



Deliverable D1.6

Manuscript and policy briefing
evaluating success of large
landscape-scale restoration

Imprint

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MERLIN Key messages

1. **MERLIN monitoring confirms that well-designed Nature-based Solutions can deliver substantial environmental, social, and economic benefits, directly supporting European Green Deal objectives including biodiversity, climate resilience, and sustainable development.**
2. **Systemic, structured monitoring is essential for scaling restoration efforts. MERLIN's approach provides decision-makers with the evidence needed to adjust interventions, allocate resources strategically, and ensure long-term effectiveness.**
3. **All 18 case studies completed structured reporting across Peatlands & Wetlands, Small Streams & Basins, and Large Transboundary Rivers, enabling comparative evaluation across landscape types and informing targeted governance responses.**
4. **Environmental outcomes were most robustly reported, particularly Biodiversity Net Gain and Climate Regulation. Gaps in socio-economic and sectoral criteria highlight the need for stronger integration of these dimensions into monitoring and planning.**
5. **A traffic light scoring approach combined impact direction and data confidence, providing a clear visual synthesis to support rapid decision-making and performance tracking.**
6. **High-confidence results were observed for Biodiversity Net Gain, backed by quantitative data such as 287 km of restored river stretches and 1,528 ha of rewetted or reconnected floodplain and wetland areas. Lower confidence for Zero Pollution and sectoral indicators signals priorities for improved data and methods.**
7. **Narrative insights complemented quantitative data in several cases, especially in complex settings. These enriched understanding of restoration outcomes and informed context-sensitive adaptation.**
8. **Trade-offs were reported, including temporary pollution increases and loss of agricultural land. Transparent identification of such tensions is critical for managing conflicts and aligning ecological restoration with socio-economic needs.**

MERLIN Executive Summary

This deliverable **assesses the monitoring data collected from 18 case studies within the MERLIN project**, which tested the systemic MERLIN Monitoring Framework to evaluate the impacts of Nature-based Solutions (NbS) for freshwater and wetland restoration. The framework integrates environmental, social, economic, and sectoral criteria from the European Green Deal (EGD), offering a comprehensive approach to assessing restoration outcomes.

The monitoring approach combined standardised reporting templates with a focused set of **Essential Restoration Variables**, ensuring consistency and comparability across diverse case studies. In general, the monitoring process was perceived to be **effective and well-supported with guidance and tools**, but a critical review of survey responses highlighted a number of recommendations for improvement. The data review shows strong reporting for environmental criteria, particularly Biodiversity Net Gain and Climate Regulation. Many case studies also provided substantial data for economic and social criteria, such as Green Growth, Health and Well-being and Inclusive Participation. Sectoral criteria, including Sustainable Energy, Sustainable Transport, and Circular Economy, were less consistently reported, often due to perceived irrelevance or resource constraints. Where direct data were limited, **narrative reports** from case study teams offered valuable **contextual insights**, especially in complex, large-scale transboundary river projects.

Data confidence varied across criteria. The strongest confidence was observed for Biodiversity Net Gain, backed by clear quantitative data such as the 287 km of restored rivers and 1,528 ha reconnected or rewetted floodplain or wetland/peatland areas. However, confidence was lower for Zero Pollution and Climate Regulation, where data were frequently modelled or incomplete, and for certain economic indicators where expertise or resources were lacking. Nonetheless, most case studies demonstrated positive impacts, particularly for environmental, social and economic criteria. Many case studies noted enhanced Health & Well-being through increased access to natural areas and active travel routes and job creation in implementation of measures.

Some **Trade-offs** were identified, particularly for **Farm2Fork and Zero Pollution** criteria. In some wetlands/peatlands projects, initial restoration activities led to short-term increases in pollutants due to sediment disturbance and changes in hydrology. Agricultural land conversion resulted in negative assessments for Farm2Fork in a few case-studies. The largest trade-off was reported for the Tisza Floodplain Rewetting Project in Hungary where significant improvement for biodiversity habitat required a 66% reduction in agricultural land to achieve. These trade-offs highlight the need to balance ecological restoration goals with socio-economic and sectoral considerations and to communicate these potential impacts transparently.

An **integrated scoring methodology and a traffic light visualization system** were used to synthesize and present the monitoring results. This approach provided a **clear and accessible overview of the magnitude and confidence of impacts** across case studies and criteria, supporting evidence-based decision-making. The findings confirm the broad potential of NbS to deliver multiple EGD goals, including climate resilience, biodiversity gains, and socio-economic benefits such as job creation and improved well-being.

For policy makers, the results underscore the importance of adopting systemic monitoring approaches that capture the multifaceted impacts of NbS. The evidence highlights the potential of NbS to generate **co-benefits across policy goals**, while also acknowledging the trade-offs and challenges that may arise. Long-term financing and monitoring capacity, improved technical support, and refinement of indicators and reporting templates will be essential to ensure sustained, high-quality data collection required for **adaptive management strategies**.

In conclusion, the **MERLIN monitoring results demonstrate that well-designed NbS interventions can provide significant environmental and social benefits, support economic development, and contribute to the EGD objectives**. Strengthening the systemic monitoring approach and addressing identified challenges will be key to scaling up NbS implementation and maximizing their contribution to sustainable development, especially climate and biodiversity targets.

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1 Introduction

1.1 General introduction

The European Green Deal (EGD) comprises a bundle of policy initiatives with the aim of implementing the United Nation's 2030 Agenda and the UN Sustainable Development Goals (European Commission, 2025). Referring to this, the implementation of Nature-based Solutions (NbS) is considered key to achieving the objectives of major EU policy priorities (European Commission, 2025).

Due to uncertainties of their outcomes, Nature-based Solutions will often benefit from an adaptive management approach, for which monitoring data are necessary to update management plans (Brears, 2020). Therefore, implementation of Nature-based Solutions should be accompanied by a solid evaluation approach, based on a robust monitoring and assessment process.

Besides understanding the impact of individual Nature-based Solutions, and improving their implementation, knowledge derived from impact monitoring is important for understanding the processes driving responses in key indicators, predicting the scale of implementation required to achieve desired outcomes, uncovering trade-offs between different policy goals (synergistic or antagonistic relationships) and developing strategies for upscaling of Nature-based Solutions. However, there is no consistent systemic approach with which to quantify the effectiveness of Nature-based Solutions on the wide range of benefits and disbenefits they could impact (e.g. Viti et al., 2022).

As a first step towards this, the MERLIN project produced a novel monitoring framework (MERLIN Deliverable D1.2 *New framework for monitoring systemic impacts of freshwater and wetland restoration actions*), for a broad systemic assessment of the impacts of restoration measures across 13 EGD policy criteria (Carvalho et al., 2022). This framework included indicators focusing on a range of policy criteria: environmental (Biodiversity Net Gain, Climate Regulation, Flood Resilience, Drought Resilience, Zero Pollution), social (Health and Well-Being, Inclusive Participation and Governance), economic (Circular Economy, Financing the Transition and Green Growth) and specific sectoral policies within the EGD (Farm to Fork, Sustainable Energy, Sustainable Transport). A small set of indicators covering these 13 policy criteria was selected as MERLIN Essential Restoration Variables. Additionally, guidance and standardised templates for reporting monitoring data were prepared for each criterion, to facilitate a consistent approach to reporting for application across 18 MERLIN restoration case studies.

At the Restoration Case Study level, a broad systemic assessment can be important for evaluating the effects of NbS on the primary goals of the measures whilst also identifying trade-offs and synergies between different criteria to inform stakeholder discussions and future upscaling opportunities. The MERLIN project was designed to provide an evidence and methodological legacy in this respect; that is, to shape and foster future decision making in NbS planning and upscaling across the 18 MERLIN Restoration Case Studies.

By September 2024, reporting was completed by all 18 case studies. We note that case studies continue to monitor, with many planning to monitor beyond the project end-date to evidence impacts over the longer term. This report represents a synthesis and critical review of the MERLIN Monitoring and Assessment Framework using data and information submitted by the 18 MERLIN case studies following over the first 36 month of the project. The main objectives of the report are to:

- (1) Evaluate a systemic monitoring approach, i.e. the practicality and success of implementation of the MERLIN monitoring framework, including the functionality of the reporting templates,
- (2) Review data across all indicators and categories submitted by the 18 MERLIN case studies by September 2024,
- (3) Conduct a synthesis analysis of submitted data including an assessment of the impacts of restoration with respect to specific goals of individual restoration measures,
- (4) Identify, using the 13 EU Green Deal policy criteria encompassed within the MERLIN Framework, synergies and trade-offs between criteria,
- (5) Provide recommendations on improving monitoring guidance and indicators through the learning gained from the widespread and diverse testing of the MERLIN Monitoring and Assessment Framework.

1.2 Target audiences

In the D5.1 *MERLIN Dissemination and Exploitation Plan* (Birk & Hering, 2022) six relevant target groups are specified for the whole project, which are the community of practice, communities and the general public, economic sectors, policy makers, investors and donors and the scientific community. Policy makers and the scientific community are identified as specific target audiences for deliverable D1.6. Accordingly, the target audiences for this deliverable vary from scientists, who are often primarily interested in scientific evidence, to decision makers (e.g. government officers, civil servants), who need precise and applicable evidence to support decision making. Thus, policy makers will be interested in understanding the broad benefits of NbS, and also the cost of implementation as well as co-benefits (i.e. jobs created, or income generated by the implementation of Nature-based Solutions). In addition, information on where submitted data were insufficient to draw clear conclusions on the impacts of specific restoration measures on policy goals is equally important.

The document is expected to be of interest also for members of the other four target groups. For example, practitioners tasked with implementing Nature-based Solutions in the field may be interested in technical aspect of the implementation process, examples of case-studies and the outcomes of specific measures. This is of particular timely interest as the recently adopted EU Nature Restoration Regulation, requires Member States to draw up national restoration plans and document the expected co-benefits of the planned restoration measures.

The general public may also be curious about a wide range of information, especially related to current environmental policy issues and the effectiveness of restoration activities to impact society and the economy. Members of the economic sectors and investors and donors may be interested in criteria related to economic impact indicators and sectoral policy impacts, as well as certain environmental criteria related to climate resilience, such as the potential for NbS to reduce the risks associated with floods and droughts.

1.3 Theory of Change – choice of primary indicators and evaluation of indicator response

The Theory of Change (ToC) offers a structured framework for understanding the causal relationships and assumptions that bridge project interventions with long-term goals. It examines how specific restoration measures lead to change, detailing the necessary steps and conditions to achieve the desired outcomes (Weiss, 1995). By tracing logical connections between activities, effects, and long-term objectives, the ToC considers available resources and system conditions as inputs, forming the basis for a qualitative narrative of a desired future. This serves as a critical component in developing restoration efforts that produce tangible, lasting impacts (Vogel, 2012).

The ToC thus serves as a pivotal framework for contextualizing indicator assessments within the specific NbS/restoration contexts of the evaluated case studies. The anticipated impacts aligned with the NbS objectives are to be examined against the evidence generated by monitoring activities, which are themselves assessed for their relevance to decision-making and potential need for adaptation. Together, the ToC and monitoring constitute integral components of a broader adaptive management strategy that is essential for effective NbS implementation. Accordingly, this deliverable presents the monitoring results in relation to the restoration impacts anticipated in the ToCs of the individual case studies (Chapter 4).

At a general assembly of the MERLIN project's consortium (26 February to 1 March 2024, Vienna, Austria) the implementation partners of 17 MERLIN case-studies collaborated with scientific partners to develop a ToC for each case study (CS18 Ervidel joined the project later). Through a supervised process, they identified challenges, mapped restoration measures, and linked anticipated positive and negative effects of these measures to the 13 Green Deal criteria, assessing both biophysical and socio-economic outcomes. Consequently, this process provided a baseline conceptual model for each case study, indicating which criteria are deemed relevant and expected effects (Pott et al., 2025).

2 Data reported

2.1 Overview of data provided by the Case Studies

All 18 case studies, which belong to three main clusters, delivered data relevant to 13 European Green Deal policy areas using the standardised reporting forms (*Table 1*).

Table 1 - Case study numbers, their short names and country codes and the associated clusters.

CS No.	CS Short name and country code	Cluster
CS01	Kvorning wetland rewetting DK	Peatlands and wetlands
CS02	Deba barrier removal ES	Small streams and basins
CS03	Beaver river engineering SE	Peatlands and wetlands
CS04	Room for the Rhine NL	Large transboundary rivers
CS05	Kampinos wetland rewetting PL	Peatlands and wetlands
CS06	Hutovo Blato peatland rewetting BiH	Peatlands and wetlands
CS07a	Danube floodplain restoration AT	Large transboundary rivers
CS07b	Danube sidearm reconnect HU	Large transboundary rivers
CS08	Danube floodplain reconnect RO	Large transboundary rivers
CS09	Tisza floodplain rewetting HU	Large transboundary rivers
CS10	Blue Belt Germany DE	Large transboundary rivers
CS11	Emscher basin restoration DE	Small streams and basins
CS12	Lima floodplain forest restoration PT	Peatlands and wetlands
CS13	Sorraia river restoration PT	Small streams and basins
CS14	Komppasuo peatland rewetting FI	Peatlands and wetlands
CS15	Tzipori basin restoration IL	Small streams and basins
CS16	Upper Scheldt restoration BE	Small streams and basins
CS17	Forth basin restoration UK	Small streams and basins / (Peatlands and wetland)
CS18	Ervidel river restoration PT	Small streams and basins

Note: CS17 is associated with both the ‘small streams and basins’ and the ‘peatland and wetlands clusters’, but data were only delivered for ‘small streams and basins’.

Using the reporting templates, altogether, more than 8,000 data records were delivered by the case studies. Not all case studies, however, delivered data for all 13 EU Green Deal criteria, because some criteria were

considered not relevant by individual case studies (e.g., sustainable transport was not relevant for many case studies as they were not dealing with navigable water bodies) (*Table 2*).

Table 2 - Overview of the reporting of data using the reporting templates for the 13 EU Green Deal criteria by the Case Studies.

Case Study	Biodiversity Net Gain	Climate Regulation	Flood Resilience	Drought Resilience	Health & Well-Being	Zero Pollution	Farm to Fork	Sustainable Energy	Sustainable Transport	Inclusive Participation and Governance	Circular Economy	Financing the Transition	Green Growth
CS01	x	x	x	x	x	x	x	x		x		x	x
CS02	x	x	x	x	x	x		x		x			
CS03	x	x	x	x	x	x	x			x	x	x	x
CS04	x	x				x	x						
CS05	x	x	x	x	x	x				x		x	x
CS06	x		x	x	x			x	x	x	x	x	x
CS07a	x	x										x	x
CS07b	x	x	x	x		x	x		x			x	x
CS08	x	x	x	x	x	x				x		x	x
CS09	x	x	x	x	x		x			x	x	x	x
CS10	x	x	x	x	x	x	x		x	x		x	x
CS11	x	x	x	x		x	x	x		x		x	x
CS12	x	x	x	x	x	x	x	x		x	x	x	x
CS13	x	x	x	x	x	x	x			x	x		x
CS14	x	x	x	x	x	x				x		x	x
CS15	x		x	x	x	x	x			x	x	x	x
CS16	x	x	x	x	x	x	x	x	x	x	x	x	x
CS17	x	x	x	x	x	x	x	x	x	x		x	x
CS18	x	x	x	x	x	x	x			x	x	x	x

Note: x - Data was reported for the criterion.

Moreover, several case studies reported data on more than one site. For example, for some criteria data were reported for sites with restoration measures implemented in the frame of the MERLIN project (so-called *implementation sites*), but for other criteria data were reported for sites where the restoration measures were carried out before the MERLIN Project (so-called *demonstration sites*). In addition to this, three cases also reported data for control sites to compare with their implementation sites.

The amount of data reported differed strongly between the individual criteria (Figure 1). By far the most datasets were reported for the Biodiversity Net Gain criterion, with comparatively high number of data being reported for Zero Pollution and Inclusivity. Low data reporting was observed for Sustainable Energy and Circular Economy criteria. For Climate Regulation, a modelling approach was used for which the necessary data were collected from all case studies.

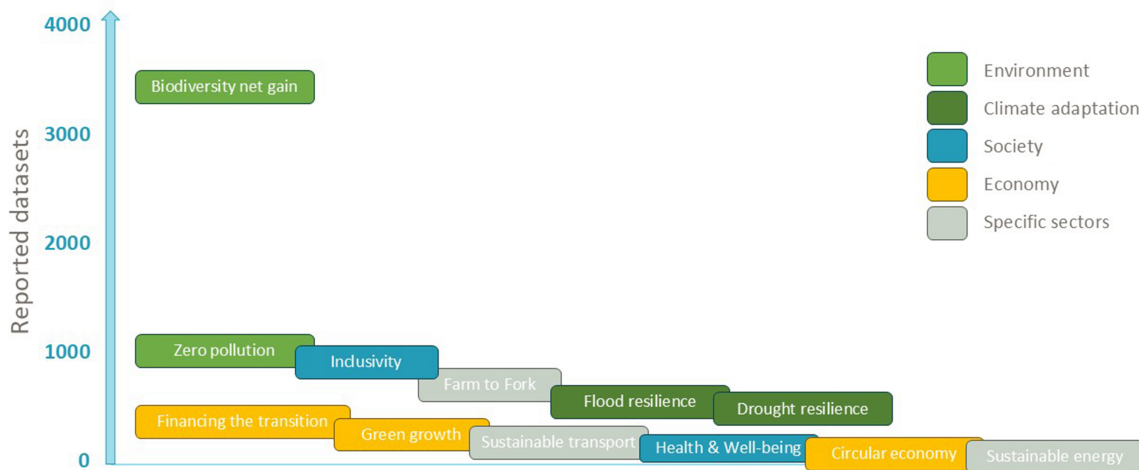


Figure 1 - Intensity of reporting on the criteria (criteria divided into those focusing on environmental aspects, society, economy or specific economic sectors; the Climate Regulation criterion is not included in the figure, because a modelling approach was used).

Narrative reports were requested from case study reporting teams to supplement their data submissions. These were commonly submitted from case studies of the Large Transboundary Rivers Cluster, where large, long-term restoration projects make it difficult to assign impact to specific individual measures, but allow for the development of narratives around the whole restoration programme across a large landscape over many years. Where appropriate, information provided by Narrative Reports were used to supplement the findings based on the data submitted.

2.2 Roles and responsibilities in the data evaluation

The implementation of the MERLIN Monitoring Framework, whose results are the focus of this deliverable, is characterized by clearly defined roles and responsibilities. Each *Case Study Reporting Lead*, typically the scientific partner in the respective case study, was responsible for acquiring, collating, and ensuring the quality of monitoring data, as well as submitting it via the designated monitoring templates to the Criterion Assessment Leads. The *Criterion Assessment Leads*, who are the primary authors of this deliverable, were tasked with verifying the quality of the data submitted for their assigned EGD criterion, develop and apply individual impact assessment methods, and conducting assessments in accordance with the aggregated scoring methodology.

3 Integrated impact across EGD goals

In this chapter we provide an integrated assessment of the impacts of restoration measures across the 18 MERLIN Case Studies and across the 13 EGD Criteria. A common scoring framework was applied to develop methodologies for each indicator based on strength of confidence in the evidence provided and direction of impact response using the monitoring data reported by case studies. An aggregated scoring methodology was then applied to produce simple and visual impact ratings at the criterion level, for each case study. The resulting data were visualised using a ‘traffic light’ system allowing comparative assessment of impacts across EGD Criteria and case studies. This assessment is outlined below with a focus on identifying patterns and potential interactions in impacts across EGD Criteria and case study clusters.

Narrative reports were requested from Restoration Case Study Reporting Leads to provide context for the aggregated assessment approach described above. However, at the time of review, many case studies—particularly the Implementation Case Studies—were still engaged in reflection and interpretation, making the request premature.

Here, we present a synopsis from one Restoration Demonstration Case Study where assessment interpretation had progressed further: Case Study 09 – the Tisza Floodplain Rewetting Project in Hungary, part of the Large Transboundary Rivers Cluster. This synopsis provides an overview of the perceived interactions among restoration impacts across the EGD Criteria (e.g., synergies and trade-offs) and illustrates how these insights have informed the Regional Scalability Planning process.

3.1 "Traffic light system" for analysis of the indicators and criteria

Due to the specific characteristics of the criteria and their indicators, individual impact assessment methods were developed by the Criterion Assessment Leads. These methods are detailed for each criterion in Annex 1. The methods were applied consistently, with each Criterion Assessment Lead responsible for collating monitoring data in a standardized manner. To ensure consistency and minimize error, a single assessor conducted the assessment for all case studies within a given criterion.

Each Criterion Assessment Lead assigned a score for the response observed in the reported data (i.e., positive, negative, or no change) and a score for the strength of evidence supporting the assessment (Box 1). These scores provided consistency across assessments. The indicator scores were then compiled and summarized, as presented in Annex 2. This initial scoring underwent expert peer review by the Case Study Reporting Leads, who provided revisions along with supporting rationale.

A standardized methodology was developed to enable Criterion Assessment Leads to aggregate individual indicator scores into an overall criterion score, as outlined in Box 2. Case Study Reporting Leads were again consulted on the aggregated scoring results. In cases where a decision was made to weight the indicator scores (i.e., following Option 2 in Box 2), this was noted in Annex 2 with a clear rationale.

Box 1 – “Traffic light system” for assessing the impact of restoration measures*Negative impact:*

-  - Clear evidence of deterioration, supported by consistent numerical data or well-defined negative narratives.
-  - Indications of deterioration, but data are somewhat ambiguous (e.g. negative trend with fluctuations) or narratives are vaguely negative.

No impact/irrelevant impact:

-  - No detectable change, with stable numerical data and explicit narratives confirming the absence of change.
-  - No significant change, but this is conveyed through less precise or more cautious narrative wording (e.g. "no significant impact").

Positive impact:

-  - Clear evidence of improvement, supported by consistent numerical data or well-defined positive narratives.
-  - Indications of improvement, but data are somewhat ambiguous (e.g. positive trend with fluctuations) or narratives are vaguely positive.
-  - Effects cannot be assessed yet, either due to lack of data or because confirmation is currently not possible.
-  - Effects remain uncertain, with narratives that are vague or inconclusive).

No data. NA - Indicator is not relevant to that CS or data was not reported for other reasons.

Box 2 - Indicators-to-criterion aggregationN = 1 indicator

→ *The assessment of the indicator is directly taken as the assessment of the criterion.*

N > 1 indicator

- If all indicators yield the same result
→ *The criterion assessment is the same as the shared indicator assessment.*
- If indicators yield different results

Option 1: All indicators are weighted equally.

→ *Calculate a weighted average, assigning numerical scores to each assessment, using these scores:*

- : +1.0; : +0.5; : -1.0; : -0.5; : 0; : 0; : not counting (=excluded from calculation); : not counting (=excluded from calculation)
- The resulting average is then classified as follows: >0.5 to 1: ; >0 to 0.5: ; 0: Special case (see below); <0 to -0.5: ; <-0.5 to -1: 
- Special case: Individual indicators all yellow =  or  (depending on majority of  or , where 50:50 → ; where 50:50 red:green transparent OR 50:50 red:green full:  or 

Option 2: Indicators are weighted differently, depending on:

- Their relevance to the type of restoration measure.
- Their alignment with the intended impact (as defined in the *Theory of Change*; Pott et al., 2025).
- Any other justified expert judgment.

→ *Exclude indicators that are irrelevant or inappropriate for the specific case. Then proceed as in Option 1 above.*

3.2 Analysis of impact across criteria

A detailed description of the assessment of the data reported for the indicators of the individual criteria, including an aggregated assessment of the criteria, is provided in Annex 2.

Table 3 summarises the assessment of impacts for the 13 EU Green Deal criteria across the 18 case-studies.

Some clear patterns in responses are evident in the aggregate criteria scores:

Frequency of reporting and relevance of EGD Criteria

High amounts of data were reported for most environmental policy criteria (except Zero Pollution) and two of the economic criteria (Financing & Green Growth), with relatively lower levels of reporting for sectoral criteria (Transport, Energy and Farming) and Circular Economy, which were often considered not relevant to many case study restoration measures in their *Theory of Change* analysis (Table 3, Table 4). There was also good reporting for the social criteria of Health and Well-being and Inclusivity, which were considered widely relevant. This is elucidated further in the survey of case study reporting teams in Chapter 4, where sometimes perceptions of relevance for several socio-economic criteria were lower than for the biodiversity and climate environmental goals. The results highlight that, in many cases, data on social and economic impact could still be gathered irrespective of initial opinions on relevance. This was particularly true for the large, transboundary river Case Studies, which rarely considered any of the economic criteria relevant, yet were able to consistently report positive impacts on Green Growth and Financing the Transition. This shows the importance of including such indicators in monitoring programmes of restoration projects so an evidence-based can be built-up to document these positive economic benefits. Despite indicating relevance of some criteria in their *Theory of Change*, a small proportion of sites were typically unable to report data for some of these criteria. Whether this highlights a lack of resources or a lack of expertise (e.g., in Greenhouse gas emission monitoring) in their monitoring programmes is unclear. This was most obvious for Zero Pollution, which was considered relevant for 16 Case Studies but only 8 reported data and three of these (all peatland/wetland restoration projects) reported negative impacts (increases in pollution). These negative impacts could potentially be a result of the limited short-term monitoring data reflecting initial pollutant impacts following catchment disturbance on Dissolved Organic Carbon levels in surface waters.

For the less relevant sectoral criteria—Sustainable Energy and Sustainable Transport—when data were reported and deemed relevant by the case studies, the impacts were generally positive. However, many case studies did not report data, despite considering these criteria relevant.

Confidence of reported data

Confidence was based on the form of data (quantitative more confident than qualitative), the amount of data (more years pre- and post-restoration) and the certainty of the reporting (e.g., areas restored was certain, changing condition was uncertain if only 1 year of data was available). The precise balance of these was different for each indicator and was based on expert opinion of the Criteria Assessment leads and checking with Case Study Reporting leads. Of the 13 criteria, confidence in the reported data (visualised by the solid faces;

Table 3

, Table 4) was highest for Biodiversity data (quantity of habitat restored) with climate resilience criteria and green growth (jobs created) also reported with high confidence. The lowest confidence (visualised by the open faces,

Table 3

, Table 4) was for Climate Regulation where most case-studies modelled impacts based on water level or water quality data and had no measurements to validate these modelled results. The data reported for Zero Pollution and Financing criteria were also quite uncertain.

Impacts of measures

The results show very clear positive effects of the NbS measures on most environmental criteria (except zero pollution) and two economic goals and on increasing inclusivity, with most Case Studies having confidence in their evidence for these criteria too. This is unsurprising, as NbS measures in the MERLIN case studies were designed to restore biodiversity while simultaneously addressing societal challenges—particularly those related to flood and drought resilience.

All case studies were assessed as having a positive impact with a high degree of confidence on **Biodiversity Net Gain**. This is consistent with the fact that all case studies considered this a relevant criterion and successfully achieved the target increase in area of habitat restored (biodiversity quantity) through the implementation of NbS. In total, 287 km of free-flowing river were restored, including reconnecting rivers with their floodplains (Danube, Emscher, Ervidel, Kvorning, Rhine and Scheldt) and removal of barriers to restore flow continuity (Deba, ES). However, the response for the indicators of biodiversity quality is more nuanced. In many cases both pre- and post-restoration data on indicators of biodiversity were not reported or consisted of only 1 year before or after restoration, making impact assessment too unreliable to use in this synthesis. Evaluation of impacts on indicators of biodiversity quality (species and habitat condition and WFD status) were available over several pre- and post-restoration years for a few case-studies, and these are illustrated further in Annex 2. One of the best long-term series for the River Tisza floodplain restoration are detailed in Section 3.3 and Annex 2.

Both **Zero Pollution** and **Farm to Fork** Criteria were assessed as having negative impacts for some clusters. In the Peatland and Wetland Cluster three of the case studies were assessed as having negative impacts reported for **Zero Pollution**, albeit with low levels of confidence. We note that few studies considered Zero Pollution as a relevant restoration objective. The reasons behind these negative impact assessments are variable and include mobilisation of sediments and silts during the implementation of restoration measures and changes in nutrient concentrations because of changes in connectivity. For **Farm to Fork**, the reasons behind the negative impacts are likely clearer; that agricultural land has been converted to habitat for biodiversity (see Section 3.3). For example, losses were high in percentage terms for the Tisza (66%) and Lima (38%) case studies. The Tzipori case study reported a loss of 100% of its agricultural land, although this was only a small area in absolute terms (one hectare).

The picture was similar for **Flood and Drought Resilience** where in many cases these two criteria were related. Indeed, we provide a joint analysis of the impacts of flood and drought indicators in Annex 2. For example, when restoring floodplains in the Large Transboundary River Cluster or restoring peatlands in the Peatland and Wetland Cluster results in an increase in water storage then this logically leads to positive interactions with Floods and Drought Resilience Criteria, even though the primary aim was Biodiversity Net Gain. The 8 MERLIN case-studies restored 1528 ha of floodplains. This is approximately the area of 12,200 Olympic-size swimming pools, which gives some illustration of the value these NbS measures provide to increase the resilience of communities to flooding.

