnaire which served a dual purpose: 1) the questions and the given answers provided a data/requirement screening, and 2) case study leads and the OPTAIN project consortium gained knowledge and an overview of the local conditions that are important to consider when developing a hydrological and water quality model and analysing the scenario results.

Based on the questionnaire results, a preliminary overview about NSWRM implementation in OPTAINs model setups was derived. The final result of this analysis is presented as a matrix, where measure implementation possibility in each case study is assessed. Due to the foreseen data demanding modelling tasks of the OPTAIN project, the final selection of the modelled measures might differ, as new data sources are identified or new measurements are gathered.

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Abbreviations

CS	Case Study
CSS	Case Study Sites
GIS	Geographic Information System
MARG	Multi-Actor Reference Group
NSWRM	Natural/Small Water Retention Measure
WP	Work Package

1. Introduction

The OPTAIN project aims to identify efficient measures for the retention and reuse of water and nutrients (NSWRM - Natural/Small Water Retention Measures) in small agricultural catchments across continental, pannonian and boreal regions of Europe, based on empirical data and scale-adapted integrated modelling. Within the OPTAIN Work Package 4 (WP 4 - Integrated assessment of NSWRM), a dedicated task aims at the assessment of local conditions that are important for NSWRM model implementation and scenario design. The results of this task underline the local conditions within each case study and provide an overview of available data, environmental issues, and the possibility to design models in a way that would be suitable for scenario implementation. This deliverable report D4.1 presents the results of the carried-out analysis. Common terms that are used in this report are:

- Measure – a shorter term for NSWRM,
- Scenario – representation of a possible implemented measure and its functionality in a model,
- Model – a hydrological and water quality environmental model for a case study, implemented using the newest version of the Soil and Water Assessment Tool (SWAT+) (Bieger et al., 2017),
- Issue – an identified environmental problem in the case study.

The report covers a short overview of the case studies, a description of the task implementation, the results of the analysis, and the conclusions that can be drawn from this analysis.

1.1. Case study overview

The OPTAIN case studies sites (CSS) cover three biogeographical regions – Boreal (4 case study sites), Continental (7 case study sites) and Pannonian (3 case study sites), including one Pannonia-Continental cross-border CSS. The south-most CSS is Cherio, Italy (45.76, 9.91), and the north-most is Sävjaån, Sweden (59.84, 17.72) (Figure 1).

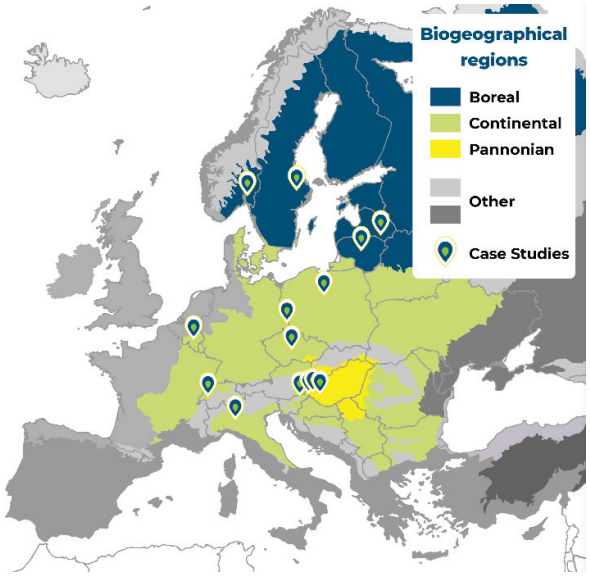


Figure 1: *OPTAIN case study sites across the biogeographical regions of Europe.*

The region differences result in various climatic and topographic conditions (Table 1), different water and water quality related issues, and differences in the possible measure selection to combat these problems.

Table 1: List of case study sites

CS nr.	Case study	Country (region)	Elevation range [m a.s.l].	Precipitation (mean annual) [mm/yr]
1	Schwarzer Schöps	Germany (continental)	160-449	670 - 830
2	Petite Glâne	Switzerland (continental)	422-828	940
3a	Csorsza	Hungary (pannonian)	110-375	496-594
3b	Felső-Válicka	Hungary (pannonian)	204*	716*
4	Upper Zglowiaczka	Poland (continental)	83-115	513
5	Pesnica	Austria/Slovenia (continental)	241-754	999*
6	Kobiljski potok/Kebele	Slovenia/Hungary (Pannonian-Continental)	155-400	760-780
7	La Wimbe	Belgium (continental)	285*	844
8	Dotnuvėlė	Lithuania (boreal)	22 – 124	615
9	Cherio	Italy (continental)	1380 –142	840
10	Hobøl	Norway (boreal)	25 - 346	864
11	Tetves	Hungary (pannonian)	104 – 280	600-650
12	Čechtický	Czech Republic (continental)	390 –610	660 -780
13	Dviete	Latvia (boreal)	114*	530 –540
14	Sävjaån	Sweden (boreal)	53*	564*

*raw data gathered from ClimateEU dataset: https://sites.ualberta.ca/~ahamann/data/climateeu.html. Otherwise collected by the CS leads from national databases.

1.2. Task description and implementation process

In this task we aimed to analyse various aspects important for model set-up and scenario design. These aspects include:

- water retention potential based on observed hydro-meteorological data and catchment characteristics,
- identification of needs for water retention within the catchments' areas,
- identification of needs for water quality improvement,
- analysis of the yield gap,
- analysis of possible suitable measures to combat the case-study specific issues,
- analysis of the presence of necessary data for measure representation by the models.

We implemented the analysis in three subsequent steps (see Figure 2):

Step 1: Issue identification, where we identified, to the best of expert and local actors' knowledge, all the relevant issues in each CSS.

Step 2: Possible measure selection, where we identified possible measures that can address and help combat the negative consequences of the identified issues in step 1.

The measures were selected from the NWRM catalogue (European Commission, 2013) and from the Multi-Actor Reference Group (MARG) activities of all case studies.

Step 3: Possibility of model implementation, where we identified all the relevant and necessary datasets for accurate measure representation by the models.

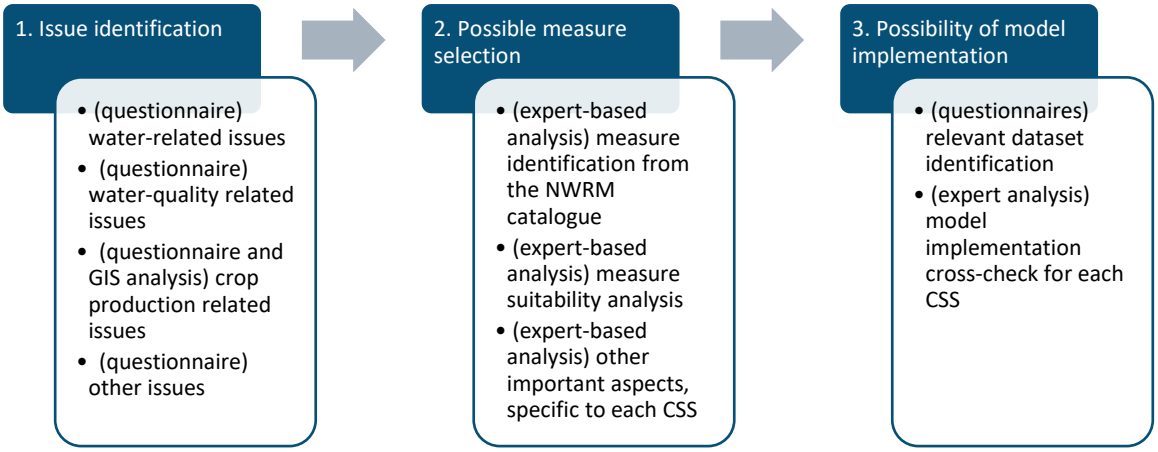


Figure 2: Task 4.1 implementation workflow scheme

The initial information (inputs) for this analysis were received from other tasks within OPTAIN, in particular from task 4.5 ('Attractiveness of NSWRM and socio-economic assessment of cropland and water management options'), task 2.1 ('Systemizing current NSWRM experience and potential'), and task 2.3 ('Participatory modelling settings and standardised guidelines for parameterisation of measures'). The governing documents (Water framework directive (EC, 2000), Flood Directive (EC, 2007), River Basin Management Plans, etc.), and engagement activities with stakeholders were the controls of this analysis. The data availability within the OPTAIN project (see Figure 3) partially defined the methods that we have chosen to perform the analysis of this deliverable D4.1.

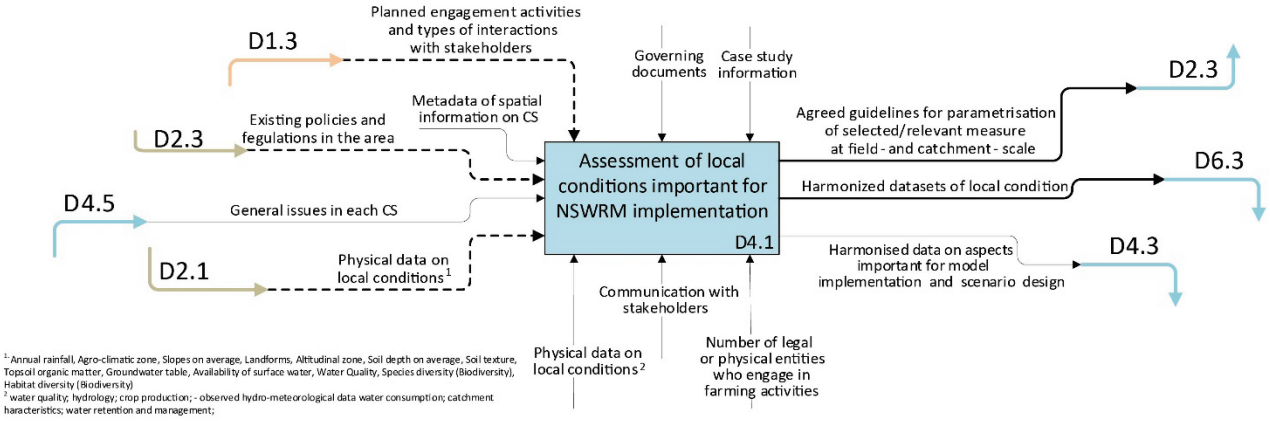


Figure 3: Deliverable 4.1 represented as a function model using the IDEF0 (Icam DEFinition for Function Modeling) notation.

The results of this deliverable D4.1 (outputs) will feed into:

- Tasks 4.3 ('Assessment of on-site NSWRM effectiveness at field scale') and Task 4.4 ('Assessment of NSWRM effectiveness at the catchment scale') – by providing the harmonised assessment on aspects important for model implementation and scenario design.
- Task 2.3 ('Participatory modelling settings and standardised guidelines for parameterisation of measures') – by providing a list of relevant measures and data requirements for possible parametrisation of these measures.
- Task 6.3 ('Cross case study evaluation of the physical and economic effectiveness of the different individual NSWRM and their combinations') – by providing a harmonised description of local conditions and environmental data.

2. Methods

2.1. Step 1: Issue identification

This step was carried out by means of a questionnaire (CS leads, with the involvement of local experts and actors, where necessary), data assimilation, and georeferenced dataset analysis for each case study site. We re-used the results of a questionnaire that was developed as part of a case study screening within OPTAINs task 4.5. This questionnaire (Appendix 3) focused on a combination of socio-economic and environmental aspects and provided us with the information about general issues in each case study.

We calculated the cumulative importance of each issue across all case studies by summing up issues which were marked as "top issue" or "relevant at both scales" (catchment and farm scale). We considered an issue to be especially relevant within the OPTAIN project if the cumulative importance was equal or more than 4. The results of the screening are presented in Table 2.

To enable an analysis and specification of issues related to water-quantity, water-quality, and crop production we gathered the required georeferenced datasets in open-access databases (see Appendix 2: Initial screening of available data). All CS leads could refer to these datasets for their catchments to conduct the analysis or to derive the necessary answers to the questionnaire, used in Step 3. The CS leads could also refer to their local datasets, if those were available.

2.2. Step 2: Possible measure selection

We assessed the relevance and possibility of NSWRM to address the issues identified in step 1 (Table 2) using OPTAINs current list of identified and relevant measures (developed and maintained in task 2.1 – 'Systemizing current NSWRM experience and potential'). The task 2.1 deliverable report is scheduled for a later stage of the OPTAIN project, hence the final measure selection might differ from the currently identified ones.

All measure related information that were needed for this assessment were gathered from the extensive general catalogue 'NWRM illustrated' (European Commission, 2013) and description of each measure separately. We considered information on the biophysical effects of the measures on specific issues as well as their implementation possibility and specific requirements. The results are presented in Table 3, including a measure specific references in a separate column of the table. In a subsequent step we

further refined the conditions and data requirements for each measure, which was used in the step 3.

2.3. Step 3: Possibility of model implementation

Once the issues and the measures were identified, we prepared a list of conditions and data requirements that enabled us to analyse the possibility of scenario development in each case study (see Table 4). For the development of Table 4 we considered the functionality of the SWAT+ model (Bieger et al., 2017) and its possibility to represent the different measures.

A screening of the CS data availability according to the prepared data requirements was part of a 2nd detailed questionnaire, which was distributed to each case study lead (Appendix 1). The questionnaire approach was chosen to harmonise the data (answers) across the various case studies. The questionnaire could be answered by a combination of local expert knowledge, georeferenced data analysis (gathered in Step 2 or from local resources), data series analysis (from local databases or services), and by involving the local actors, agencies and/or other groups. The CS leads were responsible for completing the analysis and for aggregating the answers for their case study.

The detailed questionnaire provided a dual purpose: 1) the questions and the given answers served as a data/requirement screening, and 2) CS leads and the OPTAIN project gained knowledge and an overview of the local conditions that are important to consider when developing a hydrological and water quality model and analysing the scenario results. The questions (refer to Appendix 1) can be broken-up in categories:

- Details on the identified issues related to hydrological processes and related observed data;
- Details on the identified issues and processes related to water quality;
- Flood and drought issue clarification;
- Yield-gap identification by crop type;
- Other important data identification.

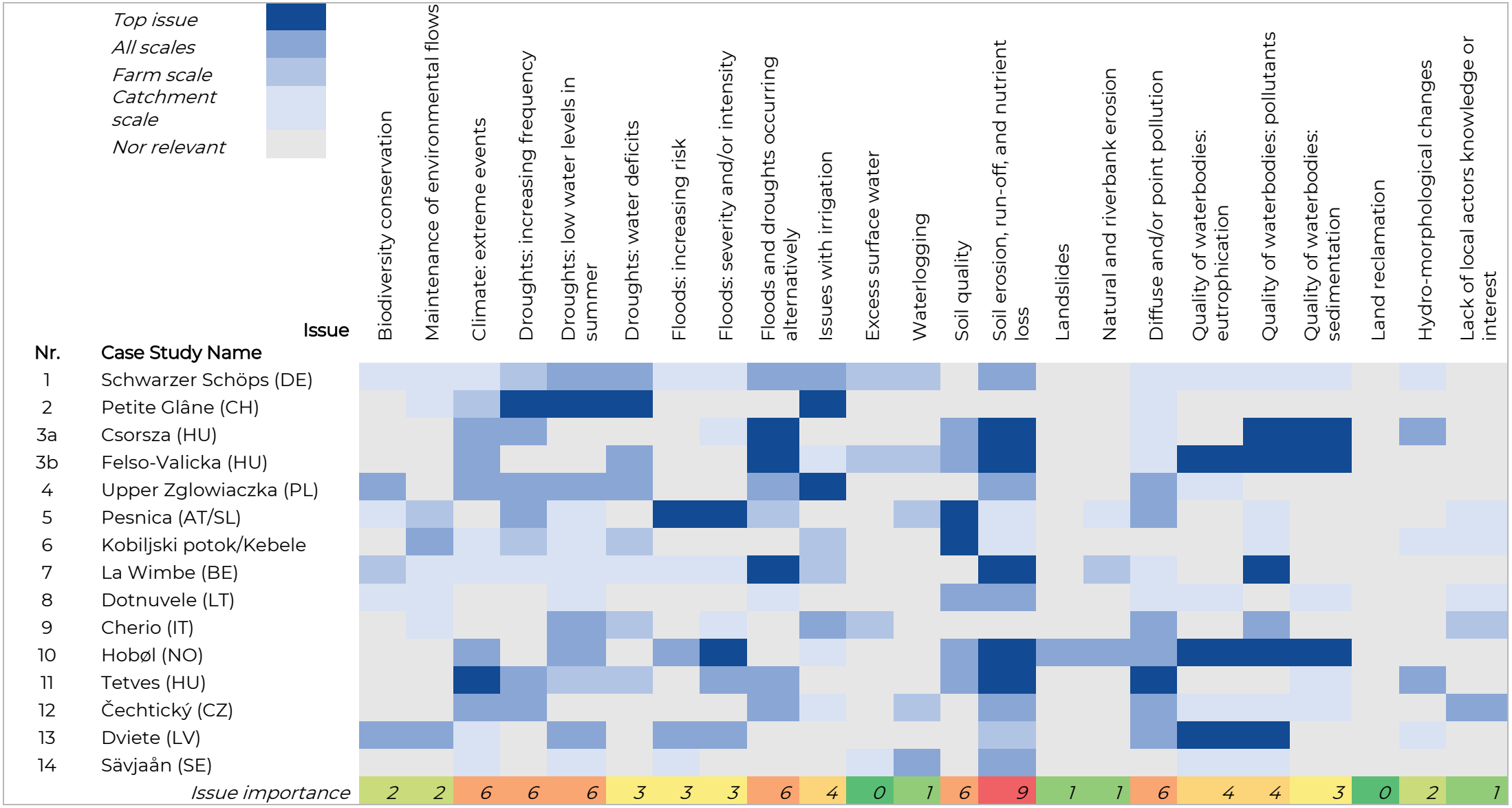
To summarize and present the results we use graphs, pie charts and matrices. We present the aggregated results of the analysis of all case studies in the following section of this report. We do not detail each CS on all the particularities, rather we focus on an overview of the current relevant conditions. In several case studies the data collection task is behind schedule, or it was identified that some of the necessary data is not present at all. Hence, we considered another approach (via the questionnaires based on CS lead and local expert input) as more suitable. We note the particular information about several specific CSS and highlight them in this report.

3. Results

3.1. Issue identification

Our initial screening of the issues in each case study site (section 2.1 “Step 1”) showed that there were ten issues with a high cumulative importance (Table 2). These ten issues were thus considered as “top issues” of this report and have been considered in all subsequent steps. The most important issues in the case studies are: extreme events due to climate change, increasing frequency of droughts, low water levels in summer due to droughts, floods and droughts occurring alternatively, issues with irrigation (water availability), deteriorating soil quality, soil erosion, run-off and nutrient loss, diffuse and/or point pollution, deteriorating quality of water bodies due to pollutants and eutrophication.

Table 2: Identified issues in all case studies and their cumulative importance



3.2. Measure selection

We rigorously analysed OPTAINs current list of identified and relevant measures (developed and maintained in task 2.1) for their impact, implementation possibilities, and requirements for certain conditions, etc. Part of this analysis is summarised in Table 3, where we bring together the measures and the ten "top issues" identified above. The indicated measures generally address several issues, based on their location, extent and maintenance, or other variables. Some "speciality" measures are A03 Crop rotation (addresses soil quality), N05 Stream bed re-naturalization, N06 Restoration and reconnection of seasonal streams, N08 Riverbed material renaturalisation, N09 Removal of dams and other longitudinal barriers, which have a positive effect on the quality of water bodies in terms of removing pollutants and combating eutrophication. While others, like A01 Meadows and pastures, A09 Early sowing, A11 Controlled traffic farming, U11 Retention Ponds, have an effect on almost all the identified issues. The possibility of measure implementation and the degree of their potential effects are largely dependent on other conditions, properties of the catchment and the implementation status of other measures. Parts of that analysis were used in Step 3, where we identified the relevant conditions, and developed a detailed questionnaire to determine these conditions in each case study.

Table 3: *List of measures and issues which they address*

Measures / Issues	Climate: extreme	Droughts: increasing	Droughts: low water	Floods and droughts	Issues with irrigation	Soil quality	Soil erosion, run-off and	Diffuse and/or point	Quality of waterbodies:	Quality of waterbodies:	Reference
Issue importance	*6*	*6*	*6*	*6*	*4*	*6*	*9*	*6*	*4*	*4*	
A01 Meadows and pastures	x[1]			x[1]		x	x	x[2]	x	x	http://nwrm.eu/measure/meadows-and-pastures
A02 Buffer strips and hedges	x[1]			x[1]			x	x[3]	x	x	http://nwrm.eu/measure/buffer-strips-and-hedges
A03 Crop rotation						x					http://nwrm.eu/measure/crop-rotation
A04 Strip cropping along contours	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/strip-cropping-along-contours
A05 Intercropping	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/intercropping
A06 No till agriculture							x	x	x	x	http://nwrm.eu/measure/no-till-agriculture
A07 Low till agriculture							x	x	x	x	http://nwrm.eu/measure/low-till-agriculture
A08 Green cover						x	x	x	x	x	http://nwrm.eu/measure/green-cover
A09 Early sowing	x[1]	x		x[1]	x	x	x	x	x	x	http://nwrm.eu/measure/early-sowing
A10 Traditional terracing	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/traditional-terracing
A11 Controlled traffic farming	x[1]			x[1]		x	x	x	x	x	http://nwrm.eu/measure/controlled-traffic-farming
A12 Reduced stocking density	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/reduced-stocking-density