In terms of benefits to **Climate Regulation**, rewetting of peatlands raises water levels towards the surface, which reduces peat degradation and consequently reduces CO₂ emissions, delivering benefits for climate regulation. Of the six peatland and wetland case studies, two (CS5 and CS14) reported positive impacts of rewetting on either measured GHG fluxes, or water table depths within the peat, allowing estimation of the reductions in GHG fluxes. This reduction in CO₂ emissions, and associated C sequestration, following rewetting is a well-established benefit of peatland rewetting (e.g. Koch et al., 2023), even though in the short to medium term the functioning of restored peatlands may not mirror that of natural sites (e.g. Loisel & Gallego-Sala 2022, Kreyling et al., 2021). In the Small Streams and Basins Cluster the restoration measures trialled and reported on have been primarily around floodplain reconnection and restoration of riparian habitat, except for one case study (CS02) who focused on the removal of in-stream obstacles (weirs). Five of the case studies reported an increase in the area of floodplain following restoration, meaning that the carbon stock in these systems is modelled to increase by 0.3 – 0.6 t C ha⁻¹ yr⁻¹ over 20 years. It should be noted that these are modelled projections and none of the restoration sites had direct measurements of changing soil carbon stock in the new floodplain soils. Across the Large Transboundary Rivers Cluster GHG emissions reductions were not listed as a priority for any of the restoration measures but the restoration actions reconnecting rivers with the floodplain are projected to increase carbon storage in soils through the changing land use in those case studies where an increased floodplain area has been reported (i.e., CS7b, CS09, CS10).

Most case studies reported on the **Health and Well-being** Criterion. Of note is the generally positive impact reported for the Small Streams and Basins Cluster, mostly with a high degree of confidence relative to other clusters. Six case studies reported an increase in length of active travel routes within or connected to the

restoration area, whereas some other six case studies reported no increase. The large-scale restoration case study CS11 (Emscher basin restoration DE) reported by far the highest value with more than 100 km. In other case studies between 7 and 27 km were restored. Several case studies reported on these indicator using narratives. A high proportion of case studies reported a positive influence of the restoration measure on features supporting well-being and/or aesthetic attractiveness of the environment (10 x improvement, 2 x no change) and features supporting access to restored natural environment (7 x improvement, 2 x no change). A lower proportion reported a positive increase in nature-based activities supporting Health and Wellbeing (7 x improvement, 4 x no change). Many case studies indicated no influence of the restoration measure on changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents, but two case studies reported an improvement, and the Tisza floodplain restoration reported a negative impact due to increasing occurrence of mosquitoes.

The **Inclusive Participation and Governance** indicator was designed to reflect the Aarhus Convention Pillars – informing, consulting, and engaging – across both physical and virtual spaces, using simple descriptive statistics to allow comparison across case studies and over time. Overall, 17 case studies submitted the reporting for this indicator. In terms of participants' visits to websites (IG1), many case studies reported more than 150 website visitors. The Large Transboundary Danube River (RO) project website had very high traffic, recording over 300,000 visits. Notably, the River Emscher also had exceptionally high online traffic (140,163), and CS14 (Komppasuo) and CS12 (Lima) each had over 1,000 visits, making them standout cases of the peatland/wetland restoration case-studies. Participation in information sessions (IG2) is an even more active measure of inclusivity, the Peatlands and Wetlands Cluster saw consistently high turnout, with four case studies reporting strong participation with CS12 (Lima) standing out with 1,571 participants. The Small Streams and Basins cluster also showed solid engagement in three sites, with CS15 (Tzipori) notably attracting 1,450 participants. In contrast, the Large Transboundary River case-studies reported limited in-person engagement, with only two reporting modest attendance. Indicators IG4-IG11 generally measured the different forms of engagement undertaken to enhance inclusivity. All case studies had online information (IG4) available by at least Year 3 of the project and only four lacked it in the pre-MERLIN or first year. CS15 used alternative channels like community groups and newsletters, showing adaptive approaches. Signage onsite (IG5) was less common, indicating stronger digital communication approaches across the case studies. Only nine sites reported formal public consultations (IG7), and just seven did that during MERLIN years, three of which did so consistently. Given that there was limited involvement of community groups reported as participants in case study boards (IG3), inadequate number of formal public consultations suggests fewer channels for broader public input. Citizen science (IG8) could have been another channel for the involvement of the general public, but this was reported by only three case studies, with CS15 (Tzipori) maintaining it over three years.

Fifteen case studies reported on six individual indicators of the **Financing the Transition** Criterion (Annex 2). An expanded data report is included in Annex 1 for Case Study 09 to exemplify the complexity of the finance landscape faced by restoration practitioners accompanied by a summary of the key points raised by this Case Study Reporting Team in their Narrative Report. Case Study 09 – The Tisza Floodplain Rewetting Project, Hungary, was the only case study to provide a Narrative Assessment Report on this criterion. Reporting across indicators and years was highly variable limiting the scope of synthesis analysis. Case Study 09 reported the longest time series of data across multiple indicators (including annual data across restoration year (RY) range -4 to +21) whereas three Case Studies provided data from only one year. One exception was the Emscher River basin where the percentage of public financing for the restoration financing was reported across a longer range of years but where the case study was split into three component parts. For the Emscher, the data reported indicated that the proportion of financing from public funds was 100% for all years. However, the Emscher represented the single largest restoration investment reported across all case studies at a total of €408 million. The total restoration budget reported on all activities (FI2) and across all case studies was €466 million, with 97% of this value being represented by the Small Stream and Basins case-studies which included the Emscher. When the Emscher was removed from the FI2 data, the average restoration budget reported across the remaining case studies was €5.2 million. The proportion of public finance contribution to the restoration budget was on average 50% for the Large Transboundary Rivers case-studies, 83% for the Peatlands and Wetlands case-studies, and 79% for Small Streams and Basins case-studies. Two case studies reported securing an upscaling budget in the latter years of the MERLIN Project; the Tisza floodplain securing 30% and the Forth Basin at 85% of the estimated required budget for upscaling.

For **Green Growth**, several case studies successfully created jobs attributable to the restoration activities. By far the highest number of jobs, more than 48,000, were created in the Emscher basin restoration, due to the large spatial and long-term nature of this case study. For scale, the next highest job creation reported was for

Tzipori at about 225 jobs. The number of jobs attributable to restoration outcomes were roughly about a tenth of those attributable to restoration actions.

Synergies and trade-offs

Most projects reported positive impacts of the restoration on environmental, social and economic criteria. The only trade-offs apparent between criteria were for Farm2Fork where land available for agricultural production declined in a few Case Studies and for Zero Pollution indicators for peatland and wetland restoration projects, although the latter may be a short-term response to implementing restoration measures.

Table 3 - Aggregated assessment of impact monitoring results reported by the 18 case studies for the 13 EU Green Deal criteria. The background colour of the cells corresponds to the Theory of Change categories: dark blue indicates a primary restoration goal, medium blue a secondary goal, light blue a restoration co-benefit, and white denotes not relevant.

Case Study 18 did not provide any information on the Theory of Change. NA=not applicable.

Case study	Biodiversity Net Gain	Climate Regulation	Flood Resilience	Drought Resilience	Health & Well-Being	Zero Pollution	Farm to Fork	Sustainable Energy	Sustainable Transport	Inclusive participation	Circular Economy	Financing Transition	Green Growth
Peatlands and wetlands													
CS01 – Kvorning wetland rewetted DK	😊	NA	😊	😊	😊	NA	NA	NA	NA	😊	NA	😊	😊
CS03 – Beaver river engineering SE	😊	😐	😊	😐	😊	😐	NA	NA	NA	😊	😐	😊	😐
CS05 – Kampinos wetland rewetted PL	😊	😊	😊	😊	😐	😊	NA	NA	NA	😊	NA	😊	😊
CS06 – Hutovo Blato peatland rewetted BiH	😊	NA	NA	NA	😊	NA	NA	😐	😊	😊	😐	😊	😊
CS12 – Lima floodplain forest restoration PT	😊	😊	😊	😊	😐	😐	😐	😊	NA	😊	😊	😊	😊
CS14 – Komppasuo peatland rewetted FI	😊	😊	😊	😊	😊	😐	NA	NA	NA	😊	NA	😊	😐
Small streams and basins													
CS02 – Deba barrier removal ES	😊	😊	😊	😐	😊	😊	NA	😊	NA	NA	NA	NA	NA
CS11 – Emscher basin restoration DE	😊 _a	😊	😊	😊	😊	😊	NA	😊	NA	😐 _a	NA	😊 _b 😊 _c 😊 _d	😊

CS13 – Sorraia river restoration PT	😊	😐	😊	😊	😡	NA	NA	NA	NA	😊	😊 ₁₈	NA	😊
CS15 – Tzipori basin restoration IL	😊	😊	😊	😊	😊	NA	😡	NA	NA	😊	NA	😊	😊
CS16 – Upper Scheldt restoration BE	😊 _f	😐	😊	😊	😊 _e 😊 _f	😊 _e	😐 _e	😐 _e 😐 _f	NA	😊	😐	😊	😊 _e 😊 _f
CS17 – Forth basin restoration UK	😊	😊	😊	😊	😊	NA	😐	NA	😐	😊	NA	😊	😊
CS18 – Ervidel river restoration PT	😊	😊	😊	😊	😊	NA	NA	NA	NA	😊	😊	😊	😊
Large transboundary rivers													
CS04 – Room for the Rhine NL	😊	😐	NA	NA	NA	😊	😐	NA	NA	NA	NA	NA	NA
CS07a – Danube floodplain restoration AT	😊	😐	😐	😐	NA	NA	NA	NA	NA	😊	NA	😊	😊
CS07b – Danube sidearm reconnect HU	😊	😊	😊	😐	NA	NA	😐	NA	NA	NA	NA	😊	😊
CS08 – Danube floodplain reconnect RO	😊	😐	😊	😊	😊	😐	NA	NA	NA	😊	NA	😊	😊
CS09 – Tisza floodplain rewetted HU	😊	😊	😊	😊	😊	NA	😡	NA	NA	NA	😊	😊	😊
CS10 – Blue Belt Germany DE	😊	😊	😊	😊	😊	😐	😊	NA	😊	😐	NA	😊	😊

Note: More information regarding the study sites is provided in Annex 1. For case studies reporting data for a given criterion for more than one implementation site, the respective sites are denoted by lower case letters: a – Emscher basin-scale DE (CS11); b – Emscher Lake Phoenix DE (CS11); c – Emscher flood-basins DE (CS11); d – Emscher mouth DE (CS11); e – Riparian buffer strips BE (CS16); f – Zwalm restoration BE (CS16).

Table 4 - Summary of responses reported by the 18 case studies for the 13 EU Green Deal criteria.

Response	Biodiversity Net Gain	Climate Regulation	Flood Resilience	Drought Resilience	Health & Well-Being	Zero Pollution	Farm to Fork	Sustainable Energy	Sustainable Transport	Inclusive participation	Circular Economy	Financing Transition	Green Growth
Positive	19	11	16	13	13	5	1	3	2	13	4	16	16
No change	0	5	1	4	2	2	4	2		1	3		2
Negative	0	0				3	3			1			
Insufficient data		1							1				
NA or no data	0	2	2	2	3	9	11	13	16	4	12	3	2
Confident	19	1	12	13	10		8	4	2	11	5	7	13
Uncertain	0	16	5	4	5	10		1	1	4	2	9	5

3.3 Interactions across EU Green Deal Criteria: the Tisza Floodplain Rewetting Demonstration Case Study

We provide, here, a synopsis from one Restoration Demonstration case study where the assessment interpretation was at a more advanced stage – Case Study 09 - the Tisza Floodplain Rewetting Project, Hungary, from the Large Transboundary Rivers Cluster. In this synopsis we first provide an overview of the restoration process implemented and the rationale for the case study. The Case Study Reporting Leads then prepared narratives to provide context to each of the criteria assessed, and an overview of perceived interactions (e.g. detailed further in Annex 3) across them, which also considers the perceptions of stakeholders on the impacts achieved.

The Tisza Floodplain Restoration case study is a MERLIN Demonstration Site located near the village of Nagykörű on the Central part of the Tisza River, Hungary; the largest sub-basin of the Danube River Basin. The restoration activities for this Demonstration Case formed part of the LIFE00-NAT-A-7051 Project implemented between 2001–2005. The beneficiary was WWF Austria, the project partner was WWF Hungary. The main aim of this project was to restore and conserve floodplain-related habitats, targeting 5 sites, which are situated along the middle section of the Tisza River in Hungary, within the “Middle Tisza Landscape Protected Area”.

The results of the aggregated Assessment are provided (Figure 2) alongside an analysis of interactions between impacts of the restoration actions provided by the Case Study Reporting Team. The measures were assessed as having positive effects on Biodiversity Net Gain, Climate Regulation (with low confidence), Flood and Drought Resilience, Health and Wellbeing, Circular Economies and Financing the Transition. Negative effects were assessed to have resulted from the implementation of measures only for the Farm to Fork Criterion. A range of interactions were identified between criteria and the contexts underpinning these are introduced in the narratives below for relevant EGD Criteria.

Interaction 1. Stable funding essential for sustaining multiple benefits. Measures were implemented on altogether 392 ha in Nagykörű, Tiszajenő and Tizsakürt. The total budget was 435,326 EUR; the EC contribution was 217,663 EUR (50%). The project was also supported by the Federal Ministry of Agriculture, Forestry, Environment Protection and Water Management of Austria. The funding from the LIFE Project ceased in 2005,

and from 2008 the active management of the site changed, and some negative effects were reported across several criteria. These include inefficient control of the sluice leading to drying of the lake leading to reduced flood and drought resilience, ingress of invasive species, and a drop in public engagement activities which were viewed as important in achieving stakeholder buy-in. From 2019, after the termination of the regulated water retention and for other reasons, access to and around the site became difficult, and the number of visitors reduced. WWF Hungary restarted its activities here in 2019 and aims to make landscape rehabilitation based on water retention work effectively in the area again. To this end, it has attracted various sources of funding (e.g. WWF Netherlands, WWF Switzerland, the MERLIN Project, Coca-Cola Foundation, Pancivis Foundation). The long-term goal is to make the management of the area (i.e., grazing, maintenance of orchards, ecotourism, processing and trading of local products) profitable for local farmers.

Interaction 2 – Combined measures delivering simultaneous multiple benefits. At the core of this project is an interaction between two measures including the construction of a sluice to retain flood water within a low-lying riverbed area creating ‘Lake Anyita’ (approx. 30-60 hectares) and through vegetation management of a floodplain meadow (approx. 15 hectares) using physical cutting and the introduction of the native Hungarian Grey Cattle herd. The restoration measures over the period of a decade and a half have transformed land-use in the area (Figure 3). The measures have supported the establishment of vegetation and habitats close to natural floodplain conditions. Biodiversity Net Gains include for macroinvertebrates, native fish species (including Natura 2000 species, spined loach and European Weatherfish) but also invasive fish species, breeding populations of water frogs (*Rana esculenta*-complex), European fire-bellied toads, and the moor frog. The habitat supports breeding bird species including the ferruginous duck and mute swan, but the importance as a breeding habitat for waterfowl, generally, appears limited. The project restored the summer dyke and constructed a sluice to allow control of inflow and release of water, thus enhancing the Flood and Drought Resilience function of the area. The full capacity of the 263 hectares floodplain site is about 10 million cubic metres (about 4 Olympic size swimming pools). In the upper part of the restoration area, which was not subject to controlled flooding, about 3 ha of hay were grazed and occasionally mown, with a volume of about 5 m³. In 2013, hay from about 10 ha of was harvested in the riverbed for power plant utilisation. In addition, the Grey Cattle herd were used to control invasive vegetation resulting in inputs to the agricultural system through productive land management measures. Since the extremely dry year of 2012, the lake has dried out in summer impacting establishment of marsh vegetation. Consequently, undesirable species including false indigo-bush (*Amorpha fruticosa*) increased cover to about 80% of the site.

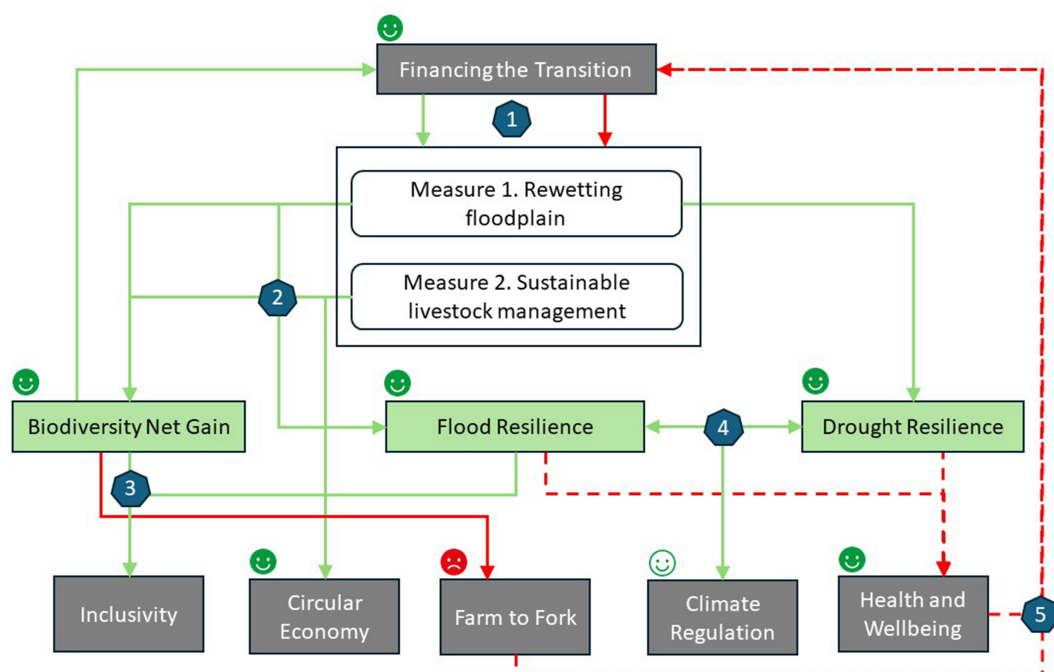


Figure 2 - Schematic diagram of the interactions inferred from available evidence for Case Study 09 - Tisza Floodplain Rewetting Project, Hungary. The diagram shows the two main measures implemented in the context of the target EU Green Deal Criteria (EGD) related to the restoration objective (green boxes). Secondary EGD Criteria are also included (grey boxes). The arrows indicate positive (green) or negative (red) interactions between the EGD Criteria, with interactions of low confidence denoted by a dashed line. The numbered heptagons are for reference to the interaction descriptions in the text.

Interaction 3. Bringing people to nature enhances inclusivity and reinforces restoration. Restoration increased access to nature and established routes for nature walks in the area. The restoration efforts received high media attention during the period of funding for the LIFE project (i.e. between 2001–2006). Highlights in the media included improved aesthetic condition for the public associated with grassland restoration and biodiversity conservation. However, the most popular news stories reaching national media were related to beaver reintroduction in 2004–2005. This media attention and increase in public awareness were important in underpinning negotiations with stakeholders who were initially reluctant to support restoration measures associated with the risk of loss of agricultural land. During the LIFE project (2000–2006), the wider restoration community were engaged through information forums, seminars and conferences were held regularly with the involvement of the municipality, local conservation and water managers. The improved accessibility of the site requires maintenance and following initial gains, access has declined in recent years.

Interaction 4. Floods, droughts, and climate regulation. The installation of the sluice allowed for controlled water retention following flooding of the Tisza above 600 cm, mainly in the winter-spring period. Between 2004 and 2008, the area was subject to regular, controlled water retention. Between 2009 and 2018, mainly due to the demands of local farmers, water releases were sporadic and only occurred in the spring-summer period. Since the extremely dry year of 2012, the lake has dried out in summer. The net greenhouse gas balance (NGB) of the restoration site was estimated by the process oriented biogeochemical model (BiomeBGC MuSo) for the past/present period. The floodplain restoration is predicted to have had a positive impact on NGB, where wetting increases biomass production and habitat condition leading to reduced greenhouse gas emissions and increased carbon sequestration. However, when in unflooded state, greenhouse gas emissions from the site

may increase and the site may become a net carbon source, which is more likely to have occurred in recent years due to inefficient management of water retention.

Changes in land cover before and after floodplain restoration at Nagykörű

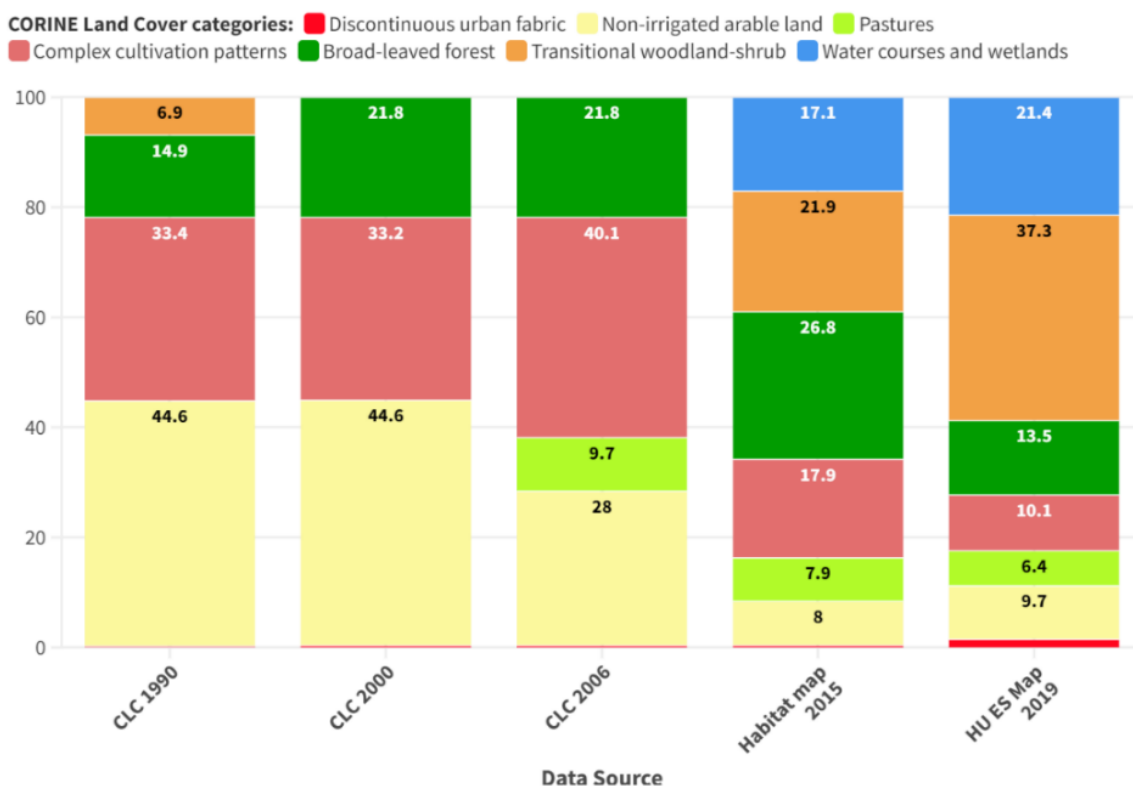


Figure 3 - Changes in land cover as percentage of total land cover in the restoration site before and after floodplain restoration at Nagykörű. Figure by Szilvia Ádám.

Interaction 5. Land-use change risks stakeholder dissatisfaction. Generally, the restoration project is perceived by stakeholders to have supported more sustainable agricultural practices and has reduced environmental pressures associated with flooding. However, some stakeholders consider the loss of agricultural land during water retention in Lake Anyita as a negative effect. There are no known water-related diseases or other water-related health issues reported in connection to the restoration impacts. However, there is a perception among some stakeholders that a lack of controlled water retention has led to occasional breeding of mosquitoes (Culicidae) in small, intermittent, warm pools, with some stakeholders calling for pest control in the area on public health grounds. These negative stakeholder perceptions can complicate planning for future restoration when project resources are low, public awareness raising efforts to counter perceptions or funding to gather evidence are limited, as recognised in the Regional Scalability Plan (Kajner et al., 2024).

Implications for the Regional Scalability Planning Process

As outlined further in Annex 3, consideration of the interactions identified above, and other information, formed an evidence base to inform the preparation of the Regional Scalability Plan (RSP) for the Tisza. Development of the Tisza RSP included input from a Case Study Board and following wider stakeholder workshops supported by the MERLIN Project in 2024. The conclusions of these discussions underpin most of the planned actions in the Tisza RSP.

The Tisza RSP has an ambition to chart a path towards developing sustainable water management and landscapes in the Tisza Plain, by 2050 (Kajner et al., 2024). A number of linkages and synergies were identified across enabling policy mechanisms that will support this vision including on integrating with basin-scale flood

alleviation programmes through water management, the review process of the Hungarian National Water Management Plan, the Hungarian 2nd National Climate Change Strategy, linking to the Common Agricultural Policy Strategy Plan, and inputting to WWF Hungary's Tisza 21 Concept. This RSP focuses on the lowlands of the Hungarian part of the Tisza River Basin.

Today the Tisza runs between flood protection dykes and has no connection with most of its former floodplains. However, there are at least 150,000 ha of deep floodplains (active and morphological floodplains, with active floodplains understood as hydraulically active inundated areas, and morphological floodplains as the combination of active and former (disconnected) floodplains, e.g. Eder et al., 2022), which could be safely reconnected to the river and used for floodplain farming. The long-term vision is to preserve and develop the natural floodplain river ecosystem along the Tisza River. If the vision is realised, measurable outcomes will include: increasing carbon sequestration in the Hungarian part of Tisza Basin by 15%; increasing the area of rewetted wetlands (other than peatlands) and the area of agricultural lands with schemes for water retention by 150,000 ha and 120,000 ha, respectively; increasing the economic value generated by agriculture in climate adaptation and water retention by 40%; attracting 2 million views of web-based information; all by 2050. Overall, the long-term impact will be to improve the ecological status of the Tisza Region, the livelihoods of its inhabitants and increase their resilience to climate change.

The Tisza RSP proposes 19 actions designed to deliver ambitions across ten EGD Goals by 2050. The estimated cost of implementing the actions is €20.5 billion, though given the timelines and scale of implementation this estimate has a low degree of confidence and will be subject to managing and monitoring a complex set of impact interactions.

4 Evaluation of the monitoring framework

The results presented in this chapter were drawn from a semi-structured questionnaire designed to evaluate the monitoring process within the MERLIN project. The questionnaire was divided into two parts (Annex 3). The first part focused on general feedback, capturing self-perception data and respondents' evaluations of key aspects of the monitoring process, including institutional setup, resource availability and adequacy, communication effectiveness, data acquisition processes, and the role of scientific evidence. The second part focusses on case study-specific questions, assessing the perceived relevance of the Green Deal criteria for monitoring restoration effects, the sources of data used for evaluating these criteria, and the level of effort required for data acquisition. Additionally, the suitability of spatial and temporal scales for selected indicators was examined. Only those Green Deal criteria and indicators that had been pre-selected based on prior monitoring efforts within the respective case studies were included in the questionnaire.

The questionnaire was distributed to all project partners who felt qualified to evaluate the monitoring process. The second part, containing case study-specific questions, was exclusively completed by individuals directly involved in data acquisition. To maintain a semi-anonymous approach, no personal identifiers were collected. Instead, respondents were categorized by their respective case study clusters and in the second part, also according to the specific case study of interest.

4.1 Reflection on the Monitoring Process

In this section the first part of the questionnaire is evaluated. Captured responses were used to reflect on key aspects of the monitoring process. A detailed breakdown of the response distribution is provided in Annex 4.

4.1.1 Implementation of the Monitoring Framework

Overall, the MERLIN monitoring framework received moderately positive evaluations, with respondents expressing general satisfaction (Q1.5, Ø3.7). The approach was considered suitable for assessing restoration measures in terms of goals, threats, and adaptations, achieving a strong and consistent rating (Q2.8, Ø3.9). However, the potential for integrating this framework into standard organisational practices obtained less consistent responses (Q1.6, Ø3.5), reflecting varying levels of perceived feasibility among participants.

The framework's capacity to enable adaptive management (Q1.3, Ø3.5) received moderate support, pointing to challenges in using the data for real-time project adjustments.

The MERLIN guidance documentation was generally positively reviewed, with the majority agreeing that it provided sufficient information (Q2.5, Ø3.8). Similarly, communication with the guidance developers was rated positively, albeit with slightly more variability (Q2.6, Ø3.9). This aligns with feedback indicating that the reporting templates were perceived as not very intuitive, highlighting the potential need for refinements in user support and documentation structure.