Measures \ Issues	Climate: extreme	Droughts: increasing	Droughts: low water	Floods and droughts	Issues with irrigation	Soil quality	Soil erosion, run-off and	Diffuse and/or point	Quality of waterbodies:	Quality of waterbodies:	Reference
A13 Mulching						x	x	x	x	x	http://nwrm.eu/measure/mulching
F01 Forest riparian buffers	x[1]			x[1]			x	x[3]	x	x	http://nwrm.eu/measure/forest-riparian-buffers
F02 Maintenance of forest cover in headwater areas	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/maintenance-forest-cover-headwater-areas
F03 Afforestation of reservoir catchments	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/afforestation-reservoir-catchments
F04 Targeted planting for 'catching' precipitation	x[1]					x	x	x	x	x	http://nwrm.eu/measure/targeted-planting-catching-precipitation
F05 Land use conversion	x[1]			x[1]		x	x	x	x	x	http://nwrm.eu/measure/land-use-conversion
F09 Sediment capture ponds	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/sediment-capture-ponds
F10 Coarse woody debris	x[1]			x[1]					x	x	http://nwrm.eu/measure/coarse-woody-debris
N01 Basins and ponds	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/basins-and-ponds
N02 Wetland restoration and management	x[1]			x[1]				x	x	x	http://nwrm.eu/measure/wetland-restoration-and-management
N03 Floodplain restoration and management	x[1]			x[1]				x	x	x	http://nwrm.eu/measure/floodplain-restoration-and-management
N04 Re-meandering	x[1]			x[1]					x	x	http://nwrm.eu/measure/re-meandering
N05 Stream bed re-naturalization									x	x	http://nwrm.eu/measure/stream-bed-re-naturalization
N06 Restoration and reconnection of seasonal streams									x	x	http://nwrm.eu/measure/restoration-and-reconnection-seasonal-streams
N07 Reconnection of oxbow lakes and similar features	x[1]			x[1]					x	x	http://nwrm.eu/measure/reconnection-oxbow-lakes-and-similar-features
N08 Riverbed material renaturalisation									x	x	http://nwrm.eu/measure/riverbed-material-renaturalization
N09 Removal of dams and other longitudinal barriers									x	x	http://nwrm.eu/measure/removal-dams-and-other-longitudinal-barriers
N10 Natural bank stabilisation	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/natural-bank-stabilisation
N11 Elimination of riverbank protection							x		x	x	http://nwrm.eu/measure/elimination-riverbank-protection
N13 Restoration of natural infiltration to groundwater	x	x	x	x	x						http://nwrm.eu/measure/restoration-natural-infiltration-groundwater
N14 Re-naturalisation of polder areas	x[1]			x[1]					x	x	http://nwrm.eu/measure/re-naturalisation-polder-areas
U04 Swales	x[1]			x[1]			x	x[3]	x	x	http://nwrm.eu/measure/swales
U06 Filter Strips	x[1]			x[1]			x	x[3]	x	x	http://nwrm.eu/measure/filter-strips

Measures / Issues	Climate: extreme	Droughts: increasing	Droughts: low water	Floods and droughts	Issues with irrigation	Soil quality	Soil erosion, run-off and	Diffuse and/or point	Quality of waterbodies:	Quality of waterbodies:	Reference
U08 Infiltration Trenches	x	x	x	x	x			x			http://nwrm.eu/measure/infiltration-trenches
U09 Rain Gardens	x[1]	x	x	x[1]	x		x	x	x	x	http://nwrm.eu/measure/rain-gardens
U10 Detention Basins	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/detention-basins
U11 Retention Ponds	x[1]	x	x	x[1]	x		x	x	x	x	http://nwrm.eu/measure/retention-ponds
U12 Infiltration basins	x[1]			x[1]			x	x	x	x	http://nwrm.eu/measure/infiltration-basins

[1] In case of increasing floods as climate extreme / [2] Continuous management and maintenance required / [3] Moderate maintenances required

3.3. Measure-specific requirements (data & local conditions)

We derived a relationship matrix that indicates necessary data and certain conditions that are required to either represent the measure in a model or to assess its effectiveness (Table 4). Many datasets are needed to accurately simulate the selected measures, whereas some data are complementary. We did not distinguish between necessary vs complimentary at this point, as this task will follow in later stages of the OPTAIN project.

The conditions and data requirements were part of the 2nd detailed questionnaire and the respective questions are considered in Table 4. The overview of local conditions and data was necessary to determine the applicability of scenarios for each case study site.

Table 4: Questions in the survey and their relationship to measure representation in the model.

Measures \ Questions	Need for improvement on the ecological status of waterbodies	Need for improvement of water quality to improve the status of next stream order downstream waterbodies	Measurable yield gap in your case study	Availability of high-resolution DEM	DEM vertical accuracy of 10 cm or better available	Availability of DEM with horizontal resolution 30m	Availability of high-resolution landuse and land cover maps	Availability of a crop pattern map	Availability of soil type map with properties	Availability of a map of waterbodies	Availability of information on modified/heavily modified waterbodies	River cross section	Hydrogeological map of the study area	Availability of groundwater surveys	Flood hazard area	Flood risk area	High-resolution IDF curve for precipitation	Developed Unit-hydrographs for the watershed	Floodplain information	Increase in frequency, duration and/or severity of agricultural droughts	Increase in frequency, duration and/or severity of hydrological droughts
A01 Meadows and pastures	x	x				x	x								x	x	x	x	x		
A02 Buffer strips and hedges	x	x		x	x		x			x					x	x	x	x	x		
A03 Crop rotation	x	x	x				x	x												x	x
A04 Strip cropping along contours	x	x		x	x		x								x	x	x	x	x		
A05 Intercropping	x	x	x				x	x												x	x
A06 No till agriculture	x	x	x				x	x												x	x
A07 Low till agriculture	x	x	x				x	x												x	x
A08 Green cover	x	x		x	x	x	x								x	x	x	x	x		
A09 Early sowing			x					x	x						x	x	x	x	x	x	x
A10 Traditional terracing	x	x		x	x		x								x	x	x	x	x		
A11 Controlled traffic farming	x	x	x				x								x	x	x	x	x	x	x
A12 Reduced stocking density	x	x					x								x	x	x	x	x		
A13 Mulching	x	x					x								x	x	x	x	x		
F01 Forest riparian buffers	x	x					x														
F02 Maintenance of forest cover in headwater areas	x	x					x								x	x	x	x	x		
F03 Afforestation of reservoir catchments	x	x					x								x	x	x	x	x		
F04 Targeted planting for 'catching' precipitation	x	x					x														

Measures \ Questions	Need for improvement on the ecological status of waterbodies	Need for improvement of water quality to improve the status of next stream order downstream waterbodies	Measurable yield gap in your case study	Availability of high-resolution DEM	DEM vertical accuracy of 10 cm or better available	Availability of DEM with horizontal resolution 30m	Availability of high-resolution landuse and land cover maps	Availability of a crop pattern map	Availability of soil type map with properties	Availability of a map of waterbodies	Availability of information on modified/heavily modified waterbodies	River cross section	Hydrogeological map of the study area	Availability of groundwater surveys	Flood hazard area	Flood risk area	High-resolution IDF curve for precipitation	Developed Unit-hydrographs for the watershed	Floodplain information	Increase in frequency, duration and/or severity of agricultural droughts	Increase in frequency, duration and/or severity of hydrological droughts
F05 Land use conversion	x	x					x								x	x	x	x	x		
F09 Sediment capture ponds	x	x		x	x	x	x			x											
F10 Coarse woody debris	x	x		x	x	x	x														
N01 Basins and ponds	x	x		x	x		x		x	x					x	x	x	x	x		
N02 Wetland restoration and management	x	x					x			x					x	x	x	x	x		
N03 Floodplain restoration and management	x	x		x	x		x			x	x				x	x	x	x	x		
N04 Re-meandering	x	x		x	x		x		x	x					x	x	x	x	x		
N05 Stream bed re-naturalization	x	x					x			x					x	x	x	x	x		
N06 Restoration and reconnection of seasonal streams	x	x								x	x				x	x	x	x	x		
N07 Reconnection of oxbow lakes and similar features	x	x								x	x				x	x	x	x	x		
N08 Riverbed material renaturalization	x	x								x	x	x									
N09 Removal of dams and other longitudinal barriers	x	x								x	x	x									
N10 Natural bank stabilisation	x	x								x	x	x									
N11 Elimination of riverbank protection	x	x								x	x	x									
N13 Restoration of natural infiltration to groundwater	x	x					x		x				x								
N14 Re-naturalisation of polder areas	x	x					x								x	x	x	x	x		
NEW: Improved infiltration	x	x	x																	x	x
U04 Swales	x	x		x	x		x								x	x	x	x	x		

Measures \ Questions	Need for improvement on the ecological status of waterbodies	Need for improvement of water quality to improve the status of next stream order downstream waterbodies	Measurable yield gap in your case study	Availability of high-resolution DEM	DEM vertical accuracy of 10 cm or better available	Availability of DEM with horizontal resolution 30m	Availability of high-resolution landuse and land cover maps	Availability of a crop pattern map	Availability of soil type map with properties	Availability of a map of waterbodies	Availability of information on modified/heavily modified waterbodies	River cross section	Hydrogeological map of the study area	Availability of groundwater surveys	Flood hazard area	Flood risk area	High-resolution IDF curve for precipitation	Developed Unit-hydrographs for the watershed	Floodplain information	Increase in frequency, duration and/or severity of agricultural droughts	Increase in frequency, duration and/or severity of hydrological droughts
U06 Filter Strips	x	x		x	x		x														
U08 Infiltration Trenches	x	x		x	x		x		x				x	x							
U09 Rain Gardens	x	x		x	x		x		x												
U10 Detention Basins	x	x		x	x		x		x				x	x	x	x	x	x	x		
U11 Retention Ponds	x	x		x	x		x		x	x			x	x	x	x	x	x	x		
U12 Infiltration basins	x	x		x	x		X		x				x	x							

“x” indicates the relevance of data availability for model scenario implementation

3.4. Data availability and issue specification

3.4.1. Measure-specific data availability

The evaluation results of data availability for potential applicability analysis as water retention measures based on questionnaire surveys from case study areas are given in Table 5. For any water retention measure, data availability higher than 66.66% means high data availability, data availability between 66.66% and 33.33% means moderate (or acceptable) data availability and data availability lower than 33.33% means poor data availability.