4.1.2 Monitoring Data

The quality of the collected monitoring data was generally rated positively (Q1.1, Ø3.7), and respondents felt the data effectively supported case-specific objective assessments (Q1.2, Ø3.6).

Though only 7% expressed concern that a BACI design might not deliver clear or actionable results, most case studies encountered challenges during implementation. Besides various logistical and technical barriers, the most common obstacles included the lack of baseline data (42%) and absence of suitable control sites (32%), both critical for establishing robust impact assessments. These hurdles highlight critical areas for methodological refinement.

4.1.3 Resource Availability

Resource availability for data delivery was rated adequate (Q1.4, Ø3.6), with funding similarly rated as sufficient (Q2.3, Ø3.6). Technical expertise was particularly well-regarded, receiving the highest score among resource-related questions (Q2.4, Ø4.2), indicating strong internal capabilities among participating organisations.

Internal expertise was the most used resource, supporting over 90% of the case studies. Access to databases, including governmental or research datasets, was also common (68%), alongside the utilization of IT

infrastructure (65%) like Geographic Information Systems (GIS) for data analysis and storage. In contrast, community participation, including e.g. citizen science approaches (29%) and formal policy or governmental support (16%) were less frequently available. Specialized resources like training and capacity building (6.5%), such as workshops, and laboratory facilities (3%) were rarely available, highlighting a strong reliance on internal capabilities and digital tools.

Long-term financial and operational capacity to maintain this monitoring framework post-project received a notably lower score (Q1.7, Ø2.6). This discrepancy between current resource availability and future capacity poses a challenge for the sustained integration of the MERLIN framework.

4.2 Indicator adequacy to detect spatial- and temporal-scale effects

The case studies provided important insights into how practical the monitoring framework was perceived. They assessed to what extent the indicators for each criterion were considered adequate in terms of spatial and temporal scale.

As shown in [Figure 4](#), most respondents considered the spatial scale of the indicators, and thus the related criteria, more suitable to evaluate restoration effects, than the temporal scale. While many indicators were rated adequate on the spatial scale, opinions on the temporal scale were more mixed. The spatial scale refers to the geographic scope at which data were collected for an indicator, while the temporal scale relates to the time frame over which monitoring occurred.

Indicators associated with environmental criteria were predominantly viewed as adequate concerning their spatial scale. The temporal scale presented a slightly more mixed but still overall positive perception of these criteria. For the social criteria, the spatial scale of the indicators received notably better evaluations relative to their temporal scale counterparts. The criterion Sustainable Food Systems was especially well-received, particularly on the temporal scale, with an 81% approval rating. Conversely, Circular Economy appeared as a criterion warranting improvement, as merely 32% of respondents on the spatial scale and 24% on the temporal scale regarded the associated indicators as adequate. Similarly, Sustainable Transport and Sustainable Energy showed moderate to weak approval across both scales.

Both the assessment of the spatial- and temporal-scale adequacy are positively correlated with the reported number of datasets for the individual criteria, but not statistically significant for the temporal scale (spatial scale: Spearman's $r_s = 0,72$, $p < 0,01$, $n = 12$; temporal scale: Spearman's $r_s = 0,53$, $p > 0,05$, $n = 12$).

The monitoring framework lacks precision regarding the temporal and spatial scale dependencies of the indicators. Incorporating such information more explicitly would significantly enhance the framework's practical value.

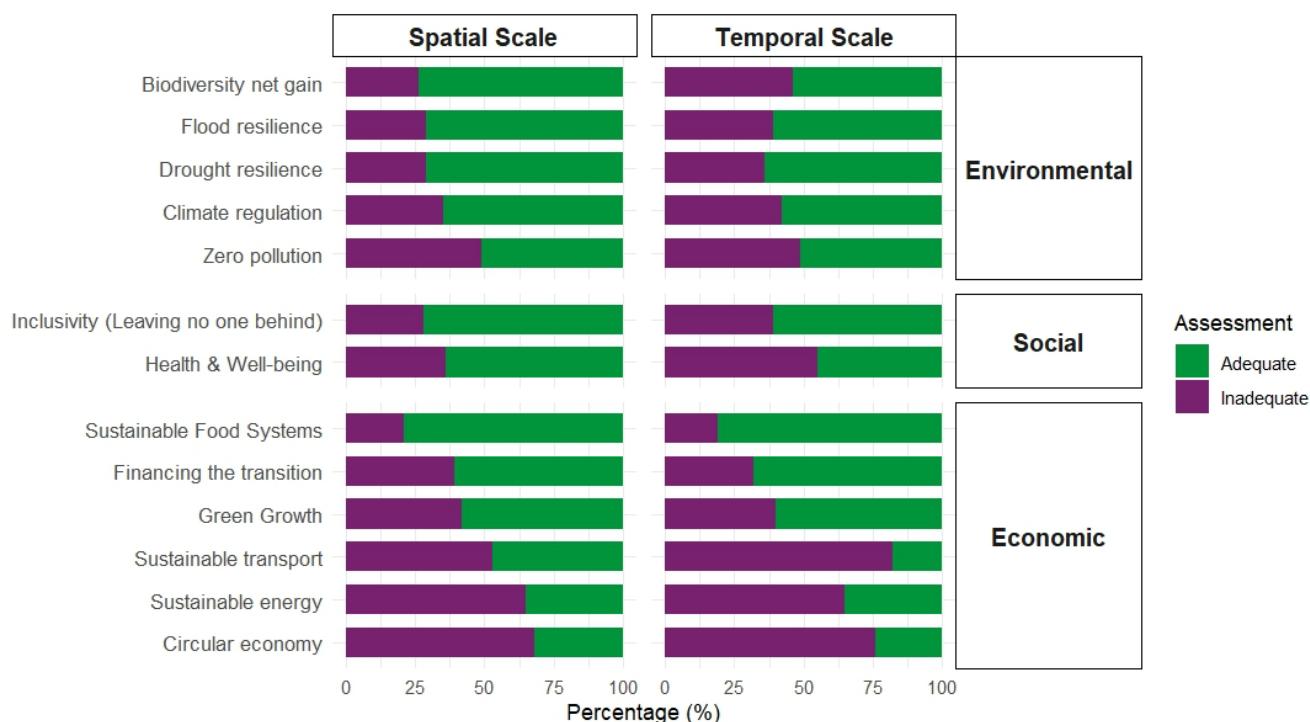


Figure 4 Evaluation of the spatial and temporal scales of the Green Deal criteria, as derived from the questionnaire survey. Responses for individual indicators were aggregated into an overall assessment for each criterion. The share of indicators rated as adequate (green) for capturing the effects of restoration is compared against the share rated as inadequate (purple).

4.3 Data availability and quality: environmental vs economic vs social indicator data

As indicated in Figure 1 (Chapter 2.1), in general, the case studies provided more data for green deal criteria with a focus on environmental policy aspects than those with a focus on socio-economic aspects. This result is corroborated by the questionnaire results (Figure 5), which indicate generally higher average relevance stated by the respondents for environmental criteria. There is a significant positive correlation of the reported number of datasets for the individual criteria and the average relevance (Spearman's $r_s=0,70$, $p<0,05$, $n=12$).

The comparison of perceived relevance and monitoring effort across the Green Deal criteria revealed several trends (Figure 5). Environmental criteria were generally perceived as both highly relevant and relatively laborious to monitor, indicating that while these factors were considered critical for achieving sustainability goals, they demanded substantial resources for effective evaluation.

In contrast, the indicators for most economic criteria and Health and Well-Being were rated as moderately relevant, with comparatively lower perceived monitoring effort. The criteria Inclusive participation and Sustainable food systems were clustered in the high-effort, low-relevance quadrant. Notably, no criteria fell within the high perceived relevance and low monitoring burden quadrant, underscoring a general trend toward increased monitoring demands for highly valued sustainability goals.

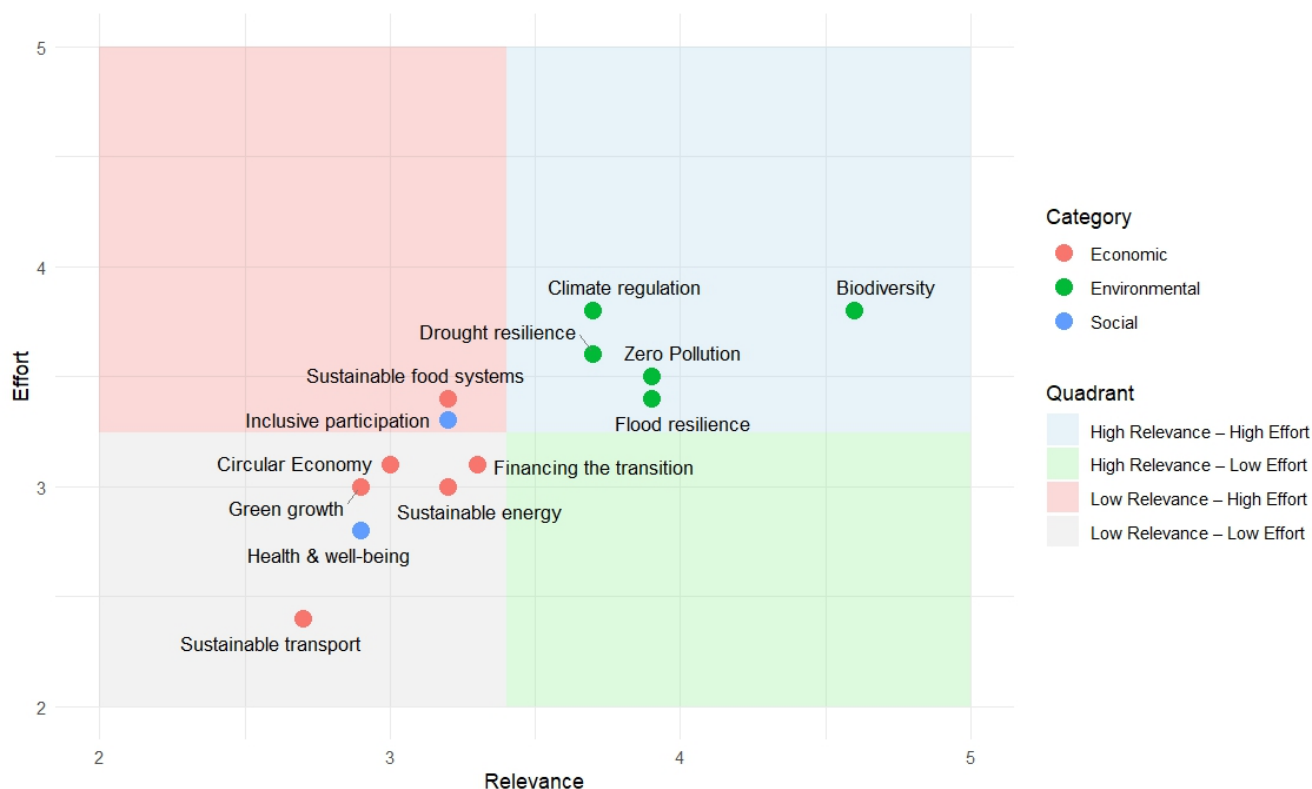


Figure 5 Classification of Green Deal criteria relevance and effort, derived from the questionnaire survey. Each dot represents a Green Deal criterion positioned according to its average perceived relevance and monitoring effort. The background quadrants indicate strategic priorities, highlighting where low-effort, high-relevance opportunities or high-effort challenges lie.

The results indicate that the monitoring framework does not clearly explain the relevance of the sectoral and socio-economic criteria and their indicators, which may explain why some of these criteria have fewer datasets reported.

4.4 Evaluation of individual indicators

The survey considered the adequacy of the MERLIN Essential Restoration Variables regarding the temporal and spatial scale according to the case studies (Table 5). For most of the indicators a high adequacy for both temporal and spatial scale was reported, which indicates that they are indeed important. However, as indicated in Table 5, two of them were rarely reported and two others are rather useful for assessing projects, but not for assessing the impact of implemented measures.

Table 5 - Adequacy of the MERLIN Essential Restoration Variables regarding the temporal and spatial scale based on the opinion of the case studies. Percent values specify the share of positive questionnaire survey replies.

Criterion	Variable	Adequateness – temporal scale	Adequateness – spatial scale	Comments
Biodiversity Net Gain	Conservation status and trend in habitat condition of HD Annex I listed habitats	55%	71%	

	Conservation status and trend of HD Annex II and IV listed species of community interest	58%	65%	
	Conservation status of Annex I listed (freshwater/wetland) species in the Birds Directive	44%	72%	
Climate Regulation	Greenhouse gas emissions	58%	65%	
Flood Resilience / Drought Resilience	Change in storage capacity (m ³) of restored rivers and streams (based on surface area of rivers, streams and other water bodies)	67%	74%	
	Change in storage capacity (m ³) of wetlands (based on surface area of restored wetlands and floodplains)	70%	85%	
	Safe discharge capacity of restored rivers and streams (m ³) (for large rivers and where recommended)	0%	50%	This indicator was rarely reported by the case studies.
Sustainable Food Systems (F2F) and Land Use	Land cover (ha/type)	93%	93%	
	Land use (ha/type) primary intended use and any secondary uses	82%	73%	
	Land tenure (public vs. private land) (ha for each type)	67%	67%	
Inclusive Participation and governance	Number of visitors to project website	65%	71%	
	Number of participants in information sessions about the project	59%	82%	
	Ability to join a formal stakeholder forum/board/working group	75%	69%	
Financing the transition	Breakdown of the total restoration budget by funding source and type [%]	65%	53%	This indicator is rather useful for assessing projects, but not for assessing the impact of implemented measures.
	Budget spent into the restoration activity by cost category (specified into management, digging, in-kind contributions, etc.) [€]	83%	75%	This indicator is rather useful for assessing projects, but not for assessing the impact of implemented measures.
	Private finance mobilized (€)	50%	50%	Low feedback, but it can be assumed that those case studies not answering did not mobilise private financing.
Green Growth	Jobs created attributable to restoration activities (jobs created by restoration activities directly)	69%	75%	

	implemented by the beneficiary and/or outsourced to contractors)			
	Jobs created attributable to restoration outcomes (e.g. jobs created by new recreation activities, new valorisation of biomass)	58%	58%	

During the analysis, a pattern emerged regarding the types of indicators that received the most positive evaluations for their scaling (Annex 4, Table 47). These were primarily indicators describing the physical extent of restoration efforts like area, length, and volume (e.g. BD5, BD6, FR9, and FR10). Similarly, indicators related to Visitor and Participation Structure (e.g. IG10 and GG4) were notably well-rated. Changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents (HWB6) and Fish density and species composition (ST7), also received particularly positive evaluations.

On this basis, the following indicators, which were assessed as being very adequate on the scales and reported regularly, might be considered to supplement the MERLIN Essential Restoration Variables:

- Area of floodplain re-connected (criterion: Biodiversity Net Gain)
- Rewetted area (criterion: Flood and Drought Resilience)
- Area of newly designated areas for flooding (spatial scale) (criterion: Flood Resilience)
- Farm structure (criterion: Farm2Fork)
- Do local residents feel positive about the MERLIN NbS and the impacts they are having on the local area? (criterion: Inclusive Governance)

It might be also considered to add indicators from the Health and Well-Being criterion.

5 Conclusions

The MERLIN project developed and implemented a monitoring framework for evaluating the broad systemic impacts of freshwater and wetland ecosystem restoration using NbS measures. This framework assesses impacts across 13 policy criteria that are relevant to implementation of the EU Green Deal (EGD). This included indicators focusing on environmental policies (Biodiversity Net Gain, Climate Regulation, Flood and Drought Resilience, Zero Pollution), societal policies (Health and Well-Being & Inclusive Participation), economic policy (Circular Economy, Financing the Transition and Green Growth) and policies for specific sectoral strategies (Farm to Fork, Sustainable Energy & Sustainable Transport).

Here we reviewed data across all indicators and categories submitted by the MERLIN case studies and conducted a synthesis analysis of the impacts of restoration with respect to the 13 EGD criteria and also in terms of the relevance of goals for individual restoration programmes.

The restoration measures implemented were largely at small scale and assessed over the short term, and do not provide data to answer questions as required scales of restoration, their relation to the scale of benefits (for example flood risk) or time required to determine benefits after restoration. For some criteria, such as flood and drought resilience, or health and well-being, much more detailed and long-term monitoring programmes, ideally with control sites for comparison, would need to be put in place to deliver the answers to these questions (see also Chapter 4.2).

Furthermore, the monitoring and evaluation framework we propose was designed as a generalized framework for restoration projects in general, which should stimulate restoration projects to think about the broad co-benefits and sectoral impacts of their restoration programmes. The indicators developed were aimed at being relatively simple indicators that all, or many, of our case-studies could collect.

Most environmental, social, and economic criteria were considered relevant, whereas sectoral criteria were only relevant to 50% or less of case studies. However, the amount of reported data was strongly biased towards criteria and their indicators with a focus on environmental aspects.

Most projects reported positive impacts of the restoration on environmental, social and economic criteria. The only trade-offs apparent between criteria were for Farm2Fork where land available for agricultural production declined in a few case studies and for Zero Pollution indicators for peatland and wetland restoration projects, although the latter may be a short-term response to implementing restoration measures.

A narrative provided by CS09 Tisza gave insight into the complexity of implementation of Nature-based Solutions, indicating that success monitoring is very “case study specific”. The narrative showed predominantly synergies but also occasional trade-offs between the Green Deal criteria.

In general, the MERLIN monitoring framework proved to be a well-supported tool. It served as a valuable attempt to create comparability across highly diverse case studies, a major challenge due to the heterogeneous ecological, social, and institutional settings.

Several limitations and points that could be improved emerged:

- Long-term integration appears constrained by organisational resource limitations.
- Strengthening institutional capacity and exploring funding continuity will be essential to sustaining monitoring beyond the project's lifetime.
- The introduction of the monitoring handbook (Carvalho et al., 2023) should be supplemented by an additional chapter with a clear explanation and justification why a systemic approach, treating environmental and socio-economic criteria as equally important, is necessary.
- The reporting templates of Carvalho et al. (2023) should be improved in order to be more intuitive.
- The “traffic light system”, which was not included as an evaluation method of the results in the handbook, can be a useful tool to help realise adaptive management.
- Discrepancies between the developed Theories of Change and reported data occurred. Possible sources:
 - Scale mismatches – both temporal and spatial (also: scale mismatched between ToC and monitoring site).
 - Specific indicators – especially regarding financing (additional data: “This indicator is rather useful for assessing projects, but not for assessing the impact of implemented measures.”).

The analysis of criteria highlights the importance of aligning perceived value with monitoring feasibility in impact frameworks. It also opens up opportunities for strategic prioritisation:

- Environmental Criteria: High relevance but also high monitoring effort – careful consideration
- Economy, Health and Well-Being – perceived as less relevant but relatively easy to collect data.

These criteria showed a relatively favourable balance between perceived relevance and effort, making them promising targets for practical policy integration. However, low-relevance and high-effort criteria (Inclusive Participation, Sustainable Food Systems) may warrant rethinking in their monitoring scope. The following actions are recommended:

- A clear recommendation of indicators, which are valuable/appropriate on respective spatial and temporal scales should be provided, both for environmental, socio-economic and sector-specific criteria (Farm to Fork, Sustainable Energy, Sustainable Transport).
- The Essential MERLIN Restoration Variables might be reviewed and redefined, where necessary (cf. Chapter 4.4).

Despite these challenges, the structured approach using predefined indicators contributed positively to cross-case comparison. However, the indicator level focus may be too granular in some cases; working at the criterion level could offer more flexibility and relevance across diverse contexts.

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Annex 1 – Characterisation of the study sites

Case Study	CS Name	Cluster	Control/Intervention	Dem. Site	Impl. Site	Site Name	Type of NBS (group number)	Biodiversity Net Gain	Climate Regulation	Flood Resilience	Drought Resilience	Health and Wellbeing	Zero Pollution	Farm to Fork	Sustainable Energy	Sustainable Transport	Inclusive Participation	Circular Economy	Financing the Transition	Green Growth
CS01	CS01 - Kvornig wetland rewetting DK	Peatlands and wetlands	Intervention	X		Meadow rewetting DK (CS01)	Wet./peatland restoration (1)	x	x	x	x	x	x	x	x		x		x	x
CS02	CS02 - Deba river barrier removal ES	Small streams and basins	Intervention		X	Barrier removal ES (CS02)	Dam removal (2)	x	x	x	x	x	x	x	x		x			
CS03	CS03 - Beaver river engineering SE	Peatlands and wetlands	Control		X	Artificial beaver dams SE (CS03)	Wet./peatland restoration (1)	x	x	x	x	x	x				x	x		x
CS03	CS03 - Beaver river engineering SE	Peatlands and wetlands	Intervention		X	Artificial beaver dams SE (CS03)	Wet./peatland restoration (1)	x	x	x	x	x	x	x			x	x		x
CS04	CS04 - Room for the Rhine NL	Large transboundary rivers	Intervention	X		Rhine branch restoration NL (CS04)	Large scale (3)	x	x	x	x	x	x	x					x	x
CS05	CS05 - Kampinos wetland rewetting PL	Peatlands and wetlands	Intervention	X		Kampinos rewetting 1 PL (CS05)	Wet./peatland restoration (1)	x	x	x	x	x	x				x		x	x
CS05	CS05 - Kampinos wetland rewetting PL	Peatlands and wetlands	Intervention		X	Kampinos rewetting 2 PL (CS05)	Wet./peatland restoration (1)										x			
CS06	CS06 Hutovo Blato peatland rewetting BIH	Peatlands and wetlands	Intervention		X	Peatland restoration BIH (CS06)	Lake/pond restoration (4)	x		x	x	x			x	x	x	x	x	x
CS07a	CS07a - Danube floodplain restoration AT	Large transboundary rivers	Intervention	X		Danube sidearm AT (CS07a)	River restoration (5)	x	x	x	x								x	x
CS07b	CS07b - Danube sidearm reconnect HU	Large transboundary rivers	Intervention	X		Danube Liberty Island HU (CS07b)	River restoration (5)	x	x	x	x			x	x				x	x
CS08	CS08 - Danube floodplain reconnect RO	Large transboundary rivers	Intervention		X	Danube floodplain reconnection RO (CS08)	Wet./peatland restoration (1)	x	x	x	x	x	x				x		x	x
CS09	CS09 - Tisza floodplain rewetting HU	Large transboundary rivers	Intervention	X		Tisza floodplains HU (CS09)	Wet./peatland restoration (1)	x	x	x	x	x		x			x	x	x	x
CS10	CS10 - Blue Belt Germany DE	Large transboundary rivers	Intervention	X		Rhine shoreline DE (CS10)	Riparian restoration (6)	x				x	x				x	x		x
CS10	CS10 - Blue Belt Germany DE	Large transboundary rivers	Control	X		Rhine shoreline DE (CS10)	Riparian restoration (6)										x			
CS10	CS10 - Blue Belt Germany DE	Large transboundary rivers	Intervention	X		Dike relocation DE (CS10)	Riparian restoration (6)			x	x	x			x					
CS11	CS11 - Emscher basin restoration DE	Small streams and basins	Intervention	X		Emscher basin-scale DE (CS11)	Large scale (3)	x	x	x	x	x			x		x		x	x
CS11	CS11 - Emscher basin restoration DE	Small streams and basins	Intervention	X		Emscher Lake Phoenix DE (CS11)	Retention basin (7)	x									x		x	
CS11	CS11 - Emscher basin restoration DE	Small streams and basins	Intervention	X		Emscher food-basins DE (CS11)	Retention basin (7)	x									x		x	
CS11	CS11 - Emscher basin restoration DE	Small streams and basins	Intervention	X		Emscher mouth DE (CS11)	River restoration (5)	x						x					x	
CS11	CS11 - Emscher basin restoration DE	Small streams and basins	Intervention	X		Emscher tributary DE (CS11)	River restoration (5)	x						x						
CS12	CS12 - Lima floodplain forest restoration PT	Peatlands and wetlands	Intervention		X	Lima floodplain forest rehab PT (CS12)	Riparian restoration (6)	x	x	x	x	x	x	x	x		x	x	x	x
CS13	CS13 - Sorraia river restoration PT	Small streams and basins	Intervention		X	Sorraia floodplains 1 PT (CS13)	Riparian restoration (6)	x				x	x	x				x		
CS13	CS13 - Sorraia river restoration PT	Small streams and basins	Intervention	X		Sorraia floodplains 2 PT (CS13)	Riparian restoration (6)		x	x	x	x					x			x
CS14	CS14 - Komppasuo peatland rewetting FI	Peatlands and wetlands	Intervention		X	Peatland rewetting small-scale FI (CS14)	Wet./peatland restoration (1)	x											x	
CS14	CS14 - Komppasuo peatland rewetting FI	Peatlands and wetlands	Intervention	X		Peatland rewetting large-scale FI (CS14)	Wet./peatland restoration (1)		x	x	x	x	x				x			x
CS15	CS15 - Tzjipori basin restoration IL	Small streams and basins	Intervention		X	Tzjipori Zevulun valley IL (CS15)	Lake/pond restoration (4)	x		x	x		x	x			x	x		
CS15	CS15 - Tzjipori basin restoration IL	Small streams and basins	Intervention	X		Tzjipori basin restoration IL (CS15)	Large scale (3)												x	x
CS16	CS16 - Upper Scheldt restoration BE	Small streams and basins	Intervention		x	Riparian buffer strips BE (CS16)	Riparian restoration (6)	x				x	x	x	x		x	x		
CS16	CS16 - Upper Scheldt restoration BE	Small streams and basins	Intervention		x	Zwalm restoration BE (CS16)	Riparian restoration (6)	x	x	x	x	x	x	x	x	x			x	x
CS17	CS17 - Forth basin restoration UK	Small streams and basins	Intervention	X		Allan Water channel restoration UK (CS17)	Riparian restoration (6)	x	x	x	x	x	x	x		x	x		x	x
CS17	CS17 - Forth basin restoration UK	Small streams and basins	Control	X		Allan Water channel restoration UK (CS17)	Riparian restoration (6)	x	x				x							
CS18	CS18 - Ervidel river restoration PT	Small streams and basins	Intervention		X	Ervidel riverbanks 1 PT (CS18)	Riparian restoration (6)	x		x	x	x							x	x
CS18	CS18 - Ervidel river restoration PT	Small streams and basins	Intervention	X		Ervidel riverbanks 2 PT (CS18)	Riparian restoration (6)		x				x	x			x	x		

Annex 2 – Analysis and assessment of the data reported for the indicators including an aggregated assessment of the criteria

Approach

For assessing of the individual indicators and criteria the “traffic light system” based scheme as shown in Chapter 3.1 was applied.

It should be noted that – when analysing the results provided by the case studies for the individual indicators of the respective the criteria – it was important that the impact was considered in relation to the spatial and temporal extent of the measures and also the type of the measure.

Individual criteria

Biodiversity Net Gain

All 18 case-studies reported data on the biodiversity indicators with the most commonly reported being for habitat condition, habitat trend and ecological status of waterbody (15, 13 and 13 CS respectively), whilst the greatest number of individual records were reported for bird condition and trends (Table 6). However, in many cases both pre- and post-restoration data were not delivered, or consisted of only 1 year before or after restoration, making impact assessment unreliable for most case-studies. What can be reliably evaluated is the quantity of habitat restored and this was used to summarise whether impacts were positive or negative (Table 7). As NbS implementation at all case-studies involved increasing habitat quantity the measures were all indicated as having a positive impact for biodiversity. Habitat quality measures were not included because they were typically unavailable or limited to short-term post-restoration monitoring.

In total, 287 km of free-flowing river has been restored at nine case-studies (Table 7) including reconnecting rivers with their floodplains (Danube, Emscher, Ervidel, Kvorning, Rhine and Scheldt) and removal of barriers to restore flow continuity (Deba, ES). It should be made clear that our methodology for calculating free-flowing river restored focused on lateral barrier length removed and length of river reconnected upstream following complete removal of longitudinal barriers (CS02 Deba – dam removal). The method did not follow the ECOSTAT methodology (van de Bund 2024) as this was published after our MERLIN monitoring guidance (Deliverable D1.2) was published. We did not evaluate if upstream rivers connected were of homogenous reaches or examine all the criteria for “free-flowing river” that the ECOSTAT guidance outlines, such as sediment connectivity and ecological flows.

In total, the MERLIN case-studies represent 1528 ha of restored floodplains (Table 7). This is approximately the area of 12,200 Olympic-size swimming pools, which gives some illustration of the potential this provides for flood storage capacity, increasing the climate resilience of these regions.

These positive impacts do not mean that the biodiversity quality is necessarily improved in response to these changes in habitat quantity – improvements in quality may depend upon further management measures, such as the control of pollution or invasive species. Some case-studies had longer time-series on specific indicators of biodiversity condition (habitat and species condition, ecological status) and these data are examined further to illustrate the use of the indicators for assessing change in biodiversity quality.

Table 6 - Overview of biodiversity data reported by case-studies.

Indicator number	Indicator name	CS01 – Kvorning wetland rewetting DK	CS02 – Deba barrier removal ES	CS03 – Beaver river engineering SE	CS04 – Room for the Rhine NL	CS05 – Kampinos wetland rewetting PL	CS06 – Hutovo Blato peatland rewetting Bi	CS07a – Danube floodplain restoration AT	CS07b – Danube sidearm reconnect HU	CS08 – Danube floodplain reconnect RO	CS09 – Tisza floodplain rewetting HU	CS10 – Blue Belt Germany DE	CS11 – Emscher basin restoration DE	CS12 – Lima river floodplain forest restoration PT	CS13 – Sorraia river restoration PT	CS14 – Komppasuo peatland rewetting FI	CS15 – Tzipori catchment (IL)	CS16 – Scheldt catchment (BE)	CS17 – Forth basin restoration UK	CS18 – Ervidel river restoration PT	Count of CS reporting	Total records
1a	Habitat_condition	8			9	9	22	40	2		27	4		51	3	15	2	5	4	1	15	202
1b	Habitat_trend	8			4	9		24	2		27	4		12	3	15		5	4	1	13	118
2a	Species_condition	12	10		4		38	98	62		56	4			6	21		4		1	12	316
2b	Species_trend	16	10		4			49	60		56	4			6	21		4		1	11	231
3a	Bird_condition					12	69	226	12	62	91	33			147	18		2		1	11	673
3b	Bird_trend				17	12		113	12	62	91	33			147	18		2		1	11	508
4	Total area protected	3	5					4	9		7	4	3	18			1	3			10	57
5	Length of free-flowing river re-connected	3	15					1	7		7	4	7				1	3		2	10	50

6	Area of re-connected floodplain	3	5			3			9	1	7	4	2		2				4		10	40
7	Ecological status of waterbody	16	12	2		3		2	1	2		4	27	3		6		8	2		13	88
7b	Ecological status of BQE		12	2								16	48						16		5	94
8	nEQR of BQE	64	9										35						12		4	120
9	Presence of invasive non-native species	24	5				24		142			12	139	12	6		6	6	8	2	12	386
10	Control of invasive non-native species	24	5						21			12		12	6		6		8	2	9	96
11	Other		33	286				65				1		8		3			5	65	8	466
12	Pollinator species richness											3		4	3		2	13		1	6	26
13	Pollinator abundance											3		4	3		2	14		1	6	27
	Total	181	121	290	38	48	153	622	339	127	369	142	261	120	329	117	18	55	63	78	160	3471

Table 7 – Summary of biodiversity restored
(biodiversity quantity indicators only).

CS name	Free-flowing river re-connected (km)	Area of floodplain re-connected (ha)	Area of peatland or wetland restored (ha)	Change
CS01 – Kvorning wetland rewetting DK	9.5	230	500	😊
CS02 – Deba barrier removal ES	18.5			😊
CS03 – Beaver river engineering SE			10,000–1,000,000	😊
CS04 – Room for the Rhine NL	4.4			😊
CS05 – Kampinos wetland rewetting PL		362		😊
CS06 – Hutovo Blato peatland rewetting BiH			1,490	😊
CS07a – Danube floodplain restoration AT (Demo site)	4.3			😊
CS07b – Danube sidearm reconnect HU– (Demo site)	1.8	66		😊
CS08 – Danube floodplain reconnect RO		400		😊
CS09 – Tisza floodplain rewetting HU		263		😊
CS10 – Blue Belt Germany DE	1.5			😊
CS11 – Emscher basin restoration DE	241	155		😊
CS12 – Lima river floodplain forest restoration PT			32	😊
CS13 – Sorraia river restoration PT		49		😊
CS14 – Komppasuo peatland rewetting FI			120	😊
CS15 – Tzipori basin restoration IL (Implementation site)	1.5			😊
CS16 – Upper Scheldt restoration BE (Implementation site)	2.4			😊
CS17 – Forth basin restoration UK		3		😊
CS18 – Ervidel river restoration PT	2.0			😊
CS Count	10	8		
CS%	53%	42%		
Sum	287	1,528		

Habitat condition: status and trend

Case-studies were asked to evaluate freshwater and wetland habitats based on condition assessment for the Habitats Directive (HD). However, due to the HD assessment typically being based on habitats across large biogeographic regions, case-studies were asked to assess condition based largely on the “structure and function” criteria of their local restoration landscape. This criterion related to the presence or absence of “typical” characteristic plant species for that habitat type. In total, 13 case-studies reported data on habitat condition and trends, but only 6 case-studies had data pre- and post-restoration, covering 21 freshwater and wetland habitat types, with most only having 1 or 2 years of pre- and post-restoration data. The River Tisza floodplain restoration had the most data with 2 years pre- (15 and 5 years before) and 4 years post-restoration (3, 8, 14 and 19 years after). This provides good long-term evidence of change in habitat condition following floodplain restoration. Of their results, only alluvial forest habitat showed a clear improving picture from unfavourable condition pre-restoration to favourable post-restoration; the other two habitat types (naturally eutrophic lakes and alluvial meadows) showed a short-lived improvement up to 3 years later, but 8 years after restoration had returned to an unfavourable condition (Table 8).

A more refined approach for tracking habitat condition was applied at the Lima case-study in Portugal, where an over-arching class of status was not reported, but the % of habitat area in favourable (and unfavourable) condition was reported, providing a more continuous reporting scale. Their assessment of 4 habitat types showed a consistent increase in % area in favourable condition in 3 of the 4 habitats 1 year after restoration (Figure 6). The 4th habitat (3260 – Rivers with submerged or floating vegetation of water crowfoot (*Ranunculus*) species or aquatic mosses – was already 100% in favourable condition pre-restoration and remained so 1 year post-restoration, highlighting that the floodplain restoration had no negative impact on the river vegetation (Figure 6).

Table 8: Condition and trend of River Tisza floodplain habitats pre- and post-restoration

Habitat	Years since restoration	Restoration stage	Year	BD1a - Habitat condition status	BD1b - Habitat condition trend
3150 - Natural eutrophic lakes	-15	Pre	1990	Unfavourable_Bad	Deteriorating
	-5	Pre	2000	Unfavourable_Bad	Deteriorating
	0	Restoration	2005	Favourable	Improving
	3	Post	2008	Favourable	Stable
	8	Post	2013	Unfavourable-Inadequate	Deteriorating
	14	Post	2019	Unfavourable_Bad	Deteriorating
	19	Post	2024	Unfavourable_Bad 😞	Deteriorating 😞
6440 - Alluvial meadows	-15	Pre	1990	Unfavourable_Bad	Deteriorating
	-5	Pre	2000	Unfavourable_Bad	Deteriorating
	0	Restoration	2005	Favourable	Improving
	3	Post	2008	Favourable	Improving
	8	Post	2013	Unfavourable-Inadequate	Deteriorating
	14	Post	2019	Unfavourable_Bad	Deteriorating
	19	Post	2024	Unfavourable_Bad 😞	Deteriorating 😞
91E0 - Alluvial forest	-15	Pre	1990	Unfavourable_Bad	Deteriorating
	-5	Pre	2000	Unfavourable-Inadequate	Deteriorating
	0	Restoration	2005	Favourable	Improving

	3	Post	2008	Favourable	Improving
	8	Post	2013	Favourable	Stable
	14	Post	2019	Favourable	Stable
	19	Post	2024	Unfavourable-Inadequate ☹️	Improving 😊

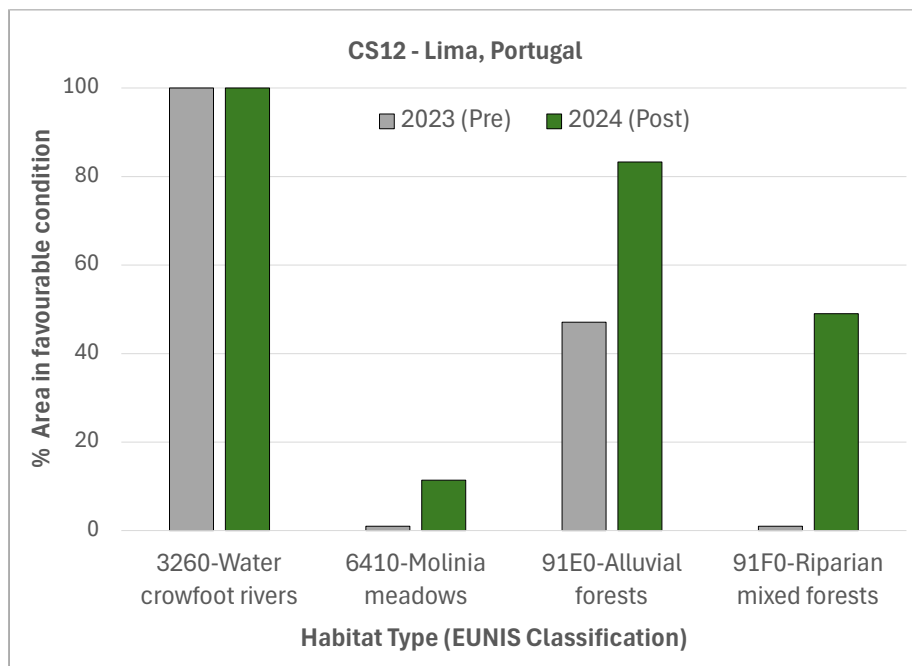


Figure 6: Percentage area of habitat in favourable condition.

Species condition: status and trend

11 case-studies reported data on species condition for 117 freshwater and wetland species (excluding birds), although only 4 case-studies had pre- and post-restoration data on 12 species. The most endangered species were recorded in the Deba River, although the restoration has not had an impact on populations in this region yet (Table 9). This is not unexpected as these species are both affected by pressures across much greater areas, with the migratory fish, the European eel (*Anguilla anguilla*), impacted by pressures along the coast and in the Atlantic Ocean too. The Tisza floodplain restoration had the most data on species condition with 2 years pre- (15 and 5 years before) and 4 years post-restoration (3, 8, 14 and 19 years after) for 7 species (Table 10). Change was evaluated across a wide range of biological groups associated with the river and wetland habitats including an amphibian (toad), fish, reptile (terrapin), 2 mammals (otter and pond bat) and a wetland-associated butterfly. This revealed short-term improvements in species condition 3 and 8 years after restoration, but a deterioration again 14 & 19 years after restoration, alongside the deterioration in the eutrophic lake and alluvial meadow habitat conditions. A more detailed narrative of the reasons for the changes observed at the Tisza site is provided in Appendix 2. What is important to highlight here is the value of long-term biodiversity monitoring across a wide range of groups provides strong evidence of both improving and deteriorating conditions that can be used in adaptive management to take further actions when deterioration is returning. A higher frequency of monitoring may have picked up these changes earlier prompting quicker action.

Other species monitoring associated with river restoration (Table 11) and peatland restoration (Table 12) showed no change in condition in the very short-term (1- or 2-years post-restoration).

Table 9: Condition of species pre- and post-restoration, Deba barrier removal.

Species	Common name	IUCN status	CS02: Deba barrier removal ES				
			2020	2021	2022	2023	2024
			Pre	Pre	Post	Post	Post
<i>Anguilla anguilla</i>	European eel	Critically endangered	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate
<i>Mustela lutreola</i>	European mink	Critically endangered	Unfavourable_Bad	Unfavourable_Bad	Unfavourable_Bad	Unfavourable_Bad	Unfavourable_Bad

Table 10: Condition of species pre- and post-restoration, Tisza floodplain rewetting.

Species	Common name	IUCN status	CS09: Tisza floodplain rewetting HU						
			CS09	2000	2005	2008	2013	2019	2024
			Pre	Pre	Restoration	Post	Post	Post	Post
<i>Bombina bombina</i>	European fire-bellied toad	Least concern	Unfavourable_Bad	Unfavourable-Inadequate	Favourable	Favourable	Favourable	Unfavourable_Bad	Unfavourable_Bad
<i>Castor fiber</i>	Eurasian beaver	Least concern	Unfavourable_Bad	Unfavourable_Bad	Favourable	Favourable	Unfavourable-Inadequate	Unfavourable_Bad	Unfavourable_Bad
<i>Emys orbicularis</i>	European pond terrapin	Near Threatened	Unfavourable_Bad	Unfavourable_Bad	Favourable	Favourable	Unfavourable_Bad	Unfavourable_Bad	Unfavourable_Bad
<i>Lutra lutra</i>	Eurasian Otter	Near Threatened	Unfavourable_Bad	Unfavourable_Bad	Favourable	Favourable	Unfavourable-Inadequate	Unfavourable_Bad	Unfavourable_Bad
<i>Lycaena dispar</i>	Large copper	Near Threatened	Unfavourable_Bad	Unfavourable_Bad	Favourable	Favourable	Unfavourable-Inadequate	Unfavourable_Bad	Unfavourable_Bad
<i>Myotis dasycneme</i>	Pond bat	Near Threatened	Unfavourable_Bad	Unfavourable_Bad	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate	No data	No data
<i>Rhodeus sericeus amarus</i>	European bitterling	Least concern	Unfavourable_Bad	Unfavourable_Bad	Favourable	Favourable	Favourable	Unfavourable_Bad	Unfavourable_Bad

Table 11: Condition of species pre- and post-restoration, Blue Belt Germany.

Species	Common name	IUCN status	CS10: Blue Belt Germany DE			
			2018	2019	2022	2023
			Pre	Pre	Post	Post
<i>Aspius</i>	Aral asp	Least concern	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate	Unfavourable-Inadequate

Table 12: Condition of species pre- and post-restoration, Komppasuo peatland rewetting.

Species	Common name	IUCN status	CS14: Komppasuo peatland rewetting FI		
			2022	2023	2024
			Pre	Pre	Post
<i>Typha latifolia</i>	Great reedmace	Least concern	Unfavourable_Bad	Unfavourable_Bad	Unfavourable_Bad
<i>Equisetum fluviatile</i>	Water horsetail	Least concern	Unfavourable_Bad	Unfavourable_Bad	Unfavourable_Bad

Table 13: Condition of species pre- and post-restoration, Sorraia river restoration.

Species	Common name	IUCN status	CS13: Sorraia river restoration PT		
			2019	2022	2023
			Pre	Pre	Post
<i>Pelophylax perezi</i>	Perez's frog	Least concern	No data	No data	Favourable

Ecological status of waterbodies

The ecological status of waterbodies (WBs) is widely assessed and reported across Europe. It is a composite measure based on the status of 4 biological quality elements (BQEs) (algae, plants, invertebrates and fish) and so provides a good over-arching indicator of the health of freshwater biodiversity.

It should be made clear that the river restoration measures evaluated in MERLIN, with one exception (CS02 Deba) were not focused on removing the cause of WBs not achieving Good Status. For this reason, there were no expectations that status class would be improved in any case-study. This indicator was included in the monitoring and evaluation framework simply because it is an important policy objective for rivers and many of our river case-studies had data to evaluate any indirect impacts of their restoration measures.

Differences were observed in responses between case-studies and for different waterbodies within case-studies and changes sometimes occurred before MERLIN measures were implemented. The changes observed are described below on a case-by-case basis as there are no generalisations on impact that can be made. Ecological status was reported for six of the river case-studies, with several WBs reported for some case-studies. For three of these case-studies (CS05 Kampinos, CS10 Blue Belt and CS14 Komppasuo) there was no change in status after restoration. For the three others, a variable response was seen. The Deba River in Spain (CS02) reported on three WBs. These showed improvement in ecological status from moderate to good status, but for two of the three WBs this improvement was evident before the dam removal. At two sites (Lower and Upper Deba) it has remained at good status post-restoration, whilst at the Middle Deba it declined back to moderate status 2 years after dam removal (Figure 7). The Rhine branches (CS04) show a long history of being in poor ecological status, with a few years at 2 sites assessed as moderate status in more recent years (Figure 8). These changes are not considered to be a response to the floodplain reconnections being evaluated in MERLIN. The long-term Poor status of these WBs is associated with other pressures, such as hydromorphological changes, including barriers restricting the movement of migratory fish, as well as poor water quality from sewage, agricultural and industrial discharges that occur further downstream the Rhine. The Emscher River was assessed as Bad ecological status for many years pre-restoration, with some years, particularly upstream WBs, assessed as Poor or Moderate status (Figure 9). The post-restoration status has not changed, but that is not surprising as the restoration measures on the bankside flower meadows were not expected to change the ecological status of the river communities.

Ecological status is defined by the poorest quality of the 4 component BQEs (the WFD one-out-all-out principle), so a composite indicator like this can be relatively insensitive to recovery in one or more of the constituent BQEs. As it is a categorical classification it also does not reflect any changes within status class.

To overcome this, we also showcased the importance of evaluating restoration measures through evaluating change in individual BQEs. This is highlighted in the Forth case-study (CS17). Here the status class of two BQEs, macrophytes and benthic invertebrates, were compared between the restoration site and a control site pre- and post-restoration. This showed a decline in status for river macrophytes but an improvement in benthic invertebrates, although there was no difference between control and restoration sites, indicating that these changes were not due to the restoration measures implemented in MERLIN but due to another factor affecting the sites over time (Figure 10). This is an important example as it showcases the value of having a control site to evaluate whether changes observed are due to the restoration, another pressure, or even just due to community change associated with different hydrological conditions between years.

For a more nuanced analysis of impact it is better to use the EQR values of the 4 component BQEs. EQR values, however, do not have to be reported by Member States and are, therefore, not widely available Europe-wide, making their use problematic for pan-European assessment.

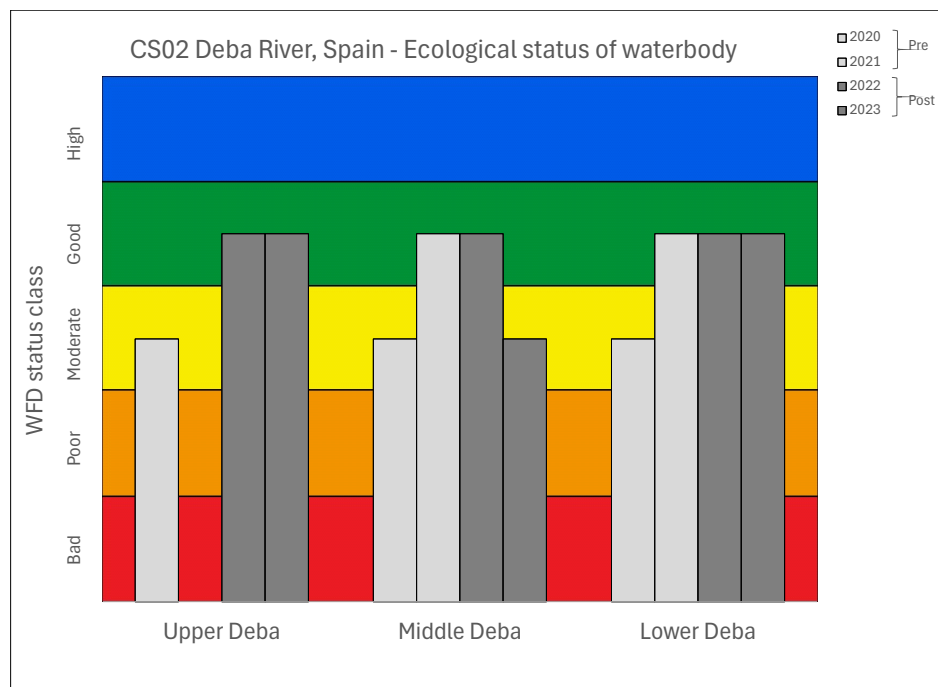


Figure 7: Ecological status of the Deba River pre- and post-restoration.

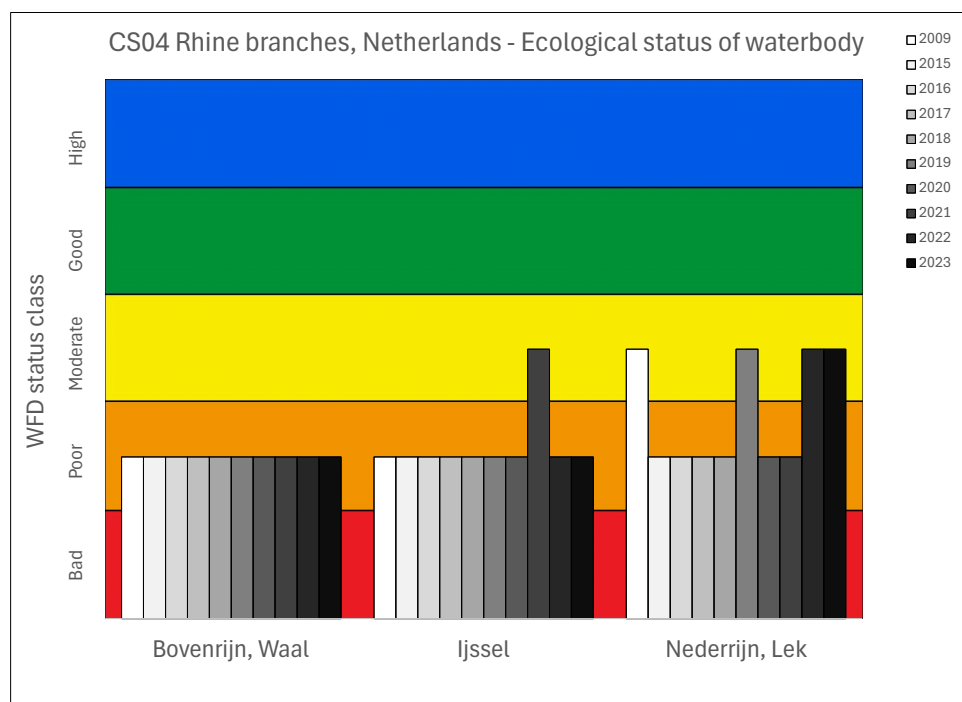


Figure 8: Ecological status of 3 branches along the River Rhine over 14 years.

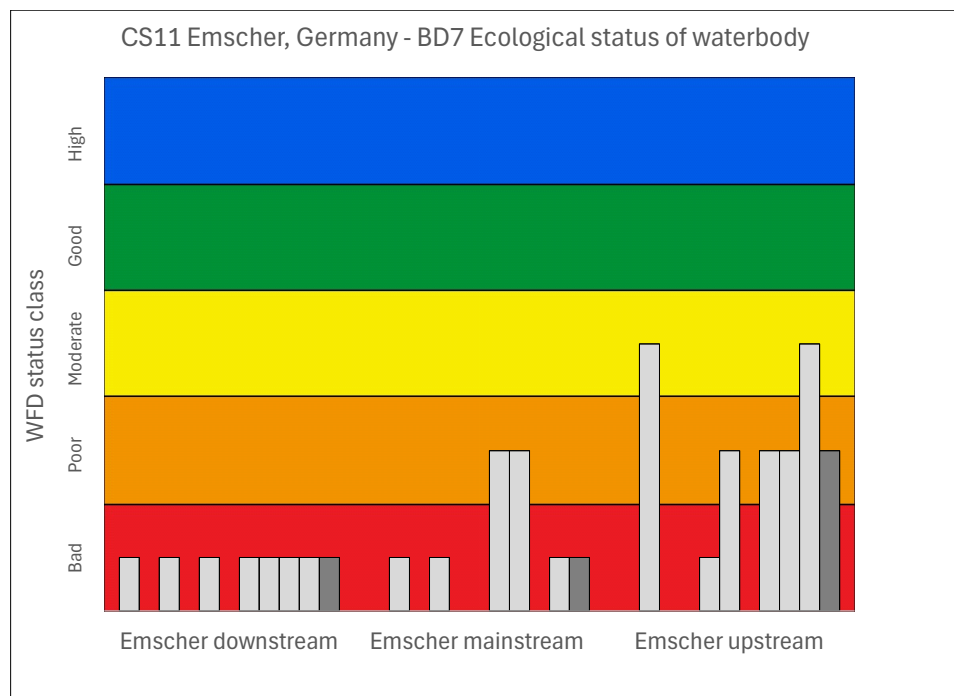


Figure 9: Ecological status of 3 sites along the Emscher River pre- and post-restoration.

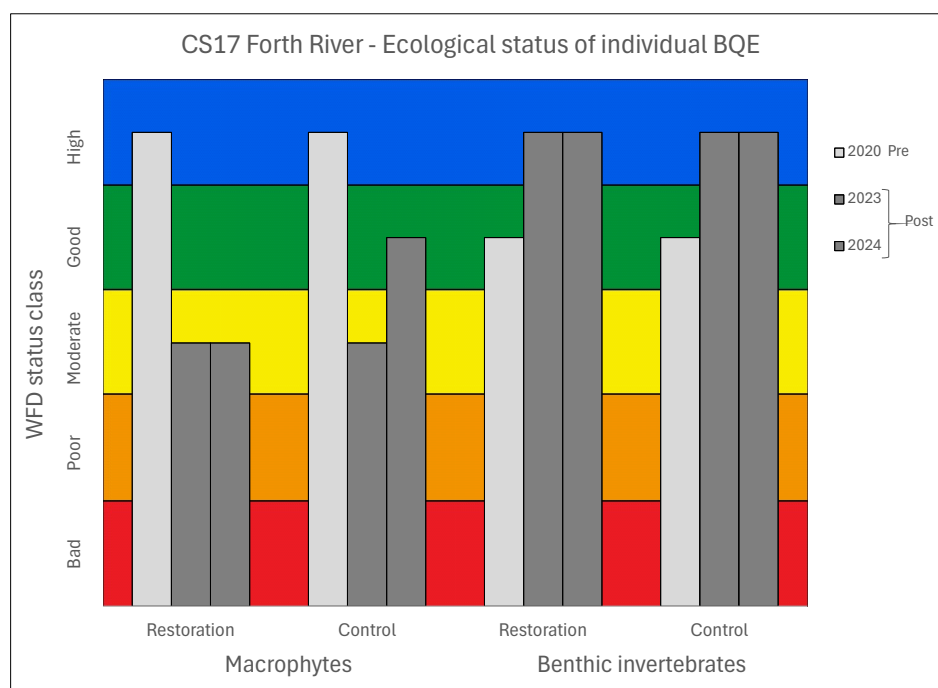


Figure 10: Ecological status of macrophytes and benthic invertebrates in the Forth, comparing restoration and control sites.

WFD Ecological Quality Ratios (EQRs) of Biological Quality Elements

Assessing change in individual BQEs can provide a more sensitive assessment for measuring biodiversity impacts of restoration compared with the composite and categorical use of “ecological status”. Using the EQR as an indicator of change provides a more continuous measure of community compositional change for the BQE. For this reason EQRs are recommended as a strong indicator of change on freshwater biodiversity (EuropaBON, 2023). Normalised EQR (nEQR) values have been used here, where the EQR scale has been standardised for class widths of 0.2, to allow comparable results across river types and countries.

The value of using nEQR is highlighted with the nEQR values of benthic invertebrates in the Deba River. These show a positive improvement, moving from moderate status to good status, although the improvement occurring 1 year pre-restoration (Figure 11). One of the three Deba WBs shows a decline in nEQR 2 years post-restoration. Without longer-term data it is impossible to state if these are a response to restoration measures or just dynamics due to natural inter-annual variability.

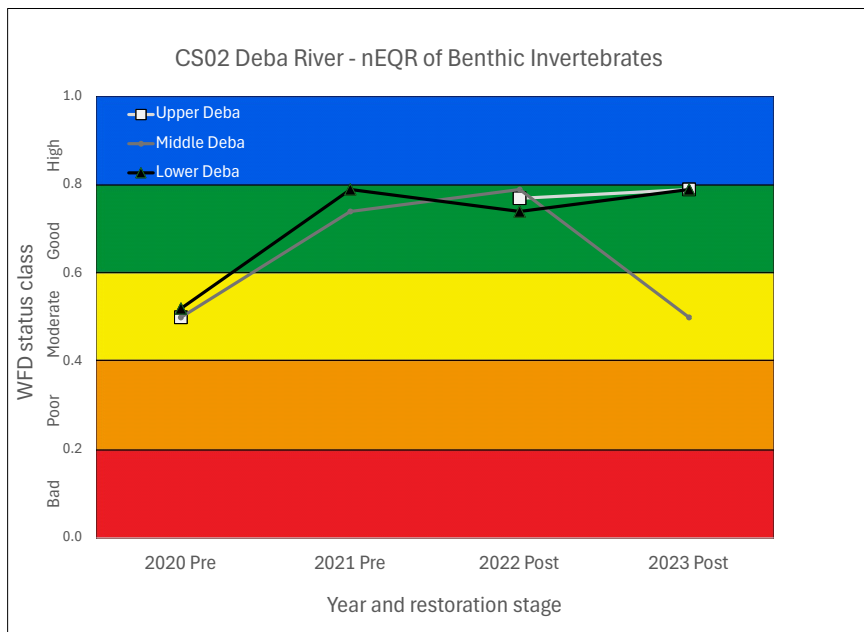


Figure 11: nEQR of benthic invertebrates in Deba River pre- and post-restoration.