Table 5: *Data availability for potential model application of water retention measures (based on survey results)*

Water Retention Measure	General data availibility (all case studies)	Averaged data availability (all case studies)	Number of CS with poor data availability	Number of CS with moderate data availability	Number of CS with high data availability
F01 Forest riparian buffers	High	74.60%	1	0	14
F04 Targeted planting for 'catching' precipitation	High	74.60%	1	0	14
N13 Restoration of natural infiltration to groundwater	High	72.00%	0	5	10
F09 Sediment capture ponds	High	71.93%	0	6	9
U09 Rain Gardens	High	69.93%	0	5	10
F10 Coarse woody debris	High	69.40%	1	4	10
U06 Filter Strips	High	68.67%	0	6	9
U08 Infiltration Trenches	High	68.53%	0	5	10
U12 Infiltration basins	High	68.53%	0	5	10
A03 Crop rotation	High	67.93%	0	6	9
A05 Intercropping	High	67.93%	0	6	9
A06 No till agriculture	High	67.93%	0	6	9
A07 Low till agriculture	High	67.93%	0	6	9
NEW: Improved infiltration	High	66.67%	0	8	7
N08 Riverbed material renaturalization	Moderate	55.33%	5	4	6
N09 Removal of dams and other longitudinal barriers	Moderate	55.33%	5	4	6
N10 Natural bank stabilisation	Moderate	55.33%	5	4	6
N11 Elimination of riverbank protection	Moderate	55.33%	5	4	6
U11 Retention Ponds	Moderate	54.80%	3	8	4
N01 Basins and ponds	Moderate	53.40%	2	11	2
N04 Re-meandering	Moderate	53.40%	2	11	2
U10 Detention Basins	Moderate	52.33%	3	9	3
A02 Buffer strips and hedges	Moderate	51.40%	3	9	3
A11 Controlled traffic farming	Moderate	51.27%	0	14	1
N03 Floodplain restoration and management	Moderate	50.60%	3	8	4
A08 Green cover	Moderate	50.00%	2	10	3
N02 Wetland restoration and management	Moderate	49.73%	3	9	3
N05 Stream bed re-naturalization	Moderate	49.33%	3	9	3
A04 Strip cropping along contours	Moderate	47.67%	4	9	2
A10 Traditional terracing	Moderate	47.67%	4	9	2
U04 Swales	Moderate	47.67%	4	9	2
A01 Meadows and pastures	Moderate	47.60%	3	10	2
A09 Early sowing	Moderate	46.33%	2	12	1
A12 Reduced stocking density	Moderate	44.80%	3	12	0

A13 Mulching	Moderate	44.80%	3	12	0
F02 Maintenance of forest cover in headwater areas	Moderate	44.80%	3	12	0
F03 Afforestation of reservoir catchments	Moderate	44.80%	3	12	0
F05 Land use conversion	Moderate	44.80%	3	12	0
N14 Re-naturalisation of polder areas	Moderate	44.80%	3	12	0
N06 Restoration and reconnection of seasonal streams	Moderate	43.47%	5	9	1
N07 Reconnection of oxbow lakes and similar features	Moderate	43.47%	5	9	1

Considering the information summarized in Table 5, forest riparian buffers, targeted planting for 'catching' precipitation, restoration of natural infiltration to groundwater, sediment capture ponds, rain gardens, coarse woody debris, filter strips, infiltration trenches, infiltration basins, crop rotation, intercropping, no-till agriculture, low-till agriculture, improved infiltration have high data availability in general; where for very few case studies have low data availability for forest riparian buffers, targeted planting for 'catching' precipitation and coarse woody debris only. On the other hand, there is generally moderate data availability for some of the waterbody-based water retention measures (such as riverbed material re-naturalization, removal of dams and other longitudinal barriers, natural bank stabilisation, elimination of riverbank protection) where at least one of the case studies have poor data availability.

Conducting a similar analysis on case study basis, four case studies have high availability of data; other case studies have at least moderate availability of data and only two case studies are relatively close to low data availability (less than 40%) considering all of the possible water retention measures.

These analyses of survey results will provide important inputs for the model building and scenario analyses steps in the forthcoming work tasks and deliverables of the OPTAIN project. Further details on the survey results are given in following sections and appendices.

3.4.2. Flood and drought issues

Flood and droughts are a particular issue in the light of the changing climate. Many case study leads indicated that the issues of more frequent droughts (in 9 case studies), and flood and drought alternating occurrence (in 6 case studies) are the major ones in their areas (Table 2). Hence, the detailed questionnaire focused on determining the physical setting and the data availability to model and analyse these trends.

When defining the flood risk and flood hazard areas we follow the Floods Directive (2007/60/EC) (EC, 2007) definitions. Five case study sites (CH, BE, IT, HU, LV) are in a flood risk area and four case study sites (DE, CH, BE, IT) are in a flood hazard area, as defined by the EU Floods Directive.

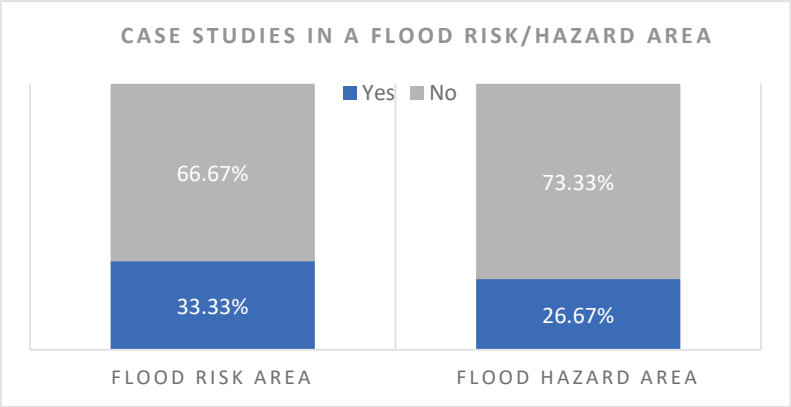


Figure 6: Percentage of case studies within a flood risk and/or hazard area

We define agricultural droughts as lack of sufficient moisture in the surface soil layers to support crop growth. Hydrological droughts were defined as low levels of water in the hydrological system, i.e. abnormally low streamflow in rivers as well as abnormally low levels in lakes, reservoirs, and groundwater. The answers from the questionnaire provided information on the change in severity, duration, and frequency of both types of droughts as well as the primary source of this knowledge in each CS site.

Case study leads performed the analysis (or derived the necessary information from other sources) on both types of droughts. Most of the case studies (10) experience an increase in the severity and frequency of hydrological droughts, with information from literature or quantitative assessment to support these observations (Figure 7). Four case study sites report that the information of hydrological droughts is unknown.

Eight case studies are impacted by the change in severity, frequency or duration of agricultural droughts (from quantitative assessment, expertise or literature), and five report that the issue is unknown. Unlike the hydrological droughts, two case studies report that the issues are not relevant for their catchments (Čechtický in Czech Republic and Dotnuvele in Lithuania).

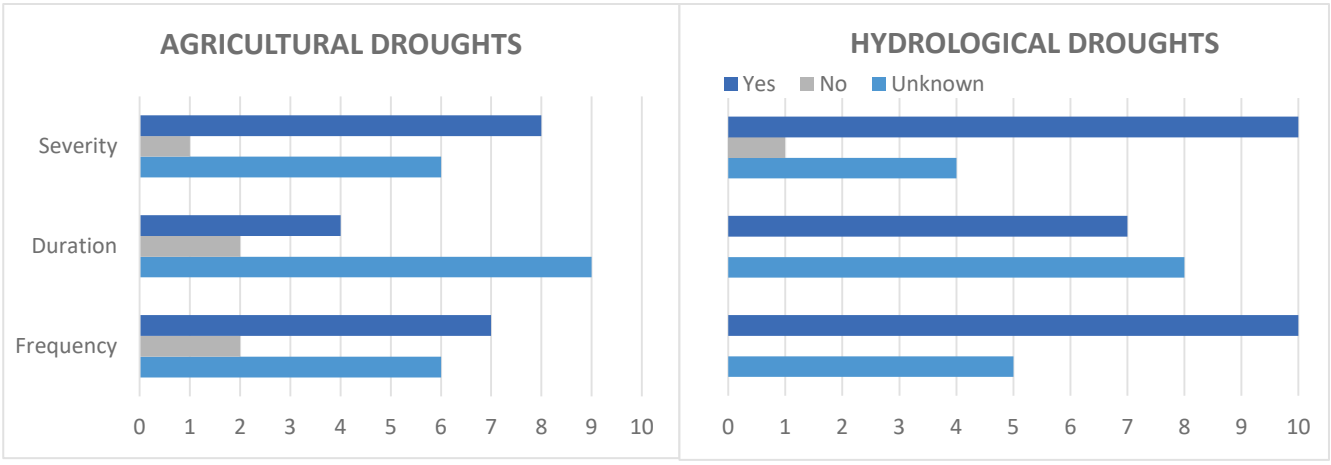


Figure 7: Change in frequency, duration, and severity of agricultural and hydrological droughts in case studies (observed or derived from literature)

When the information on droughts is unavailable, a detailed analysis must be performed to determine if the issue is relevant. However, without long-term hydrological and meteorological measurements such analysis is challenging to complete. Long-term data series availability is unknown or unavailable in the following case studies: Csorsza

(HU), Felső-Válicka (HU), La Wimbe (BE), Cherio (IT), Tetves (HU), Dviete (LV), Sävjaån (SE). Hence, prior to the modelling task, we recommend to identify the nearest flow gauge with long time series and verify its similarity to the CS catchment, as this point could serve as a reasonable proxy, if no data is available within the case study area. Other techniques (i.e. remote sensing and machine learning algorithms) might be used to determine the relevance of drought issues, but such analysis will require work and expertise beyond the OPTAIN project and can be considered at a later stage by individual case studies. If the data is completely unavailable, then the model results of measures which address drought issues in these areas will be associated with high uncertainty.

3.4.3. Water quality issues

Case study leads performed the analysis (or derived the necessary information from other sources) on the current and desired status of the water bodies in their catchment. All the relevant water bodies were listed for each CS area and their current state based on indicators defined by the 2nd River Basin Management Plan (in the EU member states) or similar policy (non-EU members) were noted. The target status was also indicated. Because the case studies listed the detailed names or sections of their catchment water bodies, there are more than one such record for each case. The screening concluded the following results (Figure 3):

- Most of the case studies reported the need to improve the water quality status of their water bodies in the areas.
- 21 water bodies need improvement by one step (i.e. from Bad to Moderate).
- Eight water bodies reported the need to improve by two steps (i.e. from Bad to Good),
- One water body was identified as in need of improvement by three steps: from Bad to Very Good.
- 18 water bodies do not need improvement since their ecological status is sufficient (Moderate or better).

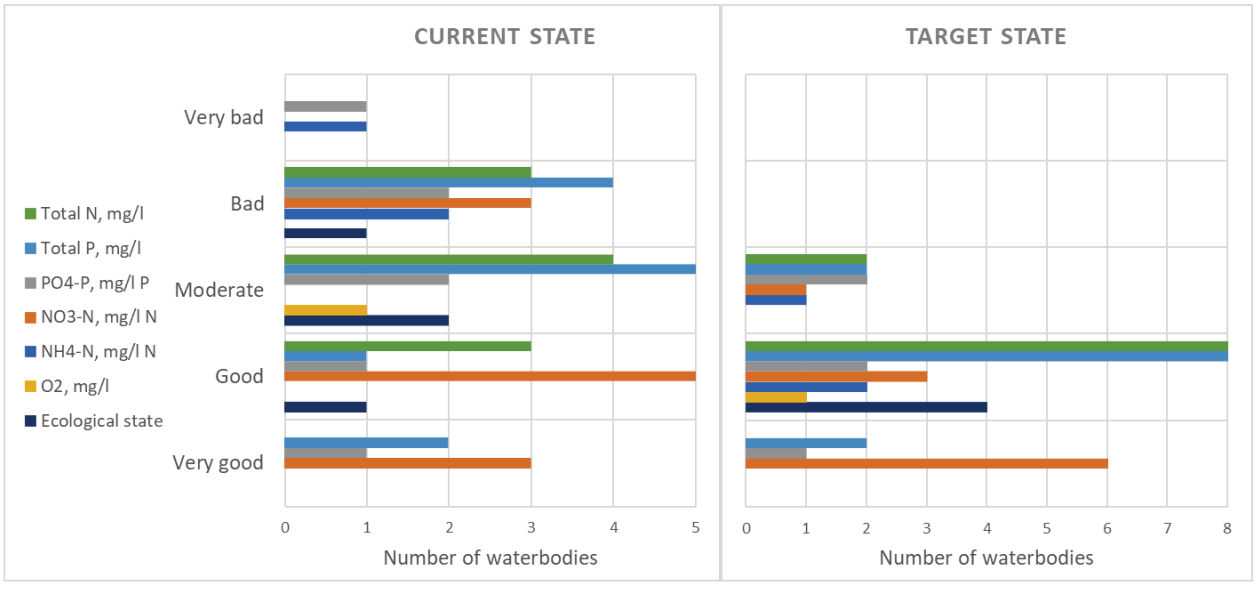


Figure 3: Current and target ecological status of the water bodies in the case study catchments according to the 2nd River Basin Management Plan

Based on the aggregated questionnaire results, the main issues are the exceedance of the total phosphorous (Total P, mg/l), total nitrogen (Total N, mg/l), and phosphate (PO4-P, mg/l P) concentrations in the rivers. These nutrients are usually associated with agriculture and, in case of P, with possible soil erosion and/or point source pollution. The target value for water quality improvement for all the case studies is “Moderate” or higher, where the majority aims for improvements to a “Good” status.

A third of the case studies reported that water quality improvement is also needed in the downstream locations of the case study sites. This shows that the selected CS locations are in the headwater or tributaries of a larger river network, where the identified issues (Table 2) are likely to be relevant, hence the possible solutions could be transferable or adaptable in the larger river basin.

3.4.4. Food production issues

Generally, case study leads indicated that there were country-wide average values for the yield gaps available. Some could be derived from the global yield gap atlas (“Home - Global yield gap atlas,”, 2020), where the resolution is coarse with a decade old data.

The aggregated questionnaire results of the yield gap (Figure 5) show that among the varieties of crop types grown in the case study areas the largest yield gap in absolute terms (t/ha) is observed with potato and silage maize crops, both in the Čechtický case study site (Czech Republic) (Figure 5 top). Where the information on the long-term average total yields was available, we calculated the relative yield gap (expressed as % from the average yield). The results show that on average the yield gap makes up 4% - 37% of the observed yields in the case study countries for barley, maize, potato, rapeseed, sugar beets, sunflower seeds and wheat crops. The highest relative percentage yield gaps are observed in Latvia (barley and wheat), Hungary and Poland (maize), Lithuania and Slovenia (potatoes), Lithuania (rapeseed), Italy and Hungary (Sugar beet), Poland (Sunflower). Germany, Sweden and Switzerland report the smallest relative yield gap (0-5%) for most of the crops. However, the yield gap percentage was calculated using the average country statistics, because the total average yields for the case study areas only was not available. Therefore, the percentage statistics does not fully represent the chosen catchment areas.

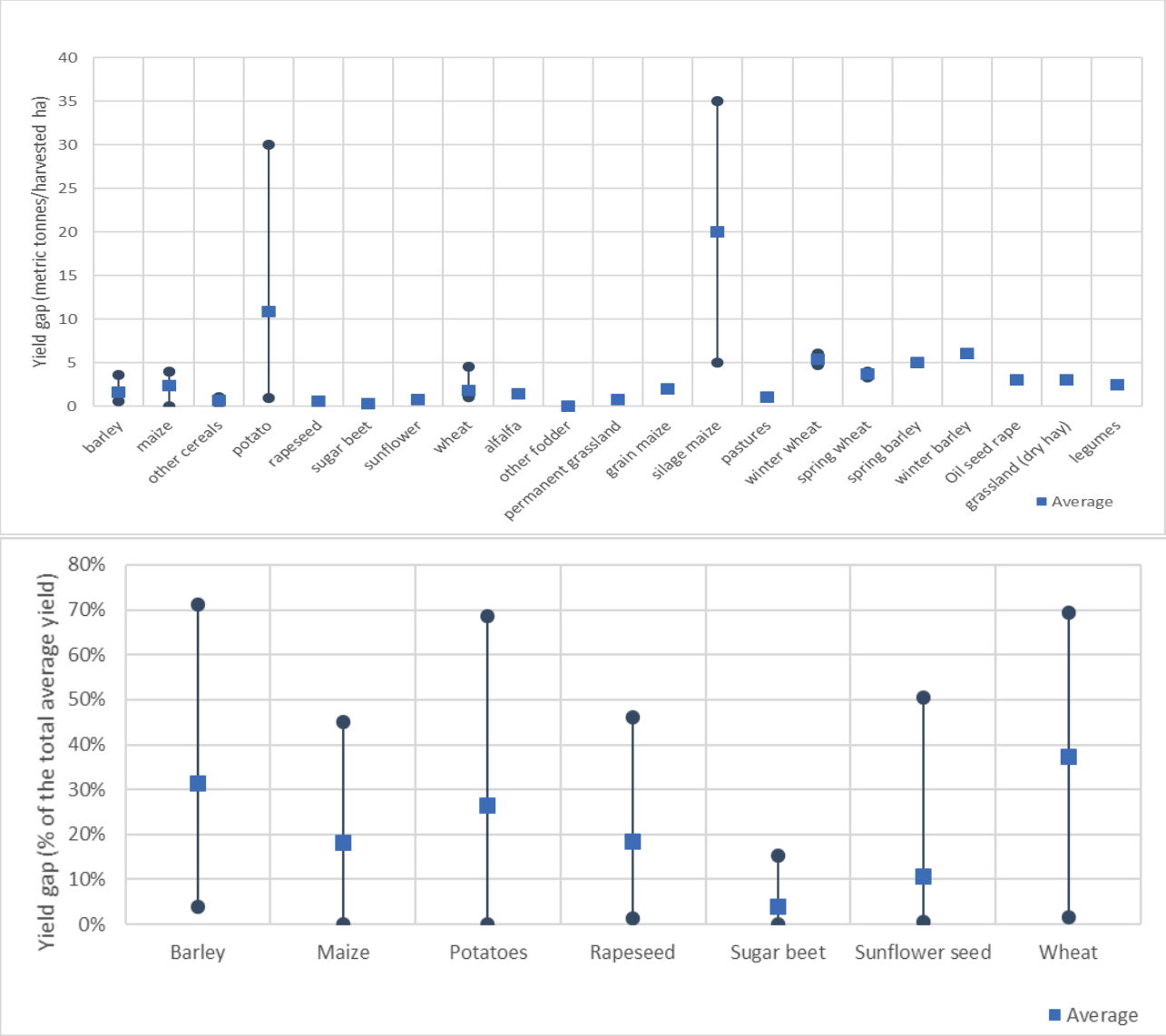


Figure 5: *Yield gap statistics thought case studies (top: total yield gap in t/ha; bottom: relative yield gap in % of the average yield)*

Case study leads report that the yield gap is not measured or is not identified as a major issue in seven case-study sites (Petite Glâne in Switzerland, Pesnica in Austria/Slovenia, Kobiljski potok/Kebele in Slovenia/Hungary, La Wimbe in Belgium, Dotnuvele in Lithuania, Dviete in Latvia, and Sävjaån in Sweden), hence the lack of local or high-resolution data to support a detail analysis.

3.4.5. Data availability for possible NSWRM scenario implementation

We identified relevant data and information which is necessary to perform the abovementioned analyses, or which can aid in the development of scenarios. To analyse the flood issue (especially in small watersheds), a detailed hydrological model with sub-daily temporal precision is needed. A simpler analysis can be performed by using the IDF (Intensity Duration Frequency) curves or hyetographs to drive a black box unit hydrograph approach and use its results together with the flood-plain and cross section information to analyse the extent of the floods. Such analysis can be further used to assess the water retention measures against floods.

Information on the river cross-sections, floodplains, unit-hydrographs, and IDF curves for precipitation is unavailable in most case studies (Figure 8). Some information can be derived, i.e. the river cross-sections in Schwarzer Schöps (DE), Upper Zglowiaczka (PL), Dotnuvele (LT), and Čechtický (CZ) case study sites. Where the information is unavailable but is crucial, a dedicated work-package (Work package 3: Retrieval of modelling data and solutions to overcome data scarcity) will provide guidance on how to derive the missing data from other sources.