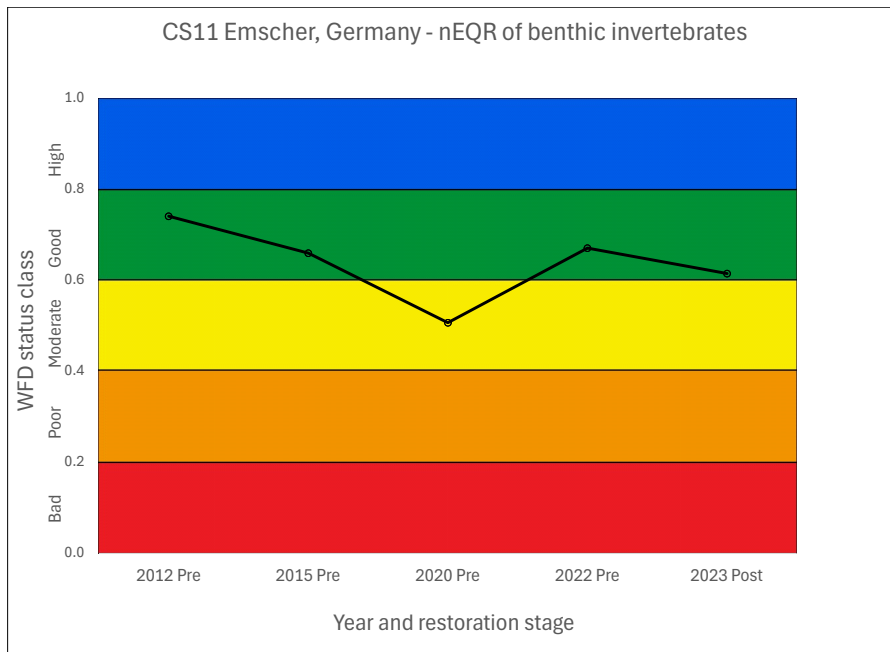


Figure 12: nEQR of benthic invertebrates in River Emscher pre- and post-restoration.

Climate Regulation (GHG emissions)

Overview

The potential for the river and wetland restoration actions to impact the climate regulation outcomes is varied and can be linked to both local and more broad scale impacts. For peatlands the primary impact considered is the effect of restoration actions on greenhouse gas (GHG) fluxes from the site, and hence how the long-term carbon store within the peat is likely to change. Peatland GHG flux has been shown to be controlled by the water levels in the peat, with drier sites emitting more CO₂ compared to wetter sites across varied land uses (Evans et al, 2021). For the rivers the outcome is more nuanced as GHG fluxes can be affected by in-stream chemistry (Upadhyay et al, 2023) and morphology (Bussman et al., 2022) so restoration measures may impact these directly. However, river restoration can also increase floodplain connectivity, and result in land use changes more widely in the catchment. The increase in connectivity can increase sediment transfer to the floodplain, and potentially increase carbon sequestration directly and can also change the land use, which can also change carbon sequestration rates. CS09 demonstrates this outcome where floodplain connectivity resulted in a change in land use from arable farming to extensive floodplain wetland, which was shown to reduce GHG emissions and have a positive impact on climate regulation.

Methods

Where taken, measured changes in greenhouse gas (GHG) fluxes have been used to quantify the short-term impacts of river and peatland restoration on climate regulation. However, on the ground, direct measurements of GHG fluxes were not possible for all case studies due to cost, time and availability of specialist monitoring equipment. To enable us to report the impacts across all case studies two modelling approaches have been used to assess the impact of the case study restoration actions on climate regulation, using simple proxies that can be reported across all case studies.

The first approach, used to model GHG fluxes from peatlands, uses the Europe wide relationship between annual water table depth and CO₂ and CH₄ fluxes from peatlands under a wide range of land use categories (Evans et al., 2021). Case studies reporting the impact of restoration on peatlands were asked to report annual mean water table depths before and after restoration, as well as peat depth, and land use before and after restoration. This is because for deeply drained sites with shallow peat the water table depth can be below the level of the peat soil. The equations from Evans et al. (2021) are shown in Equations 1 and 2, with water table depth being the annual mean water table depth or the peat depth, whichever is shallower.

The second approach uses the carbon stock change approach detailed in the IPCC Wetlands Supplement (IPCC 2013) for inland wetland mineral soils. In this approach it is assumed that past conversion of mineral wetlands to a land use type that has involved drainage has resulted in a reduction in soil carbon stocks. Conversely, when inland wetland mineral soils are rewetted, such as through the reconnection of a river with its floodplain, carbon stocks increase over a 40-year period, at the end of which they are considered to have reached the previous equilibrium state, whereby further input of carbon is balanced by carbon losses. Over the time-frame of the MERLIN project we considered that direct comparison of pre- and post-restoration soil carbon stocks would not provide sufficient evidence of change due to the very small changes expected in the time-frame available. The modelled results that are reported from this work should be considered indicative of the direction of change expected over the next 20 – 40 years should the land management continue in the new direction.

In the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Tier 1 methods were provided to calculate GHG emissions from anthropogenic water bodies, including reservoirs, canals, ponds and ditches. Although rivers are not explicitly included in these, most of the large rivers in Europe have been affected by human intervention including canalisation, and impoundment. The methods included variation by trophic status, with eutrophic water bodies having higher emissions than mesotrophic and oligotrophic water bodies. We did not have sufficient evidence to quantify GHG emissions from the river surface directly (though this was reported where direct measurements had been taken by individual case studies) but we are able to qualitatively assess the likely direction of change in GHG emissions from the water surface where restoration has improved the water quality. The link between trophic state, nutrient levels and GHG emissions from rivers has been reported in past global evidence reviews (e.g. Upadhyay et al., 2023) and in individual river scale reporting (e.g. Mwanake et al., 2023).

Results

Small streams and basins

Table 14 – Summary of Impacts of restoration actions on climate regulation for the small streams and basins cluster. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Site	Intervention reported on	In stream GHG	Surrounding land GHG	Overall change
CS02 – Deba barrier removal ES	Weir demolition, restoration of river morphology and connectivity	No change in nutrients reported apart from a decline in N for one site Reduction in in-stream CH ₄ production predicted with weir removal (impounded areas hotspots of CH ₄ production) 		 ₂
CS11 – Emscher basin restoration DE	Transition to more extensive land use around river	 reduction in nutrient concentrations	 increase in flood plain area	 ₂
CS13 – Sorraia river restoration PT	Riparian restoration & habitat enhancement	 no reported changes	 no reported changes	 ₂
CS15 – Tzipori basin restoration IL	Floodplain reconnection, riparian restoration	No data	 increase in flood plain area	 ₁
CS16 – Upper Scheldt restoration BE	Dam removal and riparian restoration			 ₂
CS17 – Forth basin restoration UK	Floodplain reconnection, riparian restoration	 no short term change following restoration	 increase in floodplain area	 ₂
CS18 – Ervidel river restoration PT	Riparian restoration & habitat enhancement			 ₂

In the small streams and rivers, the restoration measures trialed and reported on have been primarily around floodplain reconnection and restoration of riparian habitat, with the exception of one case study (CS02) who focused on the removal of in-stream obstacles (weirs). Five of the case studies reported an increase in the area of floodplain following restoration, meaning that the carbon stock in these systems is modelled to increase by 0.3 – 0.6 t C ha⁻¹ yr⁻¹ over 20 years. It should be noted that these are modelled projections and none of the restoration sites had direct measurements of changing soil carbon stock in the new floodplain soils. The total modelled carbon stock increase per site is shown in Figure 13.

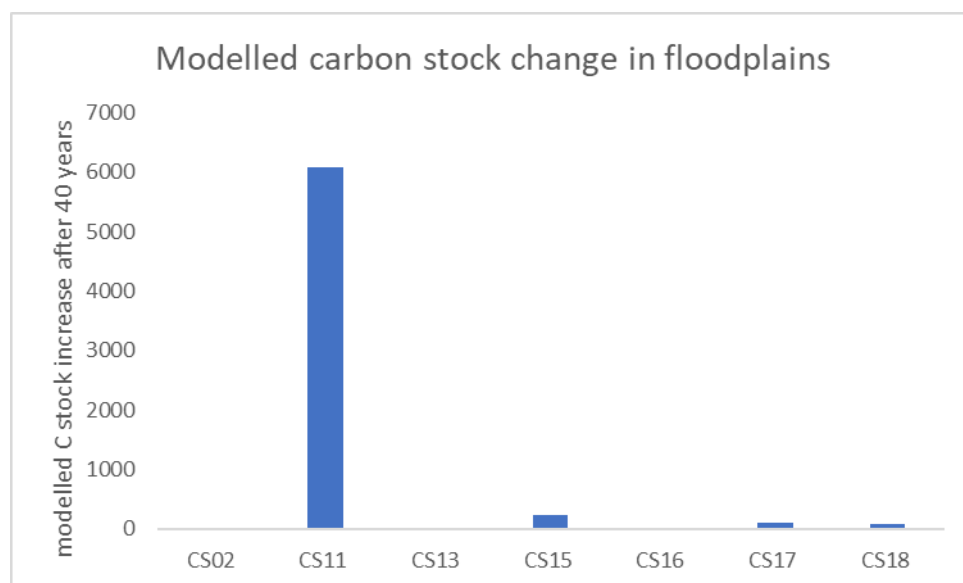


Figure 13 – Total modelled carbon stock increase for case studies of the Small Streams and Basins Cluster.

The change in in-stream nutrient concentrations was less clear cut, with most sites showing no short-term change. This is as expected, especially for those sites where water quality was good prior to restoration. The lack of change in nutrient levels suggests that in-stream GHG fluxes will also show little short-term change, a hypothesis backed up by the lack of change in GHG fluxes found in CS17, where these were measured directly.

The case study that focused on removal of weirs (CS02) found that CH₄ production was elevated in the stagnant areas directly upstream of the weir, meaning that the removal of the weirs and hence the loss of the deeper dammed would be expected to reduce CH₄ production and emission.

Overall the restoration of riparian habitat and reconnection of the rivers with their floodplains is projected to increase carbon stocks in floodplain soils and provide a net benefit for climate regulation. Where the impact of river restoration is less clear is the effect of restoration on in-stream GHG emissions. These were measured in one case study and no change was found over the monitoring time period. The removal of in-stream obstacles appears to reduce CH₄ emissions through the removal of deep, lower oxygen environments with slow water flow, immediately followed by an area of well mixed water to allow CH₄ degassing.

Large transboundary rivers

Table 15 – Summary of Impacts of restoration actions on climate regulation for the large transboundary rivers cluster. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Site	Intervention reported on	In stream GHG	Surrounding land GHG	Overall change
CS04 – Room for the Rhine NL	Reconnecting flood plain and changing land use	☹️	☹️	☹️ ¹
CS07a – Danube floodplain restoration AT	River bank restoration	No post intervention data reported	☹️	☹️ ¹
CS07b – Danube sidearm reconnect HU	No interventions planned in the time	No nutrient data reported	😊	😊 ¹

	frame of the project			
CS08 – Danube floodplain reconnect RO	Floodplain reconnection	☹️	☹️	☹️ ¹
CS09 – Tisza floodplain rewetting HU	Floodplain reconnection and rewetting, floodplain farming	☹️	😊 increase in area of restored wetlands and floodplain area	😊 ²
CS10 – Blue Belt Germany DE	No intervention listed on website, 2 demonstration projects looking at river restoration and removal of bank protection	☹️	😊 increase in area of restored wetlands and floodplain area	😊 ¹

Across the large transboundary rivers cluster GHG emissions reductions were not listed as a priority for any of the restoration measures but the restoration actions reconnecting rivers with the floodplain are projected to increase carbon storage in soils through the changing land use in those case studies where an increased floodplain area has been reported. (CS7b, CS09, CS10). For these large transboundary rivers local scale restoration actions are less likely to impact the nutrient status of the rivers, meaning that it is unsurprising that at most sites no change was reported as a result of restoration. In CS04 nutrient concentrations did reduce over 20 years following a number of restoration actions, which suggest that GHG emissions may reduce but it is extremely challenging to be confident that at this spatial and temporal scale that the restoration actions undertaken were responsible for the change.

Where changes in floodplain area were reported IPCC Tier 1 methods were used to model the change in carbon stocks that would occur over the 40 year period following restoration, and the results for the large transboundary rivers are shown below. The sites with the largest increase in carbon stock were those that reported the largest change in floodplain area.

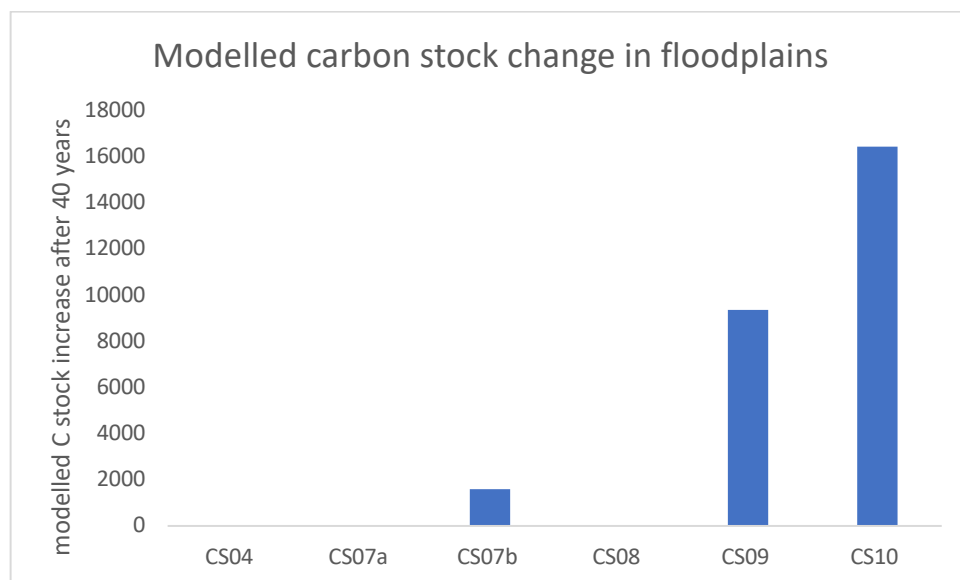


Figure 14 – Total modelled carbon stock increase for case studies of the Large Transboundary Rivers Cluster.

To summarise the impacts of large transboundary river restoration on climate regulation seen in the Merlin project is challenging as most of the effects are comparatively unclear. This is primarily because of the difficulty in reporting and linking the changes in outcome with interventions, particularly with the difficulty in isolating specific outcomes and interventions. An example of this is CS04, where reporting nutrient levels did

reduce over a 20 year period but the reconnection of the Rhine with its floodplain was not the only potential driver for change in water quality over the same time period.

Peatlands and wetlands

Table 16 – Summary of Impacts of restoration actions on climate regulation for the peatlands and wetlands cluster. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Site	Restoration	Overall change
CS01 – Kvorning wetland rewetted DK	None reported on during Merlin	--
CS03 – Beaver river engineering SE	Impacts of beaver dams	☹️ ¹
CS05 – Kampinos wetland rewetted PL	Restoration of peatlands	😊 ¹ higher water table levels
CS06 – Hutovo Blato peatland rewetted BiH	Restoration of peatlands	--
CS12 – Lima river floodplain forest restoration PT	Restoration of floodplain forest	😊 ¹ increase in area of restored wetlands
CS14 – Komppasuo peatland rewetted FI	Restoration of peatlands	😊 ¹ decrease in carbon dioxide emissions

Of the six peatland and wetland case studies two reported positive impacts of rewetted on either measured GHG fluxes or water table depths within the peat allowing estimation of the change in GHG fluxes. At these sites (CS5 and CS14) the rewetted resulted in a shallower annual average water table depth, meaning that modelled CO₂ emissions were reduced. An example is shown in Figure 15 for CS05 and CS14. There was an increase in CH₄ emissions but this was outweighed by the reduction in CO₂ emissions. CS14 directly measured CO₂ and CH₄ fluxes before and after restoration and the direct measurements showed the same trend as those modelled from the water table depth – the CO₂ fluxes reduced to near zero, while CH₄ emissions increased from near zero, or even CH₄ uptake in the driest sites, to CH₄ emissions of up to 8 mg m⁻² hr⁻¹.

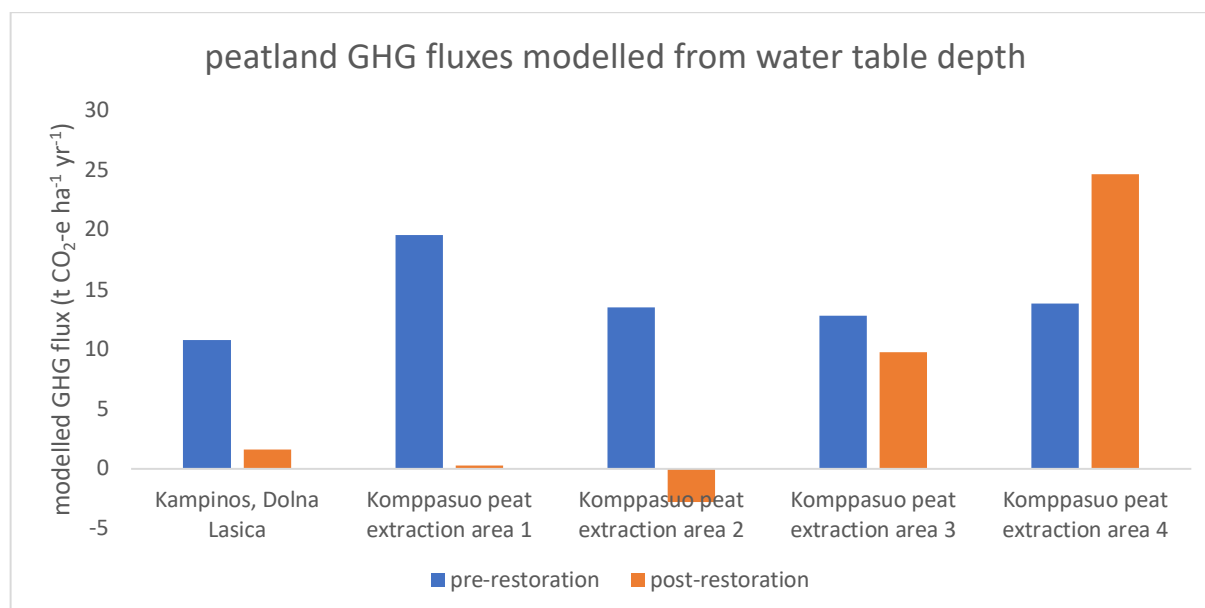


Figure 15 – Total modelled carbon stock increase for case studies of the Peatlands and Wetlands Cluster.

CS6 did not directly report any impacts of restoration on the peatland but did report a small increase in floodplain area, which is modelled to increase carbon stocks in the soils over the next 20 – 40 years.

The new wetland areas reported by CS03 after artificial beaver dam installation were small, and represented well the size of beaver dams in the Swedish forest landscape. Potential impacts could include an increase in carbon sequestration if the beaver pond is located on peatlands, but on the other hand CH₄ emissions could also increase after inundation. The direct impacts on climate mitigation were, however, not the main targets for this case study.

CS12 reported an increase in restored mineral wetlands, so using IPCC methods for mineral wetland soils suggests that carbon stocks in these soils will increase over the next 40 years, thus improving climate regulation.

CS01 did not report any peatland restoration during the Merlin project.

To summarise the impact of peatland and wetland restoration on climate regulation: the rewetting of peatlands has raised the water levels towards the surface, which has reduced CO₂ emissions, improving climate regulation. This reduction in CO₂ emissions, and even CO₂ sequestration, following rewetting is a well-established impact of peatland restoration (e.g. Koch et al., 2023), even though in the short to medium term the functioning of restored peatlands may not mirror that of natural sites (e.g. Loisel & Gallego-Sala, 2022; Kreyling et al., 2021).

The restoration of mineral wetlands has restored floodplain areas and should increase carbon stocks within the soils, but direct measurements of these changes would require longer post-restoration time frame than available within the Merlin project.

Flood Resilience

Overview

17 case studies reported on individual indicators of the flood Resilience criterion (Table 17) using the reporting templates. Two of the case studies (CS09 – Tisza floodplain rewetting HU, CS16 Upper Scheldt restoration BE) delivered additional information in form of a narrative.

Table 17 – Indicator codes, units and indicator names for the Flood Resilience criterion.

Indicator code	Unit	Indicator name
FR1	(m ³)	Storage capacity (m ³) of restored rivers and streams (based on surface area of rivers, streams and other water bodies)
FR2	(m ³)	Storage capacity (m ³) of wetlands (based on surface area of restored wetlands and floodplains)
FR3	(ha)	Area of newly designated areas for flooding (e.g., area of floodplain gain in result of dyke relocation (ha)
FR4	(ha)	Area of rewetted wetlands (other than peatlands)
FR5	(ha)	Area of rewetted peatlands (ha)
FR6	(m ³ /s)	Safe discharge capacity of restored rivers and streams (m ³ /s) (the peak volume of water which can pass the river without causing harm to the neighborhood, i.e. ecologically important riparian area)
FR7	(ha)	Area discharging runoff to the restored site (ha)
FR8	(m ³)	Volume of rewetted peat (m ³)
FR9	(ha)	Area of restored rivers and streams (ha)
FR10	(m ³)	Volume of channel retention gained as a result of restoration (m ³)
FR11	(ha) / (m)	Area of developed wetland buffer zones (ha) / length of developed buffer zone (m)
FR12	(narrative)	Changes in Flood Risk Management Plans over time (narrative)
FR13	<units>	Other measures that case-studies want to monitor

For five of the indicators – FR1 (Storage capacity of restored rivers and streams), FR2 (Storage capacity of wetlands), FR3 (Area of newly designated areas for flooding), FR4 (Area of rewetted wetlands (other than peatlands)), FR9 (Area of restored rivers and streams) – at least 10 case studies reported data. However, not in all cases both pre- and post-restoration data were delivered.

FR1 – storage capacity of restored rivers and streams (Figure 16)

At CS02 (Deba barrier removal ES), due to the obstacle removal, some storage capacity got lost. A very high increase in storage capacity of restored rivers and streams, due to the large spatial scale, was observed for CS11 (Emscher basin restoration DE; 2,340,000 m³). At CS03 (Beaver River engineering SE) the same increase was observed both at the intervention site and the control site. Therefore, it is difficult to assess whether this increase can be attributed to the restoration measure.

At CS05 (Kampinos wetland rewetting PL) data were elaborated in 8 consecutive years after the restoration measure. The data show fluctuations between 35,000 and 60,000 m³.

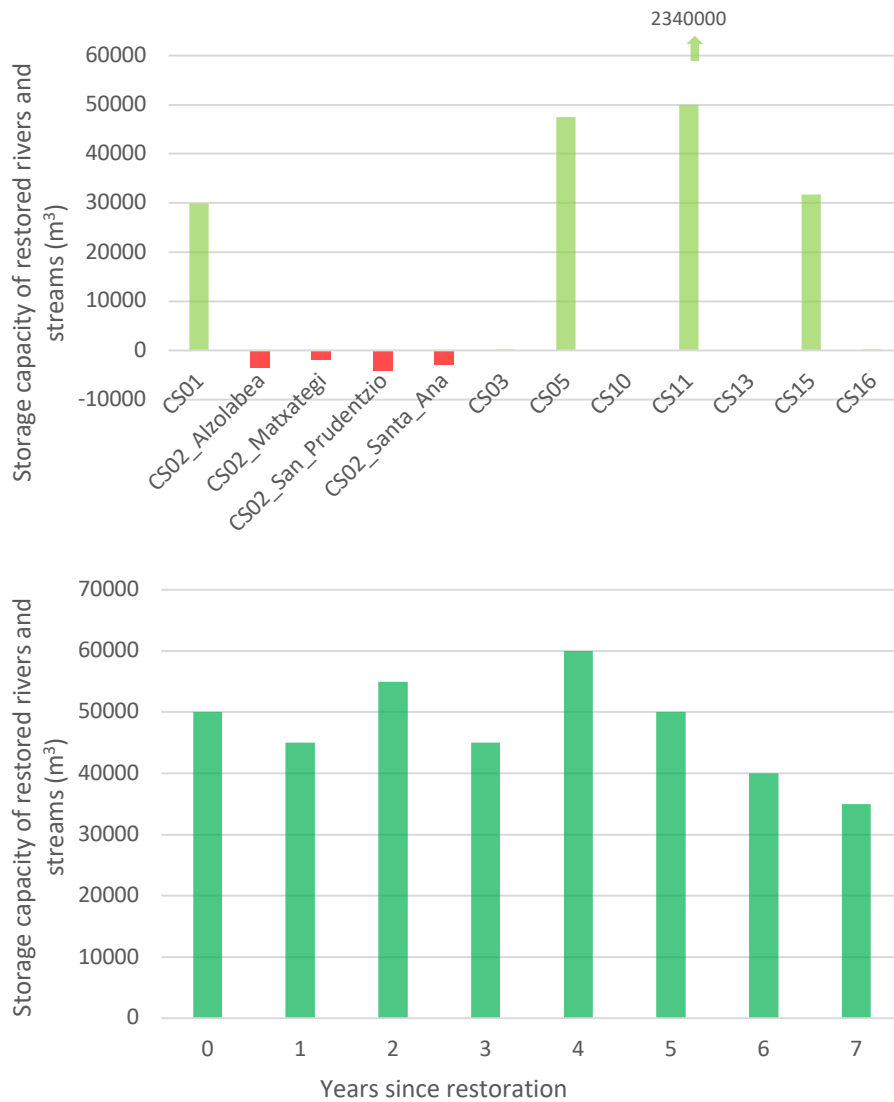


Figure 16 - Storage capacity of restored rivers and streams as result of the restoration measures. Top: Values for individual case studies (the value for CS05 is an average value); bottom: Values for CS05 after restoration.

FR2 – storage capacity of wetlands (Figure 17)

CS10 (Blue Belt Germany DE), a large-scale project, showed a very high increase in storage capacity of wetlands.

The 8 years of data after restoration elaborated at CS05 (Kampinos wetland rewetting PL) show fluctuations ranging from 500,000 to 1,200,000 m³.



Figure 17 – Storage capacity of wetlands as result of the restoration measures. Top: Values for individual case studies (the values for CS05, CS08 and CS09 are average values); bottom: Values for CS05 after restoration.

FR3 – area of newly designated areas for flooding (Figure 18)

Higher values for area of newly designated areas for flooding were reported for CS05 (Kampinos wetland rewetting PL), CS09 (Tisza floodplain rewetting HU) and CS11 (Emscher basin restoration DE).

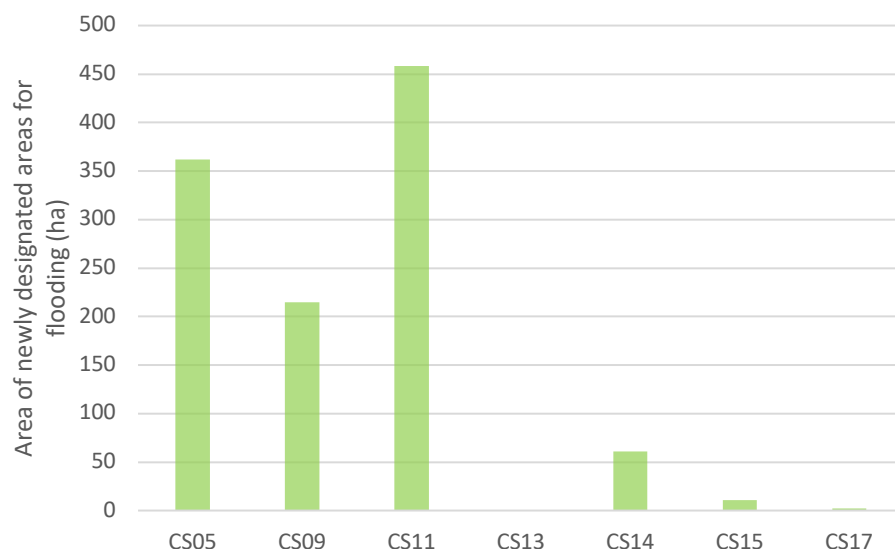


Figure 18 – Area of newly designated areas for flooding as result of the restoration measures (the values for CS05 and CS09 are average values).

FR4 – area of rewetted wetlands (other than peatlands) (Figure 19)

Particularly high values for the area of rewetted wetlands (other than peatlands) were registered for CS01 (Kvorning wetland rewetting DK) and CS05 (Kampinos wetland rewetting PL).

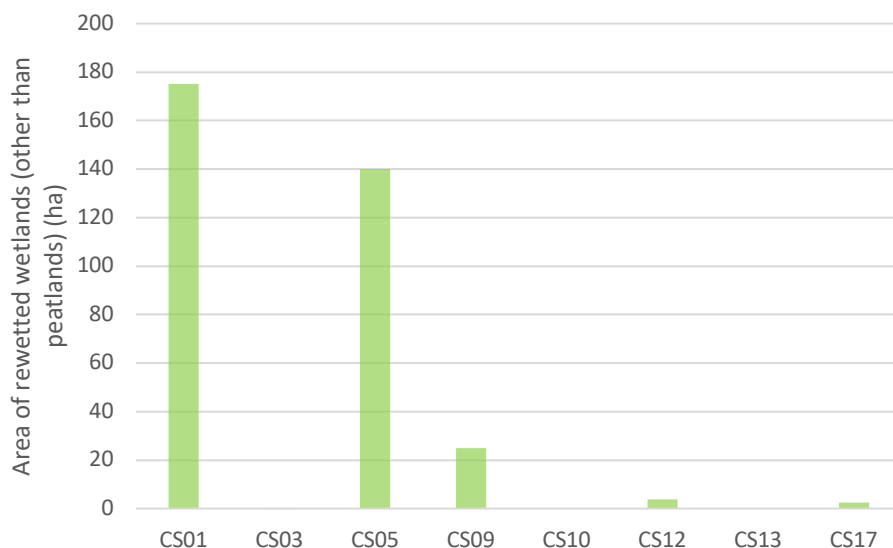


Figure 19 – Area of rewetted wetlands (other than peatlands) as result of the restoration measures (the values for CS05 and CS09 are average values).

FR9 – area of restored rivers and streams (Figure 20)

The very most case studies reported only low numbers for area of restored rivers and streams as result of the restoration measures. An exception is CS10 (Blue Belt Germany DE), which because of spatial range and type of the restoration, reported a very high amount.

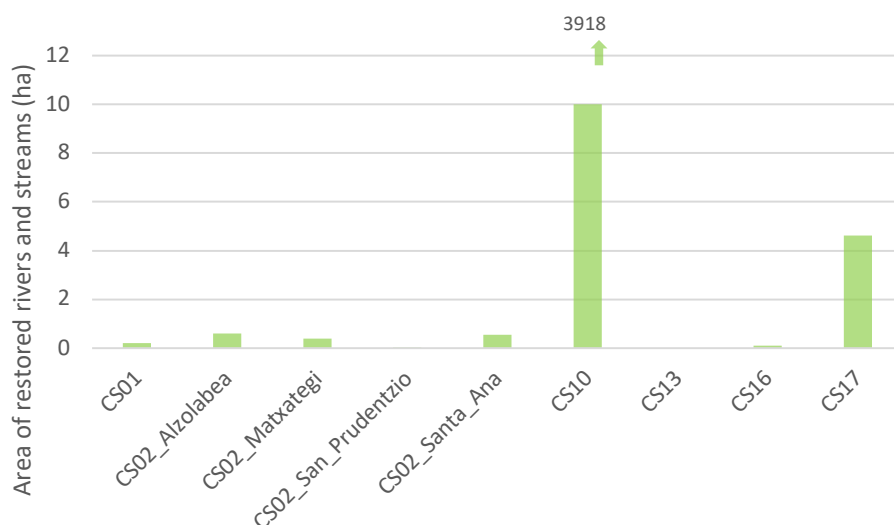


Figure 20 – Area of restored rivers and streams as result of the restoration measures.

Assessment of the criterion for individual case studies

The reported data were subjected to an attempt to assess the individual reported indicators, including a consultation with the respective case studies. Based on this assessment an aggregated assessment for the Flood Resilience criterion for the individual case studies is provided (Table 18). Assessment of indicators and the aggregated assessment were done following the approach described in chapter 3.1 of the deliverable.

Table 18 – Assessment of the reported data for the Flood Resilience criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetting DK	FR1	Increase as result of the measure. [RY -2 to +4]	😊	😊 ₇
	FR2	Increase as result of the measure. [RY -2 to +4]	😊	
	FR4	Increase as result of the measure. [RY -2 to +4]	😊	

	FR5	Increase as result of the measure. [RY -2 to +4]		
	FR7	No changes observed. [RY -2 to +4]		
	FR8	Increase as result of the measure. [RY -2 to +4]		
	FR9	Increase as result of the measure. [RY -2 to +4]		
CS03 – Beaver river engineering SE	FR1	Increase both at intervention site and control site. [RY -2 to +2]		 1
	FR4	Increase as result of the measure. [RY -2 to +2]		
CS05 – Kampinos wetland rewetting PL	FR1	Increase as result of the measure. [RY -2 to +7]		 5
	FR2	Increase as result of the measure. [RY -2 to +7]		
	FR3	Increase as result of the measure. [RY -2 to +7]		
	FR4	Increase as result of the measure. [RY -2 to +7]		
	FR5	Increase as result of the measure. [RY -2 to +7]		
CS06 – Hutovo Blato peatland rewetting BiH	Up to now only pre-restoration data reported.			NA
CS12 – Lima floodplain forest restoration PT	FR2	No changes observed. [RY -2 to +2]		 2
	FR4	Increase as result of the measure. [RY -2 to +2]		

CS14 – Komppasuo peatland rewetting FI	FR2	Increase as result of the measure. [RY -3 to +1]	😊	😊6
	FR3	Increase as result of the measure. [RY -3 to +1]	😊	
	FR5	Increase as result of the measure. [RY -3 to +1]	😊	
	FR7	Increase as result of the measure. [RY -3 to 1]	😊	
	FR8	Increase as result of the measure. [RY -3 to +1]	😊	
	FR13	Open water surface increased as result of the measure. [RY -3 to +1]	😊	
Small streams and basins				
CS02 – Deba barrier removal ES	FR1	Decrease as result of the measures, but this reduced flood risk upstream. [-2 to +2]	😊	😊4
	FR9	Increase as result of the measures. [-2 to +2]	😊	
	FR12	Overall, there is an indication that removal of the four weirs reduced the local flood risk. [-2 to +2]	😊	
	FR13	Changes in retention time: Depends on discharge intensity. [- 2 to +2]	😐	
CS11 – Emscher basin restoration DE	FR1	Increase as result of the measure. [RY – NA]	😊	😊3
	FR2	Increase as result of the measure. [RY – NA]	😊	

	FR3	Increase as result of the measure. [RY – NA]		
CS13 – Sorraia river restoration PT	FR1	No changes observed. [RY 0 (pre) to +2]		 6
	FR3	No changes observed. [RY 0 (pre) to +2]		
	FR4	No changes observed. [RY 0 (pre) to +2]		
	FR9	No changes observed. [RY 0 (pre) to +2]		
	FR10	No changes observed. [RY 0 (pre) to +2]		
	FR11	Increase as result of the measure. [RY 0 (pre) to +2]		
CS15 – Tzipori basin restoration IL	FR1	Increase as result of the measure. [RY -2 to +2]		 4
	FR2	Increase as result of the measure. [RY -2 to +2]		
	FR3	Increase as result of the measure. [RY -2 to +2]		
	FR7	No changes observed. [RY -2 to +2]		
CS16 – Upper Scheldt restoration BE	FR1	Increase as result of the measure. [RY -4 to 0 (post)]		 3
	FR9	Increase as result of the measure. [RY -4 to 0 (post)]		
	FR13	Increase as result of the measure. [RY -4 to 0 (post)]		
CS17 – Forth basin restoration UK	FR3	Increase as result of the measure. [RY -2 to +2]		 4

	FR4	Increase as result of the measure. [RY -2 to +2]	😊	
	FR9	Increase as result of the measure. [RY -2 to +2]	😊	
	FR12	Increased investments into Natural Flood Management measures. [RY -2 to +2]	😊	
CS18 – Ervidel river restoration PT	FR4	No changes observed. [RY -1 to 0 (during)]	😐	😊 ₃
	FR9	Increase as result of the measure. [RY -1 to 0 (during)]	😊	
	FR11	Increase as result of the measure. [RY -1 to 0 (during)]	😊	
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	Narrative	Effect of the removal of the traverses has no significant impact on the storage capacity. [RY – NA]	😐	😐 ₁
CS07b – Danube sidearm reconnect HU	FR3	Increase as result of the measure. [0 (during) to +9]	😊	😊 ₄
	FR9	Increase as result of the measure. [0 (during) to +9]	😊	
	FR10	Increase as result of the measure. [0 (during) to +9]	😊	
	FR11	No changes observed. [0 (during) to +9]	😐	
CS08 – Danube	FR2	Directly after measure decrease,	😊	😊 ₂

floodplain reconnect RO		but later increase. [RY 0 (pre) to +4]		
	FR7	Directly after measure decrease, but later increase. [RY 0 (pre) to +4]	😊	
CS09 – Tisza floodplain rewetting HU	FR2	Increase as result of the measure. [RY -8, -2, 0, +2, +8, +14]	😊	😊5
	FR3	Increase as result of the measure. [RY -8, -2, 0, +2, +8, +14]	😊	
	FR4	Increase as result of the measure. [RY -8, -2, 0, +2, +8, +14]	😊	
	FR7	Increase as result of the measure. [RY -8, -2, 0, +2, +8, +14]	😊	
	FR12	Indication that the flood risk is reduced. [RY -2, 0, +8]	😊	
CS10 – Blue Belt Germany DE	FR1	No changes observed. [RY – NA]	😐	😊4
	FR2	Increase as result of the measure. [RY – NA]	😊	
	FR4	No changes observed. [RY – NA]	😐	
	FR9	Increase as result of the measure. [RY – NA]	😊	

Note: For explanation of assessment symbols see Box 1. For indicator codes see Table 17.

In the majority of the cases studies the implemented measures provided with improved conditions regarding Flood Resilience. This is to a high degree due to the fact that the measures itself improved directly the conditions for one or more of the indicators. In many cases, the improvements measured by the respective indicators were a target of the restoration measures itself, as is also indicated by some of the more frequently selected indicators (e.g. area of newly designated areas for flooding, area of rewetted wetlands, area of restored rivers and streams).

Drought Resilience

Overview

17 case studies reported on individual indicators of the Flood Resilience criterion (Table 19) using the reporting templates. Two of the case studies (CS09 – Tisza floodplain rewetting HU, CS16 Upper Scheldt restoration BE) delivered additional information in form of a narrative.

Table 19 – Indicator codes, units and indicator names for the Drought Resilience criterion.

Indicator code	Unit	Indicator name
DR1	(m ³)	Storage capacity (m ³) of restored rivers and streams (based on surface area of rivers, streams and other water bodies)
DR2	(m ³)	Storage capacity (m ³) of wetlands (based on surface area of restored wetlands and floodplains)
DR3	(ha)	Area of rewetted wetlands (other than peatlands) (ha)
DR4	(ha)	Area of rewetted peatlands (ha)
DR5	(m ³)	Increase in storage capacity (m ³) due to peatland rewetting
DR6	(ha)	Area discharging runoff to the restored site (ha)
DR7	(ha)	Area of agricultural lands with applied schemes for water retention (ha)
DR8	(m)	Length of rivers gained through reconnection of oxbows (m)
DR9	(cm)	Average annual increase of water levels in restored wetlands (cm)
DR10	(m ³)	If feasible (site dependent) – change of groundwater water abstraction by sector over time (e.g. last 20 years) (m ³)
DR11	(m ³)	If feasible (site dependent) – change of surface water abstraction by sector over time (e.g. last 20 years) (m ³)
DR12	(no. of households)	If feasible (site dependent) – number of households implementing water-saving technologies (no. of households)
DR13	<units>	Other measures that case-studies want to monitor

With respect to four of the indicators – DR1 (Storage capacity of restored rivers and streams), DR2 (Storage capacity of wetlands), DR3 (Area of rewetted wetlands (other than peatlands)), DR6 (Area discharging runoff to the restored site) – at least six case studies reported data. However, not in all cases both pre- and post-restoration data were delivered.

Selected statistical analyses

Because DR1, DR2 and DR3 are synonymous with FR1, FR2 and FR4 respectively, for results on relevant indicators of the Drought Resilience criterion see Figure 16, Figure 17 and Figure 19.

Assessment of the criterion for individual case studies

The reported data were subjected to an attempt to assess the individual reported indicators, including a consultation with the respective case studies. Based on this assessment an aggregated assessment for the Drought Resilience criterion for the individual case studies is provided (Table 20). Assessment of indicators and the aggregated assessment were done following the approach described in chapter 3.1 of the deliverable.

Table 20 – Assessment of the reported data for the Drought Resilience criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetted DK	DR1	Increase as result of the measure. [RY -2 to +4]	😊	😊 ₆
	DR2	Increase as result of the measure. [RY -2 to +4]	😊	
	DR3	Increase as result of the measure. [RY -2 to +4]	😊	
	DR4	Increase as result of the measure. [RY -2 to +4]	😊	
	DR5	Increase as result of the measure. [RY -2 to +4]	😊	
	DR6	No changes observed. [RY -2 to +4]	😐	
CS03 – Beaver river engineering SE	DR1	Increase both at intervention site and control site. [RY -2 to +2]	😐	😐 ₂
	DR7	No changes observed. [RY -2 to +4]	😐	
	DR12	No changes observed. [RY -2 to +2]	😐	
CS05 – Kampinos wetland rewetted PL	DR1	Increase as result of the measure. [RY -2 to +7]	😊	😊 ₅
	DR2	Increase as result of the measure. [RY -2 to +7]	😊	

	DR3	Increase as result of the measure. [RY -2 to +7]		
	DR4	Increase as result of the measure. [RY -2 to +7]		
	DR5	Increase as result of the measure. [RY -2 to +7]		
CS06 - Hutovo Blato peatland rewetting BiH	Up to now only pre-restoration data reported.			NA
CS12 – Lima floodplain forest restoration PT	DR2	No changes observed. [RY -2 to +2]		 3
	DR3	Increase as result of the measure. [RY -2 to +2]		
	DR8	No changes observed. [RY -2 to +2]		
CS14 – Komppasuo peatland rewetting FI	DR2	Increase as result of the measure. [RY -3 to +1]		 1
	DR4	Increase as result of the measure. [RY -3 to +1]		
	DR5	Increase as result of the measure. [RY -3 to +1]		
	DR6	Increase as result of the measure. [RY -3 to +1]		
	DR9	Increase as result of the measure. [RY -3 to +1]		
Small streams and basins				
CS02 – Deba barrier removal ES	DR1	Very small decrease as result of the measures. Has no effect on drought resilience. [RY -2 to +2]		 1
	DR1	Increase as result of the measure. [RY – NA]		 2

CS11 – Emscher basin restoration DE	DR2	Increase as result of the measure. [RY – NA]		
CS13 – Sorraia river restoration PT	DR1	No changes observed. [RY 0 (pre) to +1]		 3
	DR3	No changes observed. [RY 0 (pre) to +1]		
	DR13	Temporary pool refuges, which have a significant number of days of permanency of water, created. [RY – 0 (pre) - +1]		
CS15 – Tzipori basin restoration IL	DR1	Increase as result of the measure. [RY -2 to +2]		 3
	DR2	Increase as result of the measure. [RY -2 to +2]		
	DR6	No changes observed. [RY -2 to +2]		
CS16 – Upper Scheldt restoration BE	DR1	Increase as result of the measure. [RY -4 to 0 (post)]		 1
CS17 – Forth basin restoration UK	DR3	Increase as result of the measure. [RY -2 to +2]		 1
CS18 – Ervidel river restoration PT	DR13	Increased water saving resulting from agriculture practices. [RY -1 to 0 (during)]		 1
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	Narrative	Effect of the removal of the traverses has no significant impact on the storage capacity. [RY – NA]		 1
CS07b – Danube	DR8	No changes observed. [RY 0 (during) to +9]		 1

sidearm reconnect HU				
CS08 – Danube floodplain reconnect RO	DR2	Increase as result of the measure. [RY 0 (pre) to +4]		 3
	DR6	Directly after measure decrease, but later increase. [RY 0 (pre) to +4]		
	DR9	Increase as result of the measure. [RY 0 (pre), +1, +3, +4]		
CS09 – Tisza floodplain rewetting HU	DR2	Increase as result of the measure. [RY -8, - 2, 0, +2, +8, +14]		 5
	DR3	Increase as result of the measure. [RY -8, - 2, 0, +2, +8, +14]		
	DR6	Increase as result of the measure. [RY -8, - 2, 0, +2, +8, +14]		
	DR7	No changes observed. [RY -8, -2, 0, +2, +8, +14]		
	DR9	Increase only for short time, but higher maximum. [RY -8, -2, 0, +2, +8, +14]		
CS10 – Blue Belt Germany DE	DR1	No changes observed. [RY – NA]		 3
	DR2	Increase as result of the measure. [RY – NA]		
	DR3	No changes observed. [RY – NA]		

Note: For explanation of assessment symbols see Box 1. For indicator codes see Table 19.

With respect to drought resilience also many case studies reported a positive impact of the restoration measures. This is not a surprise, because often flood resilience and drought resilience are related. Therefore, several of the indicators for changes in drought resilience are in accordance with indicators for changes in flood resilience.

Health and Well-Being

Overview

Altogether, 15 case studies reported on individual indicators of the Health and Well-Being criterion (Table 21) using the reporting templates. One of the case studies (CS09 – Tisza floodplain rewetting HU) delivered additional information in form of a narrative.

Table 21 – Indicator codes, units and indicator names for the Health and Well-Being criterion.

Indicator code	Unit	Indicator name
HWB1	km / km2 of restored area	Length of active travel routes within or connected to the restoration area
HWB2	%	% of active travel routes in proximity to (or within) disadvantaged communities
HWB3	narrative	Features supporting well-being and/or aesthetic attractiveness of the environment
HWB4	narrative	Nature-based activities supporting Health and Wellbeing
HWB5	narrative	Features supporting access to restored natural environment
HWB6	narrative	Changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents
HWB7	<units>	Other

Particularly high amount of case studies reported on the indicators HWB1 (Length of active travel routes within or connected to the restoration area, 11 case studies), HWB3 (Features supporting well-being and/or aesthetic attractiveness of the environment, 11 case studies), HWB4 (Nature-based activities supporting Health and Wellbeing, 10 case studies), HWB5 (Features supporting access to restored natural environment, 8 case studies) and HWB6 (Changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents, 8 case studies). In the most cases both pre- and post-restoration data were reported.

HWB1 – Length of active travel routes within or connected to the restoration area (Figure 21)

Six case studies reported an increase in length of active travel routes within or connected to the restoration area, whereas some other six case studies reported no increase. The large-scale restoration case study CS11 (Emscher basin restoration DE) reported by far the highest number with more than 100 km. In the other case studies the values were between 7 and 27 km.

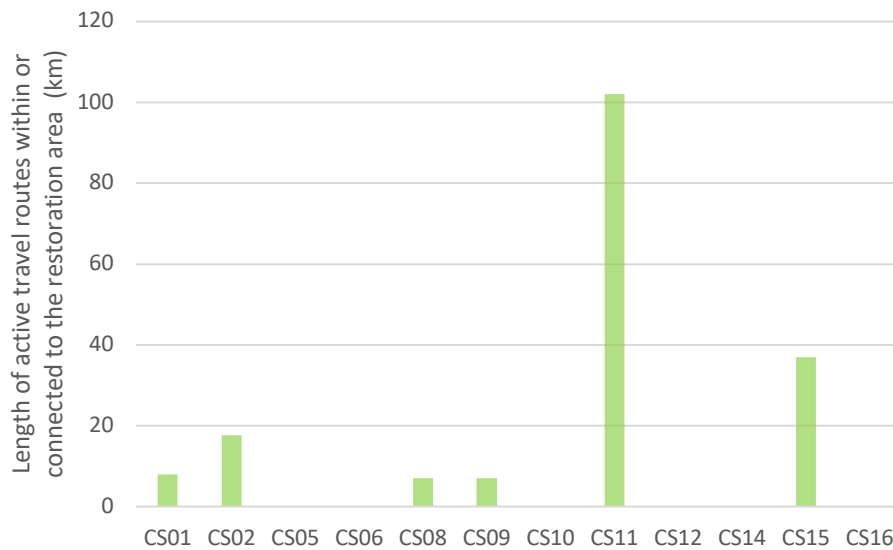


Figure 21 - Length of active travel routes within or connected to the restoration area as result of the restoration measures.

HWB3 – Features supporting well-being and/or aesthetic attractiveness of the environment, HWB4 – Nature-based activities supporting Health and Wellbeing, and HWB5 – Features supporting access to restored natural environment

Several case studies reported on these indicator using narratives. Whereas a high proportion of case studies demonstrated a positive influence of the restoration measure on features supporting well-being and/or aesthetic attractiveness of the environment (10 x improvement, 2 x no change) and features supporting access to restored natural environment (7 x improvement, 2 x no change), a lower proportion reported a positive influence on nature-based activities supporting Health and Wellbeing (7 x improvement, 4 x no change).

HWB6 – Changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents

Many case studies indicated no influence of the restoration measure on changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents, but two case studies reported an improvement and one case study reported a negative impact.

Assessment of the criterion for individual case studies

The results of an aggregated assessment for the Health and Well-Being criterion for the individual case studies based on an assessment of the reported data are shown in Table 22. Assessment of indicators and the aggregated assessment were done following the approach described in chapter 3.1 of the deliverable.

Table 22 – Assessment of the reported data for the Health and Well-Being criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetting DK	HWB1	Increase as result of the measure. [RY – NA]	😊	😊5
	HWB2	No changes observed. [RY – NA]	😐	
	HWB3	Improvement as result of the measure. [RY – NA]	😊	
	HWB4	Improvement as result of the measure. [RY – NA]	😊	
	HWB5	Improvement as result of the measure. [RY – NA]	😊	
CS03 – Beaver river engineering SE	HWB3	Narrative indicates some improvement. [RY – NA]	😊	😊3
	HWB4	No changes observed. [RY – NA]	😐	
	HWB6	No significant changes observed. [RY – NA]	😐	
CS05 – Kampinos wetland rewetting PL	HWB1	No changes observed. [RY – NA]	😐	😐1
CS06 – Hutovo Blato peatland rewetting BiH	HWB1	No changes observed. [RY – NA]	😐	😊3
	HWB3	Narrative describes improvement as result of the measure. [RY – NA]	😊	
	HWB4	No changes observed. [RY – NA]	😐	
CS12 – Lima floodplain forest restoration PT	HWB1	No changes observed. [RY – NA]	😐	😐6
	HWB2	No changes observed. [RY – NA]	😐	
	HWB3	No changes observed. [RY – NA]	😐	
	HWB4	No significant changes (narrative might even indicate a slight decrease). [RY – NA]	😐	
	HWB5	No changes observed. [RY – NA]	😐	
	HWB6	No changes observed. [RY – NA]	😐	

CS14 – Komppasuo peatland rewetting FI	HWB1	No changes observed. [RY – NA]	😐	😊6
	HWB2	No changes observed. [RY – NA]	😐	
	HWB3	Improvement as result of the measure. [RY – NA]	😊	
	HWB4	According to narrative probably no changes with respect to hunting activities. [RY – NA]	😐	
	HWB5	Improvement as result of the measure. [RY – NA]	😊	
	HWB6	No changes observed. [RY – NA]	😐	
Small streams and basins				
CS02 – Deba barrier removal ES	HWB1	Increase as result of the measure. [RY – NA]	😊	😊3
	HWB3	Narrative indicates some improvement. [RY – NA]	😊	
	HWB6	Improvement as result of the measure. [RY – NA]	😊	
CS11 – Emscher basin restoration DE	HWB1	Increase as result of the measure. [RY – NA]	😊	😊4
	HWB4	Improvement as result of the measure. [RY – NA]	😊	
	HWB5	Improvement as result of the measure. [RY – NA]	😊	
	HWB6	Improvement as result of the measure. [RY – NA]	😊	
CS13 – Sorraia river restoration PT	HWB7	Geocaching as result of the measure. [RY – NA]	😊	😐2
	HWB7	Reduced number of Wikiloc hiking trails as result of the measure. [RY – NA]	😞	
CS15 – Tzipori basin restoration IL	HWB1	Increase as result of the measure. [RY – NA]	😊	😊6
	HWB2	Increase as result of the measure. [RY – NA]	😊	
	HWB3	Improvement as result of the measure. [RY – NA]	😊	
	HWB4	Improvement as result of the measure. [RY – NA]	😊	

	HWB5	Improvement as result of the measure. [RY – NA]	😊	
	HWB6	No changes observed. [RY – NA]	😐	
CS16 – Upper Scheldt restoration BE - site 1	HWB3	Improvement as result of the measure. [RY – NA]	😊	😊 ₃
	HWB4	Narrative indicates some improvement. [RY – NA]	😊	
	HWB5	Improvement as result of the measure. [RY – NA]	😊	
CS16 – Upper Scheldt restoration BE - site 2	HWB1	No changes observed. [RY – NA]	😐	😊 ₄
	HWB3	Improvement as result of the measure. [RY – NA]	😊	
	HWB4	Narrative indicates some improvement. [RY – NA]	😊	
	HWB5	Improvement as result of the measure. [RY – NA]	😊	
CS17 – Forth basin restoration UK	HWB3	Improvement as result of the measure. [RY – NA]	😊	😊 ₁
CS18 – Ervidel river restoration PT	HWB7	Number of hunters and hunting activities increased. [RY – NA]	😊	😊 ₁
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	No monitoring data reported.			NA
CS07b – Danube sidearm reconnect HU	No monitoring data reported.			NA
CS08 – Danube floodplain reconnect RO	HWB1	Increase as result of the measure. [RY – NA]	😊	😊 ₅
	HWB3	No changes observed. [RY – NA]	😐	
	HWB4	Narrative indicates some improvement as result of the measure. [RY – NA]	😊	
	HWB5	No changes observed. [RY – NA]	😐	
	HWB6	No changes observed. [RY – NA]	😐	

CS09 – Tisza floodplain rewetting HU	HWB1	Increase as result of the measure. [RY – NA]	😊	😊 ₆
	HWB2	Increase as result of the measure. [RY – NA]	😊	
	HWB3	Narrative indicates some improvement. [RY – NA]	😊	
	HWB4	Improvement as result of the measure. [RY – NA]	😊	
	HWB5	Improvement as result of the measure. [RY – NA]	😊	
	HWB6	Occurrence of mosquitoes. [RY – NA]	😞	
CS10 – Blue Belt Germany DE	HWB1	No changes observed. [RY – NA]	😐	😊 ₅
	HWB3	Improvement as result of the measure. [RY – NA]	😊	
	HWB4	Narrative indicates some improvement. [RY – NA]	😊	
	HWB5	Narrative indicates some improvement. [RY – NA]	😊	
	HWB6	No changes observed. [RY – NA]	😐	

Note: For explanation of assessment symbols see Box 1. For indicator codes see Table 21.

Based on the reported data for the majority of the case studies a positive impact on the Health and Well-Being criterion can be stated. All indicators were reported with a positive impact at least once. Notably, the most prominent benefits related to features supporting well-being and aesthetic attractiveness and supporting access to restored natural environment, nature-based activities supporting Health and Well-Being and the length of active travel routes.

Zero Pollution

Overview

Sixteen case studies reported on 12 individual indicators of the Zero Pollution Criterion (Table 23). Of these, case studies 16 reported on multiple locations and are dealt with separately at times in our analysis. No case study included a comprehensive assessment of Zero Pollution responses within the submitted Narrative Reports.

The use of multiple sub-indicators, or specific indicators was a particular consideration in the synthesis analysis complicating a meta-statistical approach to explore commonality in responses across indicator types (Table 24). For example, Sub-Indicator Unique Identification Codes were highly variable for many determinants, likely representing the lack of a consistent terminology used by reporting laboratories. For this reason, the analysis presented here considers site responses independently of each other. Most case studies did not employ a full Before-After-Control-Impact study design, with the exception of case study 3.

To demonstrate the variability in the data across the case studies, we present the WFD Water Quality Class assessment data as an Integrating Indicator, and one that was commonly reported, where data were submitted (Table 25).

In many cases a Before-After analysis was not possible due to lack of data from either period. In the ‘Synthetic Analysis’ approach used (Table 26), assessments of responses for Indicator Categories are given a confidence rating which is low if no control data were available, regardless of the length of data available in the Before-After analysis. For many case studies aggregated assessments presented we report very low confidence in the result. Most assessments were based on low numbers of years either before the intervention, after it, or both.

Table 23 – Indicator codes, units and indicator names for the Zero Pollution criterion.