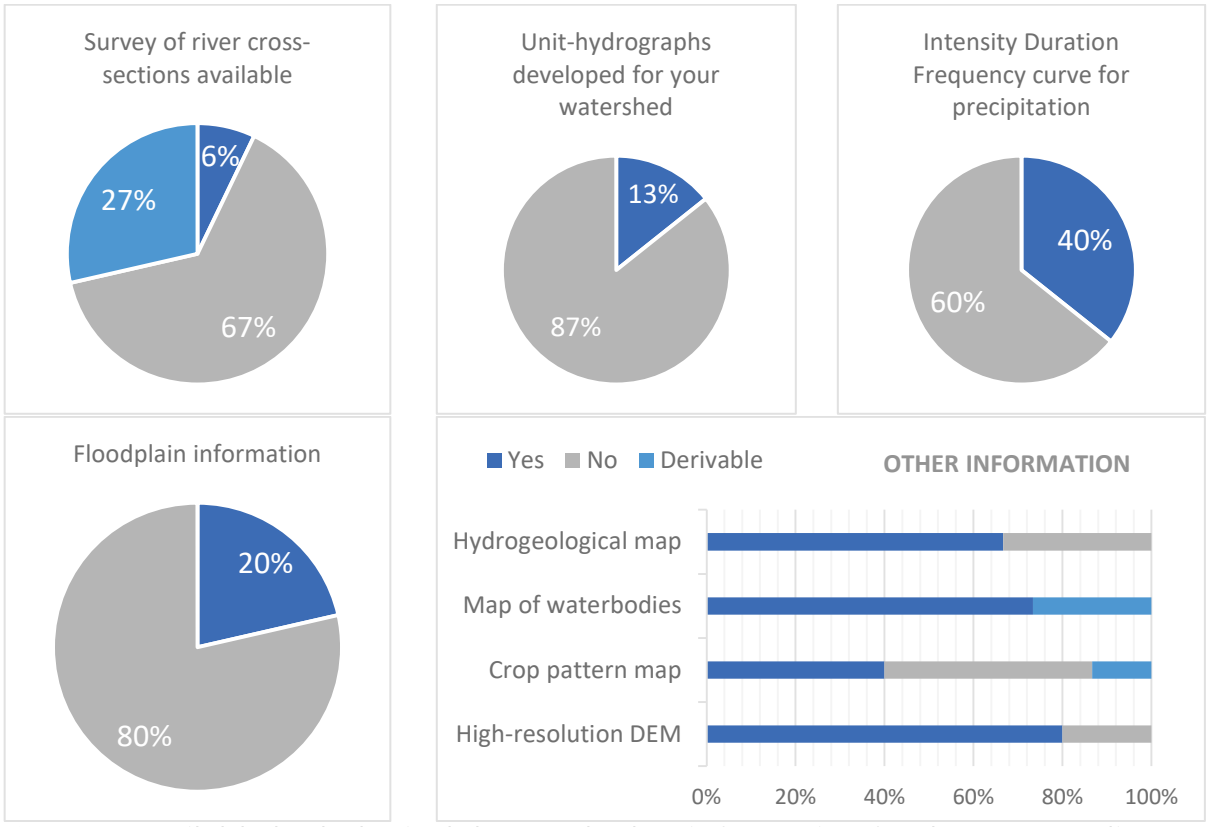
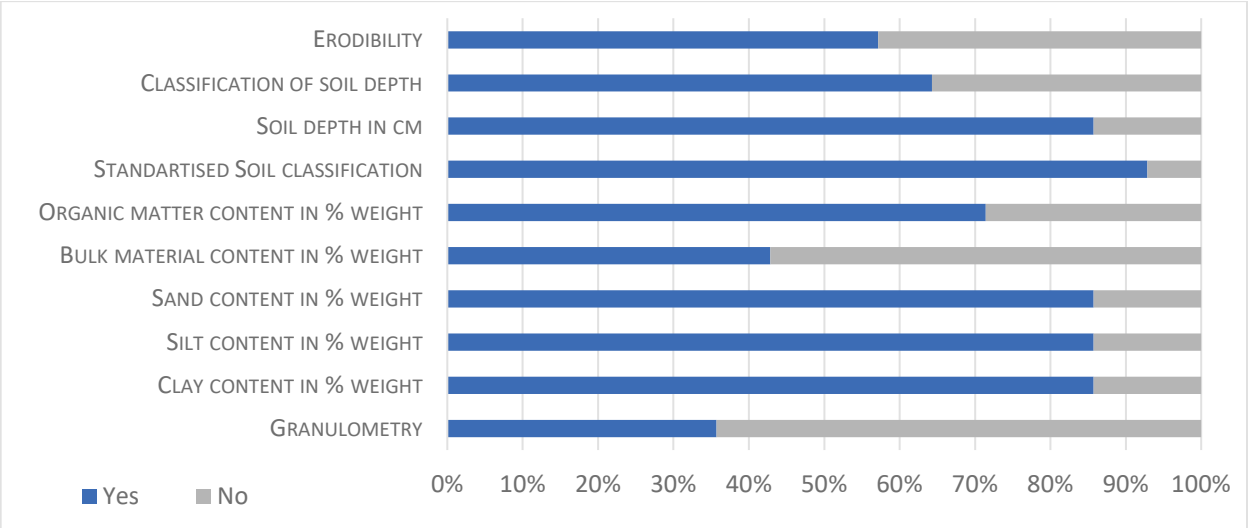


Figure 8: Available hydrological data and other information for the case studies

Information of the soil types and properties is crucial in environmental studies, hence we expected for most of the datasets to be available (Figure 9). One issue was identified – the unavailability of soil maps in one case study in Latvia. WP3 is already working on supplementing the knowledge from other sources.

Specific soil properties are necessary to determine the suitability of certain measures in a case-study area, i.e. constructed wetlands must be sealed to avoid possible contamination of groundwater and to prevent groundwater from infiltrating into the wetland (USDA - NRCS EPA, 2015). The area soils and soil density (or clay content in soils) should provide an adequate seal for the possible implemented wetland. Hence, a screening of such detailed data availability was conducted and further used to determine the possibility of measure implementation.



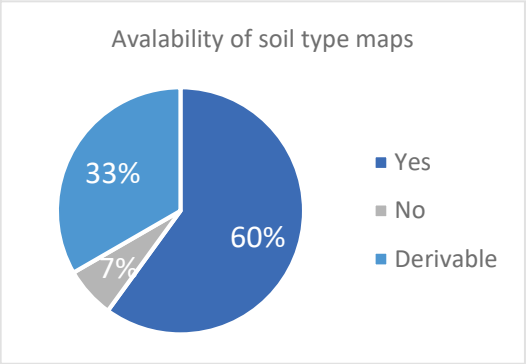


Figure 9: Availability of soil type map (pie chart) with properties (bar chart) for the case studies

We identified other data, which is needed or can be useful in the process of developing scenarios of NSWRM implementation, and asked the CS leads to provide information on it (Appendix 1). Such information is: the availability of high-resolution Digital Elevation Models (vertical and horizontal), availability of detailed soil maps, crop rotation maps, hydrogeological maps, availability of prior groundwater surveys, etc. The relevance of the information was derived by a combination of literature review on the measures (European Commission, 2013), the expert knowledge of the SWAT+ model and consultation with the model development team. Based on the gathered and processes data by each of the CS lead, we can summarise the measure scenario implementation possibility for each case study in the OPTAIN project.

3.5. Scenario implementation possibility in all case studies

An initial screening of the possibility to represent measures in models based on local issues, information, and case-study data availability is presented in Table 6. The table results can also be interpreted as an initial screening of measure relevance in the case study areas. The results are calculated based on the completeness of local dataset, where 100% means that there is sufficient data to model the measure and develop scenarios, and 0% means that there is no data, or the measure is completely irrelevant and should not be considered in the models or scenario development.

We observe that for each case study there is at least some data available for each measure, which was expected, since the case studies were selected with the aim of setting up and running models efficiently. Nevertheless, from the local information screening we can summarise the most and least data-demanding measures, and the

possible measures which can further be considered in the model scenario development tasks.

In total, measures which are the most data-demanding and have the least amount of available information throughout the case studies are: N06 Restoration and reconnection of seasonal streams, N07 Reconnection of oxbow lakes and similar features, A12 Reduced stocking density, A13 Mulching, F02 Maintenance of forest cover in headwater areas, F03 Afforestation of reservoir catchments, F05 Land use conversion, N14 Re-naturalisation of polder areas, A09 Early sowing, A04 Strip cropping along contours, A10 Traditional terracing, U04 Swales, N05 Stream bed re-naturalization. Many of these measures require high resolution or high-frequency hydrological data or are better represented by hydraulic models. Early sowing, strip cropping along contours, traditional terracing is better represented by field-scale models or in a coupled system.

Measures, which have the most data available to accurately represent them in a model are: N13 Restoration of natural infiltration to groundwater, F01 Forest riparian buffers, F09 Sediment capture ponds, and can be considered in model scenario development of most of the case studies.

Case studies with the most data for the setup of measures in a model are: Schwarzer Schöps (DE), Dotnuvele (LT), Cherio (IT), and Hobøl (NO). Data-scarce case studies are: Csorsza (HU), Felso-Valicka (HU), Petite Glâne (CH), and Tetves (HU). WP3 already initiated the necessary procedures to help and gather all the required datasets for these areas.

3.6. Further steps in measure selection and scenario development

Task 4.1 analysis focused on the important aspects for issue identification, measure selection and model scenario development in the OPTAIN case studies. This task did not assess the possibility to simultaneously represent the measures in the selected areas. Such analysis will result in an extra dimensionality in the resulting matrix (Table 4). Where one implemented measure can address an issue, it might also upscale the severity of another, or vice-versa. Some measures are also impossible to model simultaneously. Hence the decision of measure implementation in the models and scenario development will be addressed by each of the case-study team separately. The finalised matrix (Table 6) will be updated, if new data or information becomes available.

Table 6. Screening of the possibility to represent measures in models based on local conditions and data availability for each case study site

Measures / Case studies	Schwarzer Schöps (DE)	Petite Glâne (CH)	Csorsza (HU)	Felso-Valicka (HU)	Upper Zglowiaczka (PL)	Pesnica (AT/SL)	Kobiljski potok/Kebele	La Wimbe (BE)	Dotnuvele (LT)	Cherio (IT)	Hobøl (NO)	Tetves (HU)	Čechtický (CZ)	Dviete (LV)	Sävjaån (SE)
A01 Meadows and pastures	44%	44%	33%	33%	44%	67%	67%	44%	44%	56%	56%	44%	33%	61%	44%
A02 Buffer strips and hedges	55%	55%	23%	23%	45%	73%	73%	59%	55%	64%	55%	32%	36%	68%	55%
A03 Crop rotation	71%	43%	71%	71%	100%	64%	64%	57%	100%	86%	71%	71%	71%	36%	43%
A04 Strip cropping along contours	50%	50%	20%	20%	40%	70%	70%	60%	50%	60%	50%	30%	30%	65%	50%
A05 Intercropping	71%	43%	71%	71%	100%	64%	64%	57%	100%	86%	71%	71%	71%	36%	43%
A06 No till agriculture	71%	43%	71%	71%	100%	64%	64%	57%	100%	86%	71%	71%	71%	36%	43%
A07 Low till agriculture	71%	43%	71%	71%	100%	64%	64%	57%	100%	86%	71%	71%	71%	36%	43%
A08 Green cover	45%	45%	27%	27%	45%	73%	73%	55%	55%	55%	55%	36%	36%	68%	55%
A09 Early sowing	40%	55%	40%	40%	45%	60%	60%	50%	50%	75%	40%	50%	40%	20%	30%
A10 Traditional terracing	50%	50%	20%	20%	40%	70%	70%	60%	50%	60%	50%	30%	30%	65%	50%
A11 Controlled traffic farming	45%	55%	45%	45%	55%	64%	64%	45%	55%	73%	55%	55%	36%	41%	36%
A12 Reduced stocking density	50%	50%	25%	25%	38%	63%	63%	50%	38%	63%	50%	38%	25%	56%	38%
A13 Mulching	50%	50%	25%	25%	38%	63%	63%	50%	38%	63%	50%	38%	25%	56%	38%
F01 Forest riparian buffers	100%	33%	67%	67%	100%	67%	67%	67%	100%	67%	100%	67%	67%	83%	67%
F02 Maintenance of forest cover in headwater areas	50%	50%	25%	25%	38%	63%	63%	50%	38%	63%	50%	38%	25%	56%	38%
F03 Afforestation of reservoir catchments	50%	50%	25%	25%	38%	63%	63%	50%	38%	63%	50%	38%	25%	56%	38%
F04 Targeted planting for 'catching' precipitation	100%	33%	67%	67%	100%	67%	67%	67%	100%	67%	100%	67%	67%	83%	67%
F05 Land use conversion	50%	50%	25%	25%	38%	63%	63%	50%	38%	63%	50%	38%	25%	56%	38%

Measures / Case studies	Schwarzer Schöps (DE)	Petite Glâne (CH)	Csorsza (HU)	Felso-Valicka (HU)	Upper Zglowiaczka (PL)	Pesnica (AT/SL)	Kobiljski potok/Kebele	La Wimbe (BE)	Dotnuvele (LT)	Cherio (IT)	Hobøl (NO)	Tetves (HU)	Čechtický (CZ)	Dviete (LV)	Sävjaån (SE)
F09 Sediment capture ponds	71%	43%	50%	50%	86%	86%	86%	64%	100%	57%	86%	50%	71%	93%	86%
F10 Coarse woody debris	67%	33%	50%	50%	83%	83%	83%	67%	100%	50%	83%	50%	67%	92%	83%
N01 Basins and ponds	58%	54%	29%	29%	46%	71%	71%	63%	58%	63%	58%	38%	42%	63%	58%
N02 Wetland restoration and management	56%	56%	28%	28%	44%	67%	67%	50%	50%	67%	56%	39%	33%	61%	44%
N03 Floodplain restoration and management	58%	54%	21%	21%	42%	67%	67%	54%	58%	67%	58%	29%	38%	67%	58%
N04 Re-meandering	58%	54%	29%	29%	46%	71%	71%	63%	58%	63%	58%	38%	42%	63%	58%
N05 Stream bed re-naturalization	56%	56%	28%	28%	44%	67%	67%	50%	44%	67%	56%	39%	33%	61%	44%
N06 Restoration and reconnection of seasonal streams	56%	50%	17%	17%	33%	56%	56%	39%	44%	67%	56%	28%	28%	61%	44%
N07 Reconnection of oxbow lakes and similar features	56%	50%	17%	17%	33%	56%	56%	39%	44%	67%	56%	28%	28%	61%	44%
N08 Riverbed material renaturalization	90%	30%	30%	30%	70%	40%	40%	30%	90%	80%	80%	30%	60%	70%	60%
N09 Removal of dams and other longitudinal barriers	90%	30%	30%	30%	70%	40%	40%	30%	90%	80%	80%	30%	60%	70%	60%
N10 Natural bank stabilisation	90%	30%	30%	30%	70%	40%	40%	30%	90%	80%	80%	30%	60%	70%	60%
N11 Elimination of riverbank protection	90%	30%	30%	30%	70%	40%	40%	30%	90%	80%	80%	30%	60%	70%	60%
N13 Restoration of natural infiltration to groundwater	100%	50%	60%	60%	90%	70%	70%	80%	80%	70%	80%	60%	80%	50%	80%
N14 Re-naturalisation of polder areas	50%	50%	25%	25%	38%	63%	63%	50%	38%	63%	50%	38%	25%	56%	38%
NEW: Improved infiltration	60%	40%	80%	80%	100%	60%	60%	40%	100%	80%	80%	80%	60%	40%	40%
U04 Swales	50%	50%	20%	20%	40%	70%	70%	60%	50%	60%	50%	30%	30%	65%	50%

Measures / Case studies	Schwarzer Schöps (DE)	Petite Glâne (CH)	Csorsza (HU)	Felso-Valicka (HU)	Upper Zglowiaczka (PL)	Pesnica (AT/SL)	Kobiljski potok/Kebele	La Wimbe (BE)	Dotnuvele (LT)	Cherio (IT)	Hobøl (NO)	Tetves (HU)	Čechtický (CZ)	Dviete (LV)	Sävjaån (SE)
U06 Filter Strips	80%	40%	40%	40%	80%	80%	80%	80%	100%	60%	80%	40%	60%	90%	80%
U08 Infiltration Trenches	88%	56%	38%	38%	81%	81%	81%	88%	75%	69%	63%	38%	75%	69%	88%
U09 Rain Gardens	83%	42%	50%	50%	75%	75%	75%	83%	100%	58%	83%	50%	67%	75%	83%
U10 Detention Basins	62%	58%	23%	23%	50%	73%	73%	69%	46%	65%	46%	31%	46%	58%	62%
U11 Retention Ponds	64%	61%	25%	25%	54%	75%	75%	68%	50%	68%	50%	32%	50%	61%	64%
U12 Infiltration basins	88%	56%	38%	38%	81%	81%	81%	88%	75%	69%	63%	38%	75%	69%	88%

References

Bieger, K., Arnold, J.G., Rathjens, H., White, M.J., Bosch, D.D., Allen, P.M., Volk, M., Srinivasan, R., 2017. Introduction to SWAT+, A Completely Restructured Version of the Soil and Water Assessment Tool. J. Am. Water Resour. Assoc. 53. https://doi.org/10.1111/1752-1688.12482

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EC, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Off. J. Eur. Union 60.

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USDA - NRCS EPA, 2015. A HANDBOOK OF CONSTRUCTED WETLANDS.

Appendix

Appendix 1. Questionnaire template

Nr	Question			
1	What is the ecological status of the waterbodies in the catchment according to the 2nd River Basin Management Plan? What is the target state for improvement of water quality? (Max 10 most important waterbodies and indicators)			
	Waterbody name/group/type	Current state	Target state	Indicator
	Upstream	Bad	Moderate	Total N, mg/l
	Upstream	Moderate	Good	PO4-P, mg/l P
	Midstream	Very bad	Bad	PO4-P, mg/l P
	…			
2	Do you need to improve the water quality in your Case study to improve the status of next stream order downstream waterbodies (not included in your Case study)?			
	If yes: is there a target value for nutrient load reduction at the outlet of your Case study Area?			
3	Is there a measurable yield gap in your case study? (Max 10 crops)			
	Crop	Measurable yield gap present?	Value (metric tonnes/harvested ha)	
	Maize			
	Wheat			
	Other			
	…			
4	Is a high-resolution Digital Elevation Model - DEM (horizontal resolution 5-10 m) available?			
5	If a high-resolution DEM is available, is its vertical accuracy 10 cm or better?			

6	Is a DEM with horizontal resolution of 30 m available?	
7	Is a high-resolution landuse and land cover map available, containing at least the following class:	
	Artificial Surfaces	
	Agricultural Areas	
	Forests and Semi-Natural Areas	
	Wetlands	
8	Is a crop pattern map available?	
9	Is a soil type map with properties available?	
9a	If yes, please tick the available properties: (multiple choice)	
	Granulometry (cumulative particle size distribution)	
	Clay content in % weight	
	Silt content in % weight	
	Sand content in % weight	
	Bulk material content in % weight (coarse fragments (> 2 mm) in weight %)	
	Organic matter content in % weight	
	Soil classification according to USDA or any standard	
	Soil depth in cm	
	Classification of soil depth including the classes: very shallow, shallow, average, deep	
	Erodibility	
10	Is a map of waterbodies (including small and/or artificial ponds available)?	
10 a	If a map of waterbodies (including small and/or artificial ponds) is available, does it contain information about modified/heavily modified waterbodies?	
11	Is a survey of river cross sections available?	
12	Is a hydrogeological map of the study area available?	
12 a	If hydrogeological map of the study area is available, are there groundwater surveys?	
13	Is your case study area in a flood hazard area (according to the EU or similar maps)?	

14	Is your case study area in a flood risk area (according to the EU or similar maps)?
15	Do you have a IDF (Intensity Duration Frequency) curve for precipitation, of hourly or higher resolution?
16	Do you have unit-hydrographs developed for your watershed?
17	Do you have floodplain information (e.g. floodplain map)?
18	Does your catchment experience an increase in frequency, duration and/or severity of agricultural droughts (lack of sufficient moisture in the surface soil layers to support crop growth)?

Indicator	Change	Basis
Frequency:	Unknown	
Duration:	Unknown	
Severity:	Unknown	

19	Does your catchment experience an increase in frequency, duration and/or severity of hydrological droughts (low levels of water in the system: abnormally low streamflow in rivers, abnormally low levels in lakes, reservoirs, and groundwater)?

Indicator	Change	Basis
Frequency:	Unknown	
Duration:	Unknown	
Severity:	Unknown	

Appendix 2. Initial screening of available data

All the datasets were downloaded from the Joint Research Centre European Soil Data Centre (JRC ESDAC) site (https://esdac.jrc.ec.europa.eu/). Reference for all the datasets below:

1. Panagos P., Van Liedekerke M., Jones A., Montanarella L., "European Soil Data Centre: Response to European policy support and public data requirements"; (2012) Land Use Policy, 29 (2), pp. 329-338. doi:10.1016/j.landusepol.2011.07.003
2. European Soil Data Centre (ESDAC), esdac.jrc.ec.europa.eu, European Commission, Joint Research Centre.

Datasets:

1. Landslide susceptibility – landslide susceptibility levels at continental scale derived from heuristic-statistical modelling of main landslide conditioning factors using also landslide location data (https://esdac.jrc.ec.europa.eu/content/european-landslide-susceptibility-map-elsus-v2). References:
    1. Wilde, M., Günther, A., Reichenbach, P., Malet, J.-P., Hervás, J., 2018. Pan-European landslide susceptibility mapping: ELSUS Version 2. Journal of Maps, 14(2): 97-104 and supplemental map.
    2. Günther, A., Van Den Eeckhaut, M., Malet, J.-P., Reichenbach, P., Hervás, J., 2014. Climate-physiographically differentiated Pan-European landslide susceptibility assessment using spatial multi-criteria evaluation and transnational landslide information. Geomorphology, 224: 69-85
2. Net erosion and sediment transport – quantification of the potential spatial displacement and transport of soil sediments due to water erosion at European scale. Long-term averages computed of annual soil loss and deposition rates by means of the extensively tested spatially distributed WaTEM/SEDEM model. Findings indicate that soil loss from Europe in the riverine systems is about 15% of the estimated gross on-site erosion (https://esdac.jrc.ec.europa.eu/content/estimate-net-erosion-and-sediment-transport-using-watemsedem-european-union). Reference:
    1. Borrelli, P., Van Oost, K., Meusburger, K., Alewell, C., Lugato, E., Panagos, P. 2018. A step towards a holistic assessment of soil degradation in Europe: Coupling on-site erosion with sediment transfer and carbon fluxes. Environmental Research, 161: 291-298.
3. Soil erosion (forest) – Soil Erosion in forestland in Europe (Using Rusle2015). One map is the soil loss potential for 28 EU Member States; the other map is the European Forest Cover Change for 36 European countries (https://esdac.jrc.ec.europa.eu/content/soil-erosion-forestland-europe-using-rusle2015). Reference of source (Citations):
    1. Borrelli, P., Panagos, P., Langhammer, J., Apostol, B., Schütt, B. 2016. Assessment of the cover changes and the soil loss potential in European forestland: First approach to derive indicators to capture the ecological impacts on soil-related forest ecosystems. Ecological Indicators, 60, 1208–1220
    2. Borrelli, P., Modugno, S. Panagos, P., Marchetti, M. Schütt, B. Montanarella, L. (2014). Detection of harvested forest areas in Italy using Landsat imagery. Applied Geography 48 , 102-111.

3. Borrelli, P., Märker, M., Panagos, P., Schütt, B. (2014). Modeling soil erosion and river sediment yield for an intermountain drainage basin of the Central Apennines, Italy. Catena, 114, pp. 45–58.