Indicator code	Unit	Indicator name
ZP1	WFD class	Surface water: chemical status
ZP2	(mg/L)	Surface water: Nutrient concentrations (nitrogen and phosphorus)
ZP3	(mg/L)	Surface water: Dissolved and total organic carbon (DOC, TOC) (for modelling greenhouse gas emissions)
ZP4	(mg/L)	Surface water: chemical/biological oxygen demand (COD, BOD)
ZP5	(narrative)	Surface water: specific and priority chemicals, e.g. toxic metals, hydrocarbons, polyaromatic hydrocarbons, micropollutants such as pharmaceutical residuals, antibiotics, endocrine substances, pesticides, industrial chemicals such as PCB, PFC, AOX
ZP6	(narrative)	Surface water: microplastics
ZP7	(MPN/100 mL)	Surface water: pathogenic bacteria (<i>E. coli</i> , Enterococci)
ZP8	WFD class	Groundwater: chemical status
ZP9	(mg/L)	Groundwater: nitrate-nitrogen concentrations (NO ₃ -N)
ZP10	(PSU) / (S/m)	Groundwater: salinity/conductivity of groundwater
ZP11	(narrative)	Groundwater: concentrations of specific and priority chemical pollutants
ZP12	(narrative)	Restored wetlands, floodplains and buffer strips: Sediment transport in streams and rivers
ZP13	(mg/L)	Restored wetlands, floodplains and buffer strips: Nutrient concentrations (nitrogen and phosphorus)
ZP14	(narrative)	Restored wetlands, floodplains and buffer strips: Suspended solids (inorganic and organic particulate matter)
ZP15	(narrative)	Restored wetlands, floodplains and buffer strips: Chemical concentrations in soils (e.g. pesticides)
ZP16	(narrative)	Restored wetlands, floodplains and buffer strips: Modelling water quality
ZP17	(enter unit)	Other indicator not listed above

Table 24 – Summary of reporting across MERLIN Indicator Codes with case study Sites grouped across the clusters: Peatland & Wetland, Small Streams & Basins, and Large Transboundary Rivers. Confirmation of data being submitted under each Indicator Code for each case study in the submitted forms as of 29/01/2025. Blank cells – no data were submitted for the Indicator Code; Pre – at least one data record was submitted for a Specific Indicator under this Indicator Code and assigned to a pre-intervention year; Post – at least one record was submitted for a Specific Indicator under this Indicator Code and assigned to a post-intervention year. Unique IDs – the number of Specific Indicator Terms for which data records were submitted across all case studies for each Indicator Code; values in square brackets indicate the number of Unique IDs for each Indicator Code with unclear or inconsistent terminology used leading to a complication of comparative analyses [e.g. ‘Zinc Solved’ and ‘Zn’; ‘Chloride Total’ and ‘Cl-’ were both reported as Unique IDs under ZP5; nine Unique ID variations were reported under ZP2 apparently corresponding to ‘PO4-P’, ‘orthophosphate-P’, ‘Orthophosphate-phosphorus’, ‘Phosphate’, ‘Phosphate (PO₄)’, ‘PO₄’, ‘P-PO₄’, ‘SRP’, ‘Total phosphates’, in addition to a report of ‘PO₄-P’ under ZP17; similar scenarios play out for ‘NH₄-N’ and ‘NO₃-N’ limiting scope for synthesis analyses across case studies].

	Unique IDs	Peatlands & Wetlands					Small Streams & Basins								Large Transboundary Rivers			
		CS01	CS03	CS05	CS12	CS14	CS02	CS11	CS13	CS15	CS16 Site 1	CS16 Site 2	CS17	CS18	CS04	CS08	CS07b	1CS0
ZP1	1		Both		Pre	Both	Both	Pre		Pre	Both	Pre	Pre		Both	Both	Post	Both
ZP2	31	Pre	Both	Both	Both	Both	Both	Both	Pre	Pre	Both	Pre	Post	Pre	Both	Both	Post	Both
ZP3	5 [9]	Pre			Pre	Both	Pre	Both				Pre	Post		Both			Both
ZP4	4				Both	Both	Both			Pre	Both	Pre						
ZP5	30 [5]		Both			Both	Both	Both		Pre								
ZP7	1							Both		Pre								
ZP8	1					Both							Post		Both			Both
ZP9	1				Both													Both

ZP10	1																Post	
ZP14	1				Both													
ZP17	13					Both	Both		Pre		Pre	Pre						

Table 25 – Summary of data submitted by Case Study Reporting Teams in the Reporting Templates by Jan 2025. The shaded boxes represent the first reported post-intervention monitoring year for each case study. Records as reported are included for the Zero Pollution Indicator 2 (ZP2 – Surface Water Chemical Status – WFD Status Class).

RY	Peatlands & Wetlands					Small Streams & Basins								Large Transboundary Rivers			
	CS01	CS03	CS05	CS12	CS14	CS02	CS11	CS13	CS15	CS16 Site 1	CS16 Site 2	CS17	CS18	CS04	CS08	CS07b	CS10
-12							Good										
-11							Good										
-10							Good										
-9							Good										
-8							Good										
-7							Fail										
-6							Fail										
-5							Fail										
-4							Fail										
-3																	
-2		Fail		Gooda	Goodb	Good			Fail		Fail	Good		Unkn			Fail

-1	Unkn	Fail			Goodb	Good			Fail		Fail	Unkn		Unkn			Fail
0	Unkn	Fail			Goodb	Good			Unkn	Fail	Fail	Unkn		Fail	Good		Fail
1		Fail		UnKn	Goodb	Good			Unkn	Fail	Fail	Unkn		Unkn	Good		Fail
2		Fail		Unkn	Goodb	Good				Fail		Unkn		Fail	Good		Fail
3		Fail												Unkn	Good		Fail
4		Fail															Fail
5																	
6																	
7																	
8																Good	
9																Good	

Note: 'Gooda' reported as both 'Unknown' and 'Good' in the same year. 'Goodb' reported as 'Good, but one part of Lake Oijärvi is in moderate condition'. 'Unkn' – reported as 'Unknown'. 'Fail' reported as 'Failing' in all cases. For case study 7B - no indication of pre- restoration years in report template which covers the restoration year period +3 to +9, only.

Assessment of the criterion for individual case studies

Table 26 – Assessment of the reported data for the Zero Pollution criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year with year of intervention being assessed defined by the reporting team and stipulated where this varied from YR 0. 'BA' indicates a Before-After assessment using available pre- and post-implementation monitoring. 'BACI' indicates Before-After-Control-Impact Assessment where data from control sites were available and utilised in the assessment. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetting DK Meadow rewetting	Only pre-restoration data			NA
CS03 – Beaver river engineering SE	ZP1	WFD Chemical Status Class indicator reported consistently as 'failing' (RY -2 to +4) in five control upstream and five implementation downstream sites consistent annual reporting from RY -2 to +4. [BACI]	😐	😞 ₃
	ZP2	BA data (RY 0 to RY +4) from average of five implementation replicate sites indicated no clear reduction with year in Total Nitrogen concentration (TN). BACI indicated that TN concentrations increased slightly in intervention sites in years +3 and +4, although data for pre-intervention are sparse. [BACI]	😞	
	ZP5	No clear change in Mercury concentration was observed in either control or implementation sites over the monitoring period (RY 0 to RY 1); though data are sparse. [BACI]	😐	
CS05 – Kampinos wetland rewetting PL	ZP2	Monitoring period from RY -2 to +4 inclusive for Total Nitrogen (TN) and Total Phosphorus (TP). B-A comparison indicates slight reduction in both of about 13% TN and 14% TP, respectively, with the largest	😊	😊 ₁

		reduction towards the latter years. No control data limits confidence. [BA]		
CS06 – Hutovo Blato peatland rewetted BiH	No monitoring data reported.			NA
CS12 – Lima floodplain forest restoration PT	ZP2	Only one value for both pre- and post-intervention for both TP and TN, but indication of increase in both. Insufficient data to conduct robust assessment. [BA]		
	ZP4	Surface water COD/BOD for RY 1 and 2 indicated as 'Pre' and 'Post' restoration, respectively, by reporters. A reduction reported following intervention but data sparse. [BA]		
	ZP9	Groundwater NO3-N concentration for RY 1 and 2 indicated as 'Pre' and 'Post' restoration, respectively, by reporters. No change evident but data sparse. [BA]		
	ZP14	Suspended solids related to wetland restoration for RY 1 and 2 indicated as 'Pre' and 'Post' restoration, respectively, by reporters. Indication of a slight increase though data sparse. [BA]		
CS14 – Komppasuo peatland rewetted FI	ZP1	WFD Chemical Status Class indicator reported consistently as 'Good, but one part of Lake Oijärvi is in moderate condition' consistently between RY -2 and +2. No control data limits confidence. [BA]		
	ZP2	TP and TN data indicate a slight increase in concentration post-intervention though only one year of 'post-' (RY+2) data for comparison with 3 years of 'pre' data to RY -2. No control data limits confidence. [BA]		
	ZP3	Surface water DOC & TOC data indicate an increase post-intervention though only one year of 'post-' (RY+2) data for comparison with 1 years of 'pre-' data RY 0. No control data limits confidence. [BA]		

	ZP4	CODMn data indicate an increase post-intervention though only one year of 'post-' (RY+2) data for comparison with 3 years of 'pre-' data to RY -2. No control data limits confidence. [BA]		
	ZP5	Fe concentration data an increase post-intervention though only one year of 'post-' (RY+2) data for comparison with 3 years of 'pre-' data to RY -2. No control data limits confidence. [BA]		
	ZP8	Groundwater Chemical Status reported consistently as 'good' from RY -2 to RY +2. No control data limits confidence. [BA]		
	ZP17	Suspended solids concentration (RY 0 compared to RY +2) indicates a decrease, though data sparse. No control data limits confidence. [BA]		
Small streams and basins				
CS02 – Deba barrier removal ES	ZP1	WFD Chemical Status Class indicator reported consistently as 'good' (RY -2 to +2) for the 'upper', 'middle' and 'lower' Deba River sites indicating no change. No control data limits confidence. [BA]		 5
	ZP2	Comprehensive monitoring of filterable P and N determinants indicating a 50% reduction in NH4-N concentration but no change NO3-N or PO4-P. We assess this as a positive response overall. No control data limits confidence. [BA]		
	ZP4	No clear indication of BOD change following intervention though based on comparison of 'pre' data (n=4) with a single value for 'post'. No control data limits confidence. [BA]		
	ZP5	Comparison of average conditions from YR=-2 to Yr 0 with Yr +1 and +2 indicate no obvious changes across a suite of over 20 water quality determinants (mostly metals). Slight indication of consistent increase in some determinants around RY0 – possible intervention effect liberating metals for short period - but no		

		control data available to confirm. [BA]		
	ZP17	Comparison of average conditions from YR=-2 to Yr 0 with Yr +1 and +2 indicate a strong decrease in TSS concentration and Turbidity. Good data coverage across multiple sites and years although over few years and no control data available to confirm. [BA]		
CS11 – Emscher basin restoration DE	ZP2	‘Upstream’, ‘midstream’ and ‘downstream’ site data were compared as long-term ‘pre-’ intervention averages (up to RY -12) with only 1 year ‘post’ RY1. NH4-N decreased in the downstream site only and no other obvious changes were observed for NO3-N or PO4-P in any site. Overall, we assess this as no-change. No control data limits confidence. [BA]		
	ZP3	No obvious changes in TOC concentrations were observed across three sites although comparison with only 1 year post data. No control data limits confidence. [BA]		
	ZP5	Data on 8 determinants available with ‘post’ intervention data available from only RY +1. Decrease in Zn observed in midstream site only; decrease in Cl- across all sites, an apparent significant decrease especially in the downstream site; decrease in PFOS in downstream site only; decrease in Diclofenac in midstream and downstream sites. Overall, we assess this as indication of positive change but with low confidence. No control data limits confidence. [BA]		
	ZP7	<i>E. coli</i> levels highly variable and with comparisons possible with RY 0 and RY1, only. Increases in <i>E. coli</i> reported for upstream and downstream site with reduction reported midstream. Overall assessment is uncertain with low confidence. No control data limits confidence. [BA]		
CS13 – Sorraia river restoration PT	Only pre-restoration data			NA

CS15 – Tzipori basin restoration IL	Only pre-restoration data			NA
CS16 – Upper Scheldt restoration BE	ZP1	WFD Chemical Status Class indicator reported consistently as ‘failing’ for RY0 to RY+2 – noting RY0 and +1 are reported as pre-intervention. No control data limits confidence. [BA]	☹️	😊 ₃
	ZP2	Possible decrease in NH4-N, NO3-N, PO4-P, and TP, but no change evident in TN with comparison between RY 0 and + 1 (reported as ‘pre’) and RY +2 (reported as ‘post’), though data sparse. Overall, we assess this is improvement with low confidence. No control data limits confidence. [BA]	😊	
	ZP4	No obvious change in COD between conditions in RY 0 and + 1 (reported as ‘pre’) and RY +2 (reported as ‘post’), though data sparse. No control data limits confidence. [BA]	☹️	
CS17 – Forth basin restoration UK	Only pre- or post-restoration data			NA
CS18 – Ervidel river restoration PT	Only pre-restoration data			NA
Large transboundary rivers				
CS04 – Room for the Rhine NL	ZP1	WFD Chemical Status Class indicator reported as ‘failing’ (RY 0 and +2), with RY 0 reported as ‘pre’ intervention. No control data limits confidence. [BA]	☹️	😊 ₄
	ZP2	TP and TN concentrations reported consistently from RY -2 to RY +3, indicating a slight decrease I TN and a sharp decrease in TP following RY 0. Assessed as improving with low confidence as no control data. [BA]	😊	
	ZP3	TOC concentrations were lower in RY +2 when compared to RY -1.	☹️	

		Assessed as no change, bit low confidence as concentrations similar. No control data limits confidence. [BA]		
	ZP8	WFD Groundwater Status Class reported as 'Good' for both RY 0 and RY +1. Assessed as no change, but low confidence. No control data limits confidence. [BA]	☹️	
CS07a – Danube floodplain restoration AT	No monitoring data reported.			NA
CS07b – Danube sidearm reconnect HU	Only post-restoration data.			NA
CS08 – Danube floodplain reconnect RO	ZP1	WFD Chemical Status Class indicator reported as 'good' (RY 0 to +3), with RY 0 reported as 'pre' intervention. No control data limits confidence. [BA]	☹️	☹️ ₂
	ZP2	No obvious changes were reported in PO4-P, NO3-N and dissolved oxygen concentrations (RY 0 to +2), with RY 0 reported as 'pre' intervention. No control data limits confidence. [BA]	☹️	
CS09 – Tisza floodplain rewetting HU	No monitoring data reported.			NA
CS10 – Blue Belt Germany DE	ZP1	WFD Chemical Status Class indicator reported consistently as 'failing' (RY -2 to +4), with RY 0 reported as 'pre' intervention. No control data limits confidence. [BA]	☹️	☹️ ₅
	ZP2	No obvious change was reported in TP, TN, NH4-N, and SO4 over the RY reporting period -2 to +2. No control data limits confidence. [BA]	☹️	
	ZP3	No obvious change was reported in TOC concentration over the RY reporting period -2 to +2. No control data limits confidence. [BA]	☹️	
	ZP8	WFD Groundwater Status Class indicator reported consistently as 'failing' (RY -2 to +4), with RY 0 reported as 'pre' intervention. No control data limits confidence. [BA]	☹️	

	ZP9	No obvious change was observed in groundwater NO3-N concentration across the RY reporting period -2 to +2. No control data limits confidence. [BA]		
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Farm to Fork

Eight case-studies reported changes in area of agricultural land following restoration (Table 27). This showed that a loss in agricultural land was more common than an increase (only Blue Belt), although, on average there was a loss of only 4%. Losses were high in % terms for Tisza (66%) and Lima (38%). Tzipori lost 100% of its agricultural land although this was only a small area in absolute terms (1 ha) (Table 27). The % change was used to assess positive or negative impact, with +/- 10% considered as minor impact (yellow faces).

Table 27: Total agricultural land pre- and post-restoration, with change (ha) and % change.

CS	CS Name	Pre	Post	Change (ha)	Change (%)	Summary
CS04	Room for the Rhine NL	23396	22244	-1152	-5%	
CS07b	Danube sidearm reconnect HU	1663	1663	0	0%	
CS09	Tisza floodplain rewetting HU	205	70	-135	-66%	
CS10	Blue Belt Germany DE	130	289	159	122%	
CS12	Lima river floodplain forest restoration PT	13	8	-5	-38%	
CS15	Tzipori basin restoration IL	1	0	-1	-100%	
CS16	Upper Scheldt restoration BE	85	81	-4	-5%	
CS17	Forth basin restoration UK	25	25	0	0%	
Total		25518	24381	-1138	-4%	

Examining what types of agricultural land were most impacted, values for different agricultural land use were averaged for pre- and post- reporting years (only Rhine, Upper Scheldt & Tisza had multiple years) and for multiple sites (Emscher: Boye & Mainsteam). The biggest losses were observed in pasture (Kvorning) and arable (Kvorning & Tisza). Gains in arable (Rhine branches), permanent crops (Rhine) and pasture (Rhine, Tisza and Blue Belt) were also observed (). Unlike the previous analysis of “Total agricultural land”, this analysis based on Corine Land Cover classes provides a more mixed picture of gains and losses with different total changes than those observed for all agricultural land, shown in Table 28.

Table 28: Changes in agricultural land use after restoration.

CS	CS Name	Arable			Permanent crops			Pasture			Heterogeneous Agriculture			Total		
		Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
CS01	Kvorning wetland rewetting DK	122		-122				275		-275				397	0	-397
CS04	Room for the Rhine NL	2580	2813	233	20	35	15	17417	18412	995	200	128	-72	20217	21388	1171
CS07b	Danube sidearm reconnect HU	868	868	0	35	35	0	145	145	0	616	616	0	1663	1663	0
CS09	Tisza floodplain rewetting HU	117	40	-77	0	0		0	21	21	88	60	-28	205	121	-84
CS10	Blue Belt Germany DE							130	289	159				130	289	159
CS11	Emscher basin restoration DE										900	900	0	900	900	0
CS12	Lima river floodplain forest restoration PT							1	0	-1				1	0	-1
CS15	Tzipori basin restoration IL										6	0	-6	6	0	-6
CS16	Upper Scheldt restoration BE	85	81	-4										85	81	-4
CS17	Ervidel river restoration PT							25	25	0				25	25	0
Total change		31			15			899			-106			839		

Sustainable Energy

Overview

Seven case studies reported on individual indicators of the Sustainable Energy criterion (Table 29) using the reporting templates.

Table 29 – Indicator codes, units and indicator names for the Sustainable Energy criterion.

Indicator code	Unit	Indicator name
SE1	(t) / (kWh)	Changes to renewable energy production (positive or negative) as a result of restored areas, e.g. use of biomass from wetlands for energy production (tons or equivalent kWh energy production) or changes in hydropower production (kWh)
SE2	(kWh)	Energy consumption in private households and business as result of NbS implementation, e.g. due to improving irrigation (kWh)
SE3	(narrative)	Changes in active transport (narrative with data if possible)
SE4	(narrative)	Changes in self-purification capacity or changes to wastewater treatment: Narrative documenting any changes to purification capacity of streams (e.g. following dam removal) or changes to green infrastructure for water purification services, e.g. use of constructed wetlands or sustainable urban drainage ponds instead of grey infrastructure (qualitative narrative or kWh or energy cost changes)
SE5	<units>	Other measures that case-studies want to monitor

Five case studies provide data on indicator SE4 (Wastewater treatment). It is noteworthy that four cases studies reported data on “other” (self-chosen) indicators.

However, not in all cases both pre- and post-restoration data were delivered.

The low amount of reporting on the Sustainable Energy criterion does not allow a detailed statistical analysis for individual indicators.

Assessment of the criterion for individual case studies

An aggregated assessment for the Sustainable Energy criterion for the individual case studies based on an assessment of the reported data provided for many case studies no results (Table 30). Assessment of indicators and the aggregated assessment were done following the approach described in chapter 3.1 of the deliverable.

Table 30 – Assessment of the reported data for the Sustainable Energy criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetted DK	Up to now only pre-restoration data reported.			NA
CS03 – Beaver river engineering SE	No monitoring data reported.			NA
CS05 – Kampinos wetland rewetted PL	No monitoring data reported.			NA
CS06 – Hutovo Blato peatland rewetted BiH	SE1	No changes observed. [RY 0 (pre) to +1]	😐	😐 ₄
	SE2	No changes observed. [RY 0 (pre) to +1]	😐	
	SE3	No changes observed. [RY 0 (pre) to +1]	😐	
	SE4	No changes observed. [RY 0 (pre) to +1]	😐	
CS12 – Lima floodplain forest restoration PT (	SE1	Increase as result of the measure. [RY 0 (pre) to +2]	😊	😊 ₄
	SE2	No changes observed. [RY 0 (pre) to +2]	😐	
	SE3	No changes observed. [RY 0 (pre) to +2]	😐	
	SE4	No changes observed. [RY 0 (pre) to +2]	😐	
CS14 – Komppasuo peatland rewetted FI	No monitoring data reported.			NA

Small streams and basins				
CS02 – Deba barrier removal ES	SE4	Enhanced the self-purification capacity. [RY -2 to +2]		 1
CS11 – Emscher basin restoration DE	SE4	Completely wastewater-free due to construction of the Emscher sewer. [RY – NA]		 1
CS13 – Sorraia river restoration PT	No monitoring data reported.			NA
CS15 – Tzipori basin restoration IL	No monitoring data reported.			NA
CS16 – Upper Scheldt restoration BE - site 1	SE4	No changes observed. [RY – NA]		 2
	SE5	No collection of plant biomass. [RY – NA]		
	SE5	Effect on erosion cannot be quantified yet. [RY – NA]		
CS16 – Upper Scheldt restoration BE - site 2	SE4	No changes observed. [RY – NA]		 1
CS17 – Forth basin restoration UK	No monitoring data reported.			NA
CS18 – Ervidel river restoration PT	No monitoring data reported.			NA
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	No monitoring data reported.			NA
CS07b – Danube sidearm reconnect HU	No monitoring data reported.			NA

CS08 – Danube floodplain reconnect RO	No monitoring data reported.	NA
CS09 – Tisza floodplain rewetting HU	No monitoring data reported.	NA
CS10 – Blue Belt Germany DE	No monitoring data reported.	NA

Note: For explanation of assessment symbols see Box 1. For indicator codes see Table 29.

In the rare case that positive changes as result of the restoration measure were reported, this was due to changes to renewable energy production or changes in self-purification capacity.

Sustainable Transport

Overview

Since the Sustainable Transport criterion was not relevant for many case studies, only five of them reported data using the reporting templates (indicators listed in Table 31). Four case studies reported data on indicator ST7 (Fish density and species composition) and three case studies reported data on indicators ST1 (Measures to mitigate impact of navigation) and indicator ST3 (Extent of modification of the water body).

Table 31 – Indicator codes, units and indicator names for the Sustainable Transport criterion.

Indicator code	Unit	Indicator name
ST1	(type and size of the measures)	Measures to mitigate impact of navigation: NbS, technical, regulations (speed limits) (R). Units: type and size of the measures
ST2	(type of boats per day (P))	Intensity and type of navigation (cargo vessels, passenger ships, sport boats. Units: type of boats per day (P)
ST3	(% of natural banks, barriers per river km, % of impounded vs free-flowing (S), m ³ of dredging)	Extent of modification of the water body (bank protection, groynes, cross-section profile, barriers, impoundment, dredge volume). Units: % of natural banks, barriers per river km, % of impounded vs free-flowing (S), m ³ of dredging
ST4	(number canals connecting basins (S))	Artificial connectivity between river basins (dispersal routes for invasive species). Units: number canals connecting basins (S)
ST5	(amount)	Energy source (amount of reduction of fossil fuel, replacement by electricity) (P)
ST6	(narrative)	Antifouling coating (can be reported by narratives)

ST7	(species composition and abundance (I))	Fish density and species composition. Units: species composition and abundance (I)
ST8	(species composition and abundance (I))	Aquatic and shoreline vegetation. Units: species composition and abundance
ST9	(species composition, functional richness or diversity, occurrence or number of habitat specialists species vs. ubiquitous species)	Aquatic, semiaquatic and terrestrial animal species. Units: species composition, functional richness or diversity, occurrence or number of habitat specialists species vs. ubiquitous species
ST10	(shoreline ecotope (type and size) (S), substrate diversity, variance of shoreline width, structural indicators, degree of lateral connectivity to floodplains)	Habitat diversity and hydromorphological state, in particular in the shore zone. Units: shoreline ecotope (type and size) (S), substrate diversity, variance of shoreline width, structural indicators, degree of lateral connectivity to floodplains
ST11	(number and relative abundance)	Exotic species whether or not being invasive. Units: number and relative abundance
ST12	<units>	Other measures that case-studies want to monitor

However, not in all cases both pre- and post-restoration data were delivered.

The low amount of reporting on the Sustainable Transport criterion does not allow a detailed statistical analysis for individual indicators.

Assessment of the criterion for individual case studies

An aggregated assessment for the Sustainable Transport criterion for the individual case studies based on an assessment of the reported data provided for many case studies no or only rather vague results (Table 32). Assessment of indicators and the aggregated assessment were done following the approach described in chapter 3.1 of the deliverable.

Table 32 - Assessment of the reported data for the Sustainable Transport criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY - Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning	No monitoring data reported.			NA

wetland rewetting DK		
CS03 – Beaver river engineering SE	No monitoring data reported.	NA
CS05 – Kampinos wetland rewetting PL	No monitoring data reported.	NA
CS06 – Hutovo Blato peatland rewetting BiH	ST1	No changes observed. [RY -2 to +1] 😞
	ST2	No changes observed. [RY -2 to +1] 😞
	ST4	No changes observed. [RY -2 to +1] 😞
	ST5	Reduction as result of the measure. [RY -2 to +1] 😊
	ST6	No changes observed. [RY -2 to +1] 😞
CS12 – Lima floodplain forest restoration PT	No monitoring data reported.	NA
CS14 – Komppasuo peatland rewetting FI	No monitoring data reported.	NA
Small streams and basins		
CS02 – Deba barrier removal ES	No monitoring data reported.	NA
CS11 – Emscher basin restoration DE	No monitoring data reported.	NA
CS13 – Sorraia river restoration PT	No monitoring data reported.	NA
CS15 – Tzipori basin restoration IL	No monitoring data reported.	NA

CS16 – Upper Scheldt restoration BE	Up to now only pre-restoration data reported.			NA
CS17 – Forth basin restoration UK	ST7	Difficult to predict future development. [RY -1, 0, +2]	😐	😐1
CS18 – Ervidel river restoration PT	No monitoring data reported.			NA
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	No monitoring data reported.			NA
CS07b – Danube sidearm reconnect HU	Only post-restoration data.			NA
CS08 – Danube floodplain reconnect RO	No monitoring data reported.			NA
CS09 – Tisza floodplain rewetting HU	No monitoring data reported.			NA
CS10 – Blue Belt Germany DE	ST1	Biological bank protection. [RY -2, +3]	😊	😊5
	ST2	Increase due to the measure. RY -2, +3]	😞	
	ST3	% of natural banks Increase due to the measure. RY -2, +3]	😊	
	ST7	Difficult to predict future development. RY -2, +3]	😐	
	ST9	Difficult to predict future development. RY -2, +3]	😐	
	ST10	Improved due to the measure. RY -2, +3]	😊	

	ST11	Difficult to predict future development. RY -2, +3]		
	ST12	Increase length of monitoring area. RY -2, +3]		

For explanation of assessment symbols see Box 1. For indicator codes see Table 31.

In the case of positive impact as result of the restoration measure this was due to reduction of chemical impact of navigation (replacement of fossil fuel by electricity) or improving physical and biological conditions.

Inclusive Participation and Governance

Overview

This indicator was designed to reflect the Aarhus Convention pillars – informing, consulting, and engaging – across both physical and virtual spaces, using simple descriptive statistics to allow comparison across case studies and over time. Overall, 17 case studies submitted the reporting for this indicator, although there were variations in the number of reporting per indicator across the case studies (Table 33). Only CS04 (Room for the Rhine NL) and CS07b (Danube sidearm reconnect HU), both part of the large river cluster, did not report any data. For CS04, this is likely due to its scale as a large national programme, making it difficult to isolate the MERLIN-specific component. In the case of CS07b, there was no implementation project under MERLIN to monitor. Data was collected in various formats, including counts, presence/absence, and Likert scale ratings.

Table 33. Indicator code, unit, format and indicator name for inclusive governance and participation indicator. Indicators IG1, IG2 & IG3 were required, IG4, IG5, IG6, IG8 & IG9 were desirable and IG7, IG10, IG11 were optional.

Indicator code	Unit	Indicator name
IG1	count	Number of visitors to website(s) describing measure
IG2	count	Total number of participants in information sessions about the measures
IG3	count of different types	Inclusivity in CS board (representatives of the Public (IG3.1), Private (commercial, investor, etc) (IG3.2), NGO (IG3.3), Network (IG3.4), Community group (IG3.5), Others (Specify for each 'other') (IG3.6)
IG4	Presence/absence	Information on website on contacts and how to get involved
IG5	Presence/absence	Signage onsite with contacts and how to get involved
IG6	Presence/absence	Consultation on measures with case-study board
IG7	Presence/absence	Formal public consultation on measures
IG8	Presence/absence	Citizen science activities undertaken in monitoring and management of measures
IG9	Likert scale	Is the project aligned with existing societal challenges?

IG10	Likert scale	Do local residents feel positive about the MERLIN NbS and the impacts they are having on the local area?
IG10	Free text/count	Other optional indicator of your choice...

IG 1 – Number of visitors to website(s) describing measure and IG2 – Total number of participants in information sessions about the measures

In terms of participants' visit to website (IG1), the small streams and basins cluster had the widest spread, with four case studies (CS11, CS13, CS16, CS17) reporting more than 150 website visitors. The peatlands and wetlands cluster followed closely, with three cases (CS01, CS12, CS14) also above this level. The large river cluster had only one case – CS08 (Danube RO) – with very high traffic, recording over 300,000 visits. Notably, CS11 (Emscher) also had exceptionally high online traffic (140,163), and CS14 (Komppasuo) and CS12 (Lima) each had over 1,000 visits, making them standout cases in their clusters.

For participation in information sessions (IG2), the peatlands and wetlands cluster saw consistently high turnout, with four case studies (CS01, CS05, CS12, CS14) reporting strong participation. CS12 (Lima) stood out with 1,571 participants. The small streams and basins cluster also showed solid engagement in three sites (CS15, CS16, CS17), with CS15 (Tzipori) notably attracting 1,450 participants. In contrast, the large river cluster showed limited in-person engagement, with only CS07a and CS09 reporting modest attendance.

Overall, while a few individual sites – especially CS08, CS11, CS12, CS14, and CS15 – achieved very high engagement levels, participation was more consistently observed across peatland and small stream case studies.

Table 34. Number of visitors to website and participants in information sessions. Contain the sum over all reporting years, including pre-MERLIN periods.

Case study	IG1: Number of visitors to website(s) describing measure	IG2: Total number of participants in information sessions about the measures
Peatlands and wetlands		
CS01 – Kvorning wetland rewetting DK	641	330
CS03 – Beaver River engineering SE	No data reported	50
CS05 – Kampinos wetland rewetting PL	30	553
CS06 – Hutovo Blato peatland rewetting BiH	No data reported	27
CS12 – Lima floodplain forest restoration PT	1299	1571
CS14 – Komppasuo peatland rewetting FI	1722	530
Small streams and basins		
CS02 – Deba barrier removal ES	No data reported	No data reported
CS11 – Emscher basin restoration DE	140163	No data reported
CS13 – Sorraia river restoration PT	182	68
CS15 – Tzipori basin restoration IL	No data reported	1450

CS16 – Upper Scheldt restoration BE	598	185
CS17 – Forth basin restoration UK	39859	502
CS18 – Ervidel river restoration PT	No data reported	9
Large transboundary rivers		
CS04 – Room for the Rhine NL	No data reported	No data reported
CS07a – Danube floodplain restoration AT	326	76
CS07b – Danube sidearm reconnect HU	No data reported	No data reported
CS08 – Danube floodplain reconnects RO	306819	No data reported
CS09 – Tisza floodplain rewetting HU	No data reported	130
CS10 – Blue Belt Germany DE	3	60

IG3 Inclusivity in CS board (representatives of the Public (IG3.1), Private (commercial, investor, etc) (IG3.2), NGO (IG3.3), Network (IG3.4), Community group (IG3.5), Others (Specify for each 'other') (IG3.6))

Across clusters (Table 35), public sector stakeholders were the most consistently represented, especially in peatland and wetland sites where all cases (e.g., CS01, CS03, CS05) reported their inclusion. NGO and private actors were also commonly involved but to a lesser extent. Presence of community group in the CS boards, while strong in a few peatland cases (CS01 and CS05) and Tzipori (CS15), was generally limited across clusters. Small streams and basin sites showed uneven inclusivity, with some (e.g., CS17) engaging a mix of stakeholders but excluding community groups entirely. Large transboundary river sites had the least diverse representation, and only CS09 included community groups to any meaningful extent. The reason could be that these large river projects often span vast areas or regions, making the direct composition of community groups in case study boards less practical or expected.

Table 35. Number of stakeholder types involved in case study boards. CS15 submitted percentages for stakeholder type instead of exact counts, while CS13 counted individuals instead of count of types.

Case study	IG3.1 Public sector	IG3.2 Private	IG3.3 NGO	IG3.4 Network	IG3.5 Community Group	IG3.6 Other
Peatlands and wetlands						
CS01 – Kvorning wetland rewetting DK	5	4	3	0	5	2
CS03 – Beaver River engineering SE	6	5	2	0	0	0
CS05 – Kampinos wetland rewetting PL	12	1	4	0	6	4
CS06 – Hutovo Blato peatland rewetting BiH	6	6	3			

CS12 – Lima floodplain forest restoration PT	6	7	2	0	2	0
CS14 – Komppasuo peatland rewetting FI	11	4	2	0	0	0
Small streams and basins						
CS02 – Deba barrier removal ES	No data reported	No data reported	No data reported	No data reported	No data reported	No data reported
CS11 – Emscher basin restoration DE	No data reported					
CS13 – Sorraia river restoration PT	48	11	4	0	0	0
CS15 – Tzipori basin restoration IL	24	5	1	0	3	4
CS16 – Upper Scheldt restoration BE	22		1	1		
CS17 – Forth basin restoration UK	10	0	2	0	0	2
CS18 – Ervidel river restoration PT	0	3	0	0	0	0
Large transboundary rivers						
CS04 – Room for the Rhine NL	No data	No data	No data	No data	No data	No data
CS07a – Danube floodplain restoration AT	3	0	4	0	2	0
CS07b – Danube sidearm reconnect HU	No data	No data	No data	No data	No data	No data
CS08 – Danube floodplain reconnect RO	5	1	1	0	1	0
CS09 – Tisza floodplain rewetting HU	2		2	1	10	
CS10 – Blue Belt Germany DE	4	1	2	1	0	0

IG4 – IG11 measuring the various forms of participation

Indicators IG4-IG11 generally measured the different forms of engagement undertaken to enhance inclusivity. All case studies had online information (IG4) available by at least MERLIN Year 3. Only four (CS13, CS03, CS02, CS12) lacked it in the pre-MERLIN or first year. CS15 used alternative channels like community groups and newsletters, showing adaptive approaches. Signage onsite (IG5) was less common. Only seven case studies

reported having it for at least one MERLIN year, with three of these (CS02, CS05, CS08) maintaining it consistently across the first three years. This reflects stronger digital communication, but weaker on-site visibility.

Twelve case studies reported consultations with stakeholder boards (IG6), with ten confirming these took place during MERLIN years. Three case studies (CS05, CS08, CS17) held consultations for three years in a row. In contrast, only nine sites reported formal public consultations (IG7), and just seven did that during MERLIN years, three (CS02, CS08, CS11) of which did so consistently. Given that there was limited involvement of community groups in case study boards (IG3), inadequate number of formal public consultations suggests fewer channels for broader public input. Citizen science (IG8) could have been another channel for the involvement of the general public, but this was reported by only three case studies (CS11, CS12, CS15), with CS15 maintaining it over three years.

Nevertheless all 15 case studies responding to IG9 stated their measures aligned with societal challenges: 13 as “aligned” and two as “already very aligned.” One site (CS07a) marked it as not applicable. IG10, on public sentiment, had limited data: only seven case studies reported “quite” or “very positive” feedback, while others (e.g. CS01, CS10, CS13, CS03) marked it as unknown.

Four case studies used IG11 to report additional outreach. CS03 recorded 144,400 media views; CS11 had 2,683 visits to citizen science platforms; CS12 reported 36,479 social media views, 1,749 interactions, 275 participants in educational activities, and 5,500 Sustainability School Agendas distributed. CS14 logged 21 posts and 253 likes. These illustrate additional efforts to engage the public beyond the predefined mediums (IG1-IG10) of engagement.

Assessment of the criterion for individual case studies

The results of an aggregated assessment for the Inclusive participation and governance criterion for the individual case studies based on an assessment of the reported data are shown in Table 36. Only indicators that were required (IG1, IG2, IG3) with values in counts were assessed.

Table 36 – Assessment of the reported data for the inclusive governance criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetting DK	IG1	Initial rise in 1st year, then far lower than pre-reporting in 2nd year.	☹️	😊 ₃
	IG2	Major 1st-year increase; drops in years 2–3, but stays slightly above pre-reporting.	😊	
	IG3	Overall sharp increase over baseline in Year 1, including community groups, despite dropping back to zero in Year 2.	😊	
	IG1	No data reported.	N/A	😊 ₂

CS03 – Beaver river engineering SE	IG2	Increased in year one over baseline, despite dropping back to zero in years 2-3.	😊	
	IG3	Improved after baseline with steady public/private presence, but no community groups involved.	😊	
CS05 – Kampinos wetland rewetting PL	IG1	Increased between years 2-3.	😊	😊 ₃
	IG2	Increased from years 1-3.	😊	
	IG3	Increase, especially with public and NGO groups; participation declined slightly after Year 1 but remained stable.	😊	
CS06 - Hutovo Blato peatland rewetting BiH	IG1	No data reported.	N/A	😊 ₂
	IG2	Showed continues (years 2-3) increase over year one results.	😊	
	IG3	Maintained steady inclusion of public, private and NGOs.	😊	
CS12 – Lima floodplain forest restoration PT	IG1	Consistent year-on-year increase from baseline through MERLIN years.	😊	😊 ₃
	IG2	Overall increase of baseline (0) results despite some drop in year 3.	😊	
	IG3	Increased from year 2 and maintained this into year 3.	😊	
CS14 – Komppasuo peatland rewetting FI	IG1	Showed increase between years 1 & 2.	😊	😊 ₃
	IG2	Increased between year 1and 2, drop in year 3 but higher than baseline.	😊	
	IG3	Showed uptake in year 1, but no report for year 2-3.	😊	
Small streams and basins				
CS02 – Deba barrier removal ES	IG1	No data.	N/A	N/A
	IG2	No data.	N/A	
	IG3	No data.	N/A	
CS11 – Emscher basin restoration DE	IG1	Limited change from baseline results	😐	😐 ₁
	IG2	No data available.	N/A	
	IG3	No data reported.	N/A	

CS13 – Sorraia river restoration PT	IG1	No increase in year 1 but increased in year 2.	😊	😊 ₃
	IG2	Showed increase over baseline in year 1 and 2.	😊	
	IG3	Increased in year 2, but counted individuals involved not stakeholder type.	😊	
CS15 – Tzipori basin restoration IL	IG1	Zero throughout – No impact.	😐	😊 ₃
	IG2	Overall increased over baseline results.	😊	
	IG3	Overall increased with small proportion of community groups, provided percentages involved not number of stakeholder type.	😊	
CS16 – Upper Scheldt restoration BE	IG1	Showed increase in year 2 over year 1. Slight drop in year 3.	😊	😊 ₃
	IG2	Showed increase in year 2 over year 1.	😊	
	IG3	Showed increase in year 2 over year 1.	😊	
CS17 – Forth basin restoration UK	IG1	Increased over baseline (0) and continued increase through years 2&3.	😊	😊 ₃
	IG2	Overall, increased between years 1 and 2 and a slight drop in year 3.	😊	
	IG3	Same baseline numbers for the same stakeholder types throughout as they are using pre-existing group.	😐	
CS18 – Ervidel river restoration PT	IG1	No data reported.	N/A	😊 ₂
	IG2	Increased over baseline and maintain same number throughout.	😊	
	IG3	Increased over baseline and maintain same number throughout (years 2-4).	😊	
Large transboundary rivers				
CS04 – Room for the Rhine NL	No reporting data		N/A	N/A
CS07a – Danube floodplain restoration AT	IG1	Hight in 1st-year but drops in years 2–3.	😊	😊 ₃
	IG2	Increase between years 2 & 3 over year 1.	😊	
	IG3	Maintained slight increase between years 1 & 2.	😊	

CS07b – Danube sidearm reconnect HU	No data reported.		N/A	N/A
CS08 – Danube floodplain reconnect RO	IG1	Started high in year one, dipped in year two, then recovered in year three.	😊	😊 ₂
	IG2	No data reported.	N/A	
	IG3	Same baseline numbers for the same stakeholder types throughout.	😐	
CS09 – Tisza floodplain rewetting HU	IG1	Only pre-MERLIN data available.	N/A	N/A
	IG2	Only pre-MERLIN data available.	N/A	
	IG3	Only pre-MERLIN data available.	N/A	
CS10 – Blue Belt Germany DE	IG1	Only 1 increase, but seems not significant.	😐	😐 ₂
	IG2	Zero throughout – No impact.	😐	
	IG3	No MERLIN year data.	N/A	

Across most case studies, there is evidence of stakeholder engagement through activities such as website visits, participation in information sessions and consultation with case study boards. While some showed notable growth in these areas over time, others maintained steady levels of engagement. However, without consistent contextual information, it is difficult to determine the extent to which observed changes can be directly attributed to MERLIN interventions versus pre-existing governance arrangements or other external factors. The overall significance of these engagement levels is also unclear, particularly where the absolute numbers involved were relatively modest. This highlights the importance of interpreting the data in light of each case study's specific context rather than assuming that change or lack of it necessarily reflects success or shortfall. One of the highest engagement figures for visitors to the project website and longest monitored was for the Emscher restoration programme where over 5000 visitors per year. This shows a very slight declining trend from a peak in 2017, but this trend shows no rate change since the start of MERLIN. Inclusive governance and participation will be examined in greater depth in D4.9, which will explore how stakeholder engagement was facilitated across the case studies to support pathways toward just transformation.

Circular Economy

Overview

Eight case studies delivered data on indicators of the Circular Economy criterion by help of the templates (indicators listed in Table 37). One of the case studies (CS09 – Tisza floodplain rewetting HU) delivered additional information in form of a narrative.

Table 37 – Indicator codes, units and indicator names for the Circular Economy criterion.

Indicator code	Unit	Indicator name
CE1	(m ³)	Reduced net water consumption (based on local data on water consumption) (m ³)
CE2	(m ³)	Water capture (infiltration rate, rainfall storage capacity) (m ³)
CE3	(m ³)	Water reuse/re-allocation to the environment (local data on water reuse) (m ³)
CE4	(number)	Water reuse projects (number)
CE5	(amount)	Sediment reuse (amount of reused material)
CE6	(number)	Business models (number): ISO TC 323 standard on circular economy management / XP X30-901 Circular Economy – Circular economy project management system – Requirements and guidelines (based on surveys of business and stakeholders relevant for the restoration case)
CE7	(number)	Municipal staff trained on the circular economy (number)
CE8	<units>	Other measures that case-studies want to monitor

Highest numbers of case studies reported on the indicators CE5 (sediment reuse, 5 case studies) and CE2 (water capture, 4 case studies). However, not in all cases both pre- and post-restoration data were delivered.

The low amount of reporting on the Circular Economy criterion does not allow a detailed statistical analysis for individual indicators.

Assessment of the criterion for individual case studies

An aggregated assessment for the Circular Economy criterion for the individual case studies based on an assessment of the reported data provided for many case studies no or only rather vague results (Table 38). Assessment of indicators and the aggregated assessment were done following the approach described in Chapter 3.1 of the deliverable.

Table 38 – Assessment of the reported data for the Circular Economy criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetted DK	No monitoring data reported.			NA
CS03 – Beaver river engineering SE	CE1	No changes observed. [RY -2 to +4]	😐	😐 ¹
CS05 – Kampinos wetland rewetted PL	No monitoring data reported.			NA
CS06 – Hutovo Blato peatland rewetted BiH	CE1	No changes observed. [RY 0 (pre) to +2]	😐	😐 ⁷
	CE2	No changes observed. [RY 0 (pre) to +2]	😐	
	CE3	No changes observed. [RY 0 (pre) to +2]	😐	
	CE4	No changes observed. [RY 0 (pre) to +2]	😐	
	CE5	No changes observed. [RY 0 (pre) to +2]	😐	
	CE6	No changes observed. [RY 0 (pre) to +2]	😐	
	CE7	No changes observed. [RY 0 (pre) to +2]	😐	
CS12 – Lima floodplain forest restoration PT	CE7	Slight indication of positive impact of the project. [RY -1 to +2]	😊	😊 ¹

CS14 – Komppasuo peatland rewetting FI	No monitoring data reported.			NA
Small streams and basins				
CS02 – Deba barrier removal ES	No monitoring data reported.			NA
CS11 – Emscher basin restoration DE	No monitoring data reported.			NA
CS13 – Sorraia river restoration PT	CE5	No changes observed. [RY -1 to 0 (during)]	😬	😊 ₃
	CE8	Number of implemented NbS. [RY -1 to 0 (during)]	😬	
	CE8	Biomass reused. [RY -1 to 0 (during)]	😊	
CS15 – Tzipori basin restoration IL	No pre-restoration data reported.			NA
CS16 – Upper Scheldt restoration BE	CE8	No grass-flower strip cuttings for composting, both before and after restoration. [RY 0 (pre) to +2]	😬	😬 ₁
CS17 – Forth basin restoration UK	No monitoring data reported.			NA
CS18 – Ervidel river restoration PT	CE5	Sediment reuse after the measure. [RY 0 (post)]	😊	😊 ₂
	CE8	Biomass reused. [RY 0 (post)]	😊	
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	No monitoring data reported.			NA

CS07b – Danube sidearm reconnect HU	No monitoring data reported.			NA
CS08 – Danube floodplain reconnect RO	No monitoring data reported.			NA
CS09 – Tisza floodplain rewetting HU	CE2	Increase as result of the measure. [RY -8, -2, 0, +2, +8, +14]		 2
	Narrative	The project supported the achievement of the Circular Economy objectives in several ways. [RY- NA]		
CS10 – Blue Belt Germany DE	No monitoring data reported.			NA

Note: For explanation of assessment symbols see Box 1. For indicator codes see Table 37.

In the majority no monitoring data were provided or no impact could be proven. Cases showing a positive impact were for example due to training of municipal staff, sediment reuse or water capture.

Financing the Transition

Overview

Fifteen case studies reported on six individual indicators of the Financing the Transition Criterion (Table 39). Of these, Case Studies 7 and 11 reported on multiple locations and are dealt with separately at times in our analysis. An expanded data report is included for CS09 to exemplify the complexity of the finance landscape faced by restoration practitioners accompanied by a summary of the key points raised by this Case Study Reporting Team in their Narrative Report. CS09 was the only case study to provide a Narrative Assessment Report on this Criterion.

The reporting across these Indicators and across years was highly variable across the Case Studies and restoration years (Table 40) limiting the scope of synthesis analysis. CS09 reported the longest time series of data across multiple indicators (including annual data across restoration year (RY) range -4 to +21) whereas Case Studies 3 (RY 0), 7B (RY 13), and 8 (RY -2) provided data from only one year. This is with the exception of Case Study 11 where the percentage of public financing for the restoration financing was reported across a longer range of years but where the case study was split into three component parts.

For Case Study 11, the data reported indicated that the proportion of financing from public funds was 100% for all data entries in all years (Table 41). However, it should be noted that Case Study 11 represented the single largest restoration investment reported across all case studies at a total restoration budget reported (i.e. under indicator FI2) of €408 million. The total restoration budget reported on all activities (i.e. under Indicator FI2) and across all case studies was €466 million, with 97% of this value being represented by the Small Stream and Basins Cluster which includes Case Study 11. When Case Study 11 was removed from the FI2 data, the average restoration budget reported across the remaining case studies was €5.2 million.

The proportion of public finance contribution to the restoration budget was on average 50% for Large Transboundary Rivers, 83% for Peatlands and Wetlands, and 79% for Small Streams and Basins. Two case studies reported securing upscaling budget in the latter years of the MERLIN project; CS09 securing 30% and Case Study 17 at 85% of the estimated required budget for upscaling.

We used the data in Table 35 and the following rationale to present a Synthetic Analysis for the Financing the Transition Criterion. Here we do not assess the indicators against the year of restoration but instead assess funding types and categories across the full reporting period. We include FI1 [Breakdown of the total restoration budget by funding source and type as % of total budget reported averaged across years reported]; FI4 [In-kind contributions as estimated total across all years reported]; and FI6 [Percentage of (upscaling) budget already secured]. For FI1 we assign the proportion of private finance up to 50% is an open green face and beyond 50% a filled in green face. For FI4 and FI6 any value reported received a filled in green face.

Table 39 - Indicator codes, units and indicator names for the Financing the Transition criterion.

Indicator code	Unit	Indicator name
FI1	[%]	Breakdown of the total restoration budget by funding source and type [%]
FI2	[€]	Budget spent into the restoration activity by cost category (specified into management, digging, in-kind contributions, etc.)
FI3	[€/year]	Private finance mobilised [€/year]
FI4	[€/year]	In-kind contributions [€/year]
FI5	[%]	Return on Investment (of cash flow-generating measures) [%]
FI6	[%]	Percentage of (upscaling) budget already secured [%]
FI7	[Number]	New financial products or solutions *designed for* the case study [No.]
FI8	[Number]	New financial products or solutions *implemented in* the case study [No.]
FI9		Other measures that case-studies want to monitor

Table 40 - Summary of reporting across MERLIN Indicator Codes with Case Study Sites grouped across the clusters: Peatland & Wetland, Small Streams & Basins, and Large Transboundary Rivers. Shaded boxed indicate data is available in consecutive years between the two column years. Restoration years relative to intervention and number of data records per Indicator grouped as clusters.

Row Labels	-12	-9	-4	-3	-2	-1	0	1	2	3	4	5	12	13	14	21
Peatlands & Wetlands																
CS01 FI1						1	1	2	1							
CS03 FI1							1									
CS03 FI2							3									
CS05 FI1					1	1	1	1	1							
CS06 FI1								2	2	2						

CS06 FI2								2	2	2						
CS12 FI1					1	1	1	1	1							
CS12 FI4									1							
CS14 FI1					2	2	2	2	2	2						
CS14 FI2					4	4	4	4	4	4						
Small Streams & Basins																
CS11 (site 1) FI1			1	1	1	1	1	1	1	1	1	1	1			
CS11 (site 2) FI1	1	1	1	1	1	1	1	1	1							
CS11 (site 3) FI1		1	1	1	1	1	1	1	1	1						
CS15 FI1								1								
CS15 FI2								1	1	1		1				
CS15 FI3								1	1	1		1				
CS15 FI4							1	1	1	1		1				
CS16 FI1							1	1	1							
CS16 FI2							1	3	2							
CS17 FI1					1	1			1							
CS17 FI2					2				2							
CS17 FI6								1								
CS18 FI9						4	4									
Large Transboundary Rivers																
CS07a FI1				1	1	1	1	1								
CS07a FI2				1	1	1	1	1								
CS07b FI1												2				
CS07b FI3												1				
CS07b FI4												1				
CS08 FI1					1											
CS008 FI2					1											
CS8 FI3					1											

CS09 FI1			2	2	2	2	2							1	1	3
CS09 FI2			2	2	2	3	3	1	1					2	3	3
CS09 FI3			1	1	1	1	1							1	1	2
CS09 FI4								1	1							
CS09 FI6																1
CS10 FI1						1	1	1	1							
CS10 FI2						2	2	2								

Table 41 – Summary of Financing the Transition data reported across the case studies with corresponding indicators from the aggregated assessment. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Site Type	Habitat Type	Years	Year 0	FI1 Public [%]	FI2 [Total Euros]	FI3 [Total Euros]	FI4 [Total Euros]	FI6 [%]
Peatlands & Wetlands									
CS01 – Kvorning wetland rewetting DK 😊 ₁	Demo	Peatland	2021-2024	2022	100 😊	8,929,583			
CS03 – Beaver river engineering SE 😊 ₁	Imple	Peatland	2023	2023	100 😊	30,000			
CS05 – Kampinos wetland rewetting PL 😊 ₁	Demo	Peatland	2015-2019	2017	95 😊				
CS06 - Hutovo Blato peatland rewetting BiH 😊 ₁	Imple	Floodplain	2023-2025	2022	33 😊	500,000			
CS12 – Lima floodplain forest restoration PT 😊 ₂	Demo/ Imple	Peatland	2020-2024	2022	100 😊			500 😊	
CS14 – Komppasuo peatland rewetting FI 😊 ₁	Imple	Peatland	2022-2025	2022	70 😊	248,000			
	Average of FI1 and Sum of FI2-FI4				83	9,707,583		500	
Small Streams & Basins									
CS11 – Emscher basin restoration DE (site 1) 😊 ₁	Demo	River	2013-2024	2022	100 😊	68,431,575			
CS11 – Emscher basin restoration DE (site 2) 😊 ₁	Demo	River	2011-2023	2023	100 😊	110,000,000			
CS11 – Emscher basin restoration DE (site 3) 😊 ₁	Demo	River	2008-2010	2011	100 😊	230,000,000			
CS15 – Tzipori basin restoration IL 😊 ₁	Demo	River	2022-2026	2022	55 😊	43,662,774	23,017,903		
CS16 – Upper Scheldt restoration BE 😊 ₁	Imple	River	2022-2024	2022	0 😊	152,451			
CS17 – Forth basin restoration UK 😊 ₂	Demo	River	2020-2024	2022	100 😊	119,178			85 😊

CS18 – Ervidel river restoration PT 😊 ₁	Imple	Floodplain	2022-2023	2023	100 😊				
Average of FI1 and Sum of FI2-FI4					79	452,365,978	23,017,903		
Large Transboundary Rivers									
CS07a – Danube floodplain restoration AT 😊 ₁	Demo	River	2019-2023	2022	60 😊	1,143,050			
CS07b – Danube sidearm reconnect HU 😊 ₂	Demo	River/Floodplain	2008-2013	2022	73 😊		48,554	8,196	
CS08 – Danube floodplain reconnect RO 😊 ₁	Demo/ Imple	Floodplain	2020	2022	0 😊	600,000	600,000		
CS09 – Tisza floodplain rewetting HU 😊 ₃	Demo	Floodplain	2001-2026	2005	17 😊	671,948	501,848	14,500 😊	30 😊
CS10 – Blue Belt Germany DE 😊 ₁	Demo	River	2017-2020	2018	100 😊	1,420,000			
Average of FI1 and Sum of FI2-FI4					50	3,834,998	1,150,402	22,696	

Note: CS – Case Study Number. ‘Demo’ – Demonstration Site Type; ‘Imple’ – Implementation Site Type. ‘Year 0’ is the reported year at the start of the post-restoration monitoring. Note descriptions of all Indicator Codes are included in the Table above. FI1 Breakdown of the total restoration budget by funding source and type [% of total budget reported averaged across years reported]; FI2 Budget spent into the restoration activity by cost category [total euros across all years reported]; FI3 Private finance mobilised [here as estimated total across all years reported]; FI4 In-kind contributions [here as estimated total across all years reported]; FI6 Percentage of (upscaling) budget already secured [%]. If cells are blank then no data were reported.

Green Growth

Overview

Except CS02 (Deba barrier removal ES), all case studies reported on the Green Growth criterion using the reporting templates (indicators listed in Table 42). One of the case studies (CS09 – Tisza floodplain rewetting HU) delivered additional information in form of a narrative.

Table 42 – Indicator codes, units and indicator names for the Green Growth criterion.

Indicator code	Unit	Indicator name
GG1	(number)	Jobs created attributable to restoration activities (jobs created by restoration activities directly implemented by the beneficiary and/or outsourced to contractors)
GG2	(number)	Jobs created attributable to restoration outcomes (e.g. jobs created by new recreation activities, new valorisation of biomass)
GG3	(EURO)	Turn-over and Gross and Net Value Added of establishments providing recreational services (hotels, camping sites, equipment (e.g. canoe) rental agencies, restaurants, bars); to be measured in the restored area and its surrounding
GG4	(number/day x year)	Number of people visiting an area (expressed as person-days) on an annual basis; to be measured in the restored area and its surrounding
GG5	(number/year)	Number of overnight stays in an area on an annual basis; to be measured in the restored area and its surrounding
GG6	(number)	Amount of establishments providing recreational services (hotels, camping sites, equipment (e.g. canoe) rental agencies, restaurants, bars)
GG7	(kg/year) / (EURO/year)	Amount of fish and shellfish harvested, in kg and in euro, per year, by species
GG8	(kg/year)	Products harvested (e.g. reeds) in kg, by type and by year, including water yield (if relevant)
GG9	(EURO)	Turn-over and Gross and Net Value Added of products harvested in aquatic ecosystems
GG10	(EURO/year)	Monetary value of the amount of carbon sequestered annually in the ecosystem, ton C/year converted to EURO based on EU ETS carbon price
GG11	(EURO)	Fishing and hunting in the wetland, expressed as number of fishing/hunting licenses sold and kg of food harvested, by species per year
GG12	<units>	Other measures that case-studies want to monitor

Particularly high numbers of case studies reported on indicators GG1 (Jobs