4. Potential threats (biodiversity) – three major components of soil biodiversity are assesed: a) soil microorganisms, b) fauna, and c) biological functions. The maps were developed based on 13 potential threats to soil biodiversity which were proposed to experts with different backgrounds in order to assess biodiversity threat (https://esdac.jrc.ec.europa.eu/content/potential-threats-soil-biodiversity-europe). A complete description of the methodology and the application in Europe is described in the paper:
    1. Orgiazzi, A., Panagos, P., Yigini, Y., Dunbar, M.B., Gardi, C., Montanarella, L., Ballabio, C. 2016. A knowledge-based approach to estimating the magnitude and spatial patterns of potential threats to soil biodiversity. Science of the Total Environment, 545-546: 11-20

5. LS factor (Slope Length and Steepness factor) – the LS-calculation was performed using the original equation proposed by Desmet and Govers (1996) and implemented using the System for Automated Geoscientific Analyses (SAGA), which incorporates a multiple flow algorithm and contributes to a precise estimation of flow accumulation (https://esdac.jrc.ec.europa.eu/content/ls-factor-slope-length-and-steepness-factor-eu). Datasets ares in Raster format. Available in 2 different resolution datasets : a) European LS-factor map at 100m resolution b) LS-factor map at 25m resolution per country. A complete description of the methodology and the application in Europe is described in the paper:
    1. Panagos, P., Borrelli, P., Meusburger, K. (2015) A New European Slope Length and Steepness Factor (LS-Factor) for Modeling Soil Erosion by Water. Geosciences, 5: 117-126.

6. Production gap – estimation of production gap computes for each grid cell the difference between potential and actual production for 8 crops/crop groups (https://gaez.fao.org/pages/theme-details-theme-6; https://gaez.fao.org/pages/data-viewer).

Some nodata cells

------ - not covering the area

No.	Case study	Landslide susceptibility				Net erosion and sediment transport	Soil erosion (forest)		
		slope	lithology	landcover	elsus_v2		Forest Soil Loss	Forest Cover Change class	Forest fire class
1	Schwarzer Schöps	+	+	+	+	+	+	+	+
2	Petite Glâne	+	+	+	+	------	------	+	+
3a	Csorsza	+	+	+	+	+	+	+	+
3b	Felső-Válicka	+	+	+	+	+	+	+	+
4	Upper Zglowiaczka	+	+	+	+	+	+	+	+
5	Pesnica	+	+	+	+	+	+	+	+
6	Kobiljski potok/Kebele	+	+	+	+	+	+	+	+
7	La Wimbe	+	+	+	+	+	+	+	+
8	Dotnuvėlė	+	+	+	+	+	+	+	+
9	Cherio	+	+	+	+	+	+	+	+
10	Hobøl	+	+	+	+	------	------	+	+
11	Tetves	+	+	+	+	+	+	+	+
12	Čechtický	+	+	+	+	+	+	+	+
13	Dviete	+	+	+	+	+	+	+	+
14	Sävjaån	+	+	+	+	+	+	+	+

No.	Case study	Potential threats (biodiversity)												
		Climate change	compaction	erosion	GMO use	habitat fragmentation	industrial pollution	intensive human exploitation	invasive species	land use change	organic matter decline	radioactivity	salinity	sealing
1	Schwarzer Schöps	+	+	+	+	+	+	+	+	+	+	+	+	+
2	Petite Glâne	+	------	+	+	+	+	------	------	+	+	+	+	+
3a	Csorsza	+	+	+	+	+	+	+	------	+	+	+	+	+
3b	Felső-Válicka	+	+	+	+	+	+	+	------	+	+	+	+	+
4	Upper Zglowiaczka	+	+	+	+	+	+	+	------	+	+	+	+	+
5	Pesnica	+	+	+	+	+	+	+	------	+	+	+	+	+
6	Kobiljski potok/Kebele	+	+	+	+	+	+	+	------	+	+	+	+	+
7	La Wimbe	+	+	+	+	+	+	+	+	+	+	+	+	+
8	Dotnuvėlė	+	+	+	+	+	+	+	------	+	+	+	+	+
9	Cherio	+	+	+	+	+	+	+	------	+	+	+	+	+
10	Hobøl	+	------	+	+	+	+	------	------	+	+	+	+	+
11	Tetves	+	+	+	+	+	+	+	------	+	+	+	+	+

12	Čechtický	+	+	+	+	+	+	+	------	+	+	+	+	+
13	Dviete	+	+	+	+	+	+	+	------	+	+	+	+	+
14	Sävjaån	+	+	+	+	+	+	+	------	+	+	+	+	+

No.	Case study	LS factor		Production gap							
			Country file	barley	maize	other cereals	potato and sweet potato	rapeseed	sugar beet	sunflower	wheat
1	Schwarzer Schöps	+	Germany	+	+	+	+	+	------	------	+
2	Petite Glâne	------		+	+	+	+	+	------	+	+
3a	Csorsza	+	Hungary	+	+	+	+	+	------	+	+
3b	Felső-Válicka	+	Hungary	+	+	+	+	+	------	+	+
4	Upper Zglowiaczka	+	Poland	+	+	+	+	+	+	------	+
5	Pesnica	+/+	Slovenia25m/LS100m	+	+	+	+	+	------	+	+
6	Kobiljski potok/Kebele	+/+	Hungary/Slovenia	+	+	+	+	+	------	+	+
7	La Wimbe	+	Belgium	+	------	+	+	+	------	------	+
8	Dotnuvėlė	+	Lithuania	+	+	+	+	+	+	------	+
9	Cherio	+	Italy	+	+	+	+	------	+	+	+
10	Hobøl	------		+	------	+	+	+	------	------	+
11	Tetves	+	Hungary	+	+	+	+	+	------	+	+
12	Čechtický	+	Check Republic	+	+	+	+	+	+	+	+
13	Dviete	+	Latvia	+	------	+	+	+	------	------	+
14	Sävjaån	+	Sweden	+	------	------	+	+	------	------	+

Appendix 3. Screening of the case studies

PROBLEMS AND CONSTRAINTS

Relevant problems detected in the case study area.

	Farm-scale	*Catchment-scale*
Biodiversity conservation	☐	☐
Maintenance of environmental flows	☐	☐
Climate: extreme events	☐	☐
Droughts: increasing frequency	☐	☐
Droughts: low water levels in summer	☐	☐
Droughts: water deficits	☐	☐
Floods: increasing risk	☐	☐
Floods: severity and/or intensity	☐	☐
Floods and droughts occurring alternatively	☐	☐
Issues with irrigation	☐	☐
Excess surface water	☐	☐
Waterlogging	☐	☐
Soil quality	☐	☐
Soil erosion, run-off and nutrient loss	☐	☐
Landslides	☐	☐
Natural and riverbank erosion	☐	☐
Diffuse and/or point pollution	☐	☐
Quality of waterbodies: eutrophication	☐	☐
Quality of waterbodies: pollutants	☐	☐
Quality of waterbodies: sedimentation	☐	☐
Land reclamation	☐	☐
Hydro-morphological changes	☐	☐
Lack of local actors' knowledge or interest in the abovementioned issues	☐	☐

Additional comment:

..

Constraints to the adoption of NSWRMs.

☐ High costs and affordability

☐ Raise return on investment

☐ Lack of knowledge and problem awareness

☐ Lack of experience on existing technologies

☐ Risk to generate additional problems (mosquitos, odours, …)

☐ Agricultural, environmental and other regulations

☐ Lack of or low financial support and incentives

☐ Technologies unavailability

☐ Scarce autonomy in decision-making ☒ Other:

..

☐ Don't know

AGRICULTURE

How many farms operates in the case study area?

☐ ≤ 50

☐ 50 - 99

☐ 100 – 199

☐ ≥ 200

☐ Don't know

Indicate the distribution of farms amongst size classes. Give the number or the approximate percentage over total farms.

≤ 10 ha
10 – 49.9 ha

50 – 99.9 ha
100 – 199.9 ha

≥ 200 ha

☐ Don't know

Indicate the distribution of farms amongst economic size classes. Give the number or the approximate percentage over total farms.

0 – 14,999 €

15,000 – 49,999 €
50,000 – 99,999 €
≥ 100,000 €

☐ Don't know

Is certified organic farming practiced?

☐ Yes, part of or the entire agricultural area is subject to organic farming

☐ No, solely conventional farming is practiced

☐ No, only conventional farming and other forms of agriculture are practiced

☐ Don't know

If *YES*, please answer the following question:

Indicate the extent of organic farming. Give approximate area (ha) or number of farms

☐ Don't know

Indicate the dominant typology of farms.

☐ Hobby farms (not for profit motive, low income)

☐ Part-time farms (farmers engaged also in another extra-farm working activity)

☐ Full professional farms, for profit motive

☐ Don't know

Describe the farming types that can be found in your case study area. Give area or percentage over total area.

Farming type	*Number of farms*	*Total area (ha)*	*% of total area*
Specialist cereals, oilseed and other protein crops			
Specialist other field crops			
Specialist horticulture (*en-plein air*, protected)			
Specialist permanent crops (wine, fruits, olives) or permanent crops combined			
Specialist herbivores (cattle, sheep, goats)			
Other specialist (poultry, pigs, …)			
Mixed crops			
Mixed livestock			
Mixed crops and livestock			

IRRIGATION AND DRAINAGE

Is agricultural land irrigated?

☐ Yes, part of or the entire agricultural area is irrigated

☐ No, only rainfed agriculture is practiced

☐ Don't know

If *YES*, please answer the following questions:

Indicate the extent of irrigated cropland (ha or % over total agricultural area)

Which crops are irrigated?

Can farmers easily access irrigation water?

☐ Yes

☐ No

☐ Don't know

Which is the dominant source of irrigation water?

☐ Aqueducts, irrigation and reclamation boards or other similar entity

☐ Surface water bodies pertaining to farm (natural and/or constructed basins)

☐ Surface water bodies outside the farm (lakes, rivers, streams)

☐ Groundwater bodies within or close to farm boundaries (aquifer, spring wells)

☐ Other sources *(please specify)*

☐ Don't know

Which are the prevailing irrigation methods? Multiple answers possible.

☐ Surface irrigation (basin / border / furrow irrigation)

☐ Flooding irrigation

☐ Sprinkler irrigation

☐ Drip irrigation

☐ Sub-surface irrigation

☐ Other *(specify)*

☐ Don't know

Is there any subject (authority, board, collective entity, partnership, …) responsible for the management and the supply of irrigation water to farmers?

☐ Yes

☐ No

☐ Don't know

Please describe its role, governance and services provided (incl. water tariff systems)

Does any water drainage system exist in the reference area?

- ☐ Yes, for rainwater only
- ☐ Yes, for irrigation water only
- ☐ Yes, for both rainwater and irrigation water
- ☐ A previous drainage system is currently abandoned or underutilized
- ☐ No drainage system is currently implemented
- ☐ Don't know

If *YES*, please answer the following questions:

Which are the dominant types of drainage systems?

- ☐ Field (internal) system
- ☐ Main (external) system
- ☐ Mixed
- ☐ Surface system
- ☐ Subsurface system
- ☐ Natural drainage
- ☐ Artificial drainage
- ☐ Gravity systems
- ☐ Pumping systems
- ☐ Don't know

Who is responsible for the construction, management and maintenance of the drainage system?

TOP ISSUES

What each CS leader identifies as the "top" issue in the basin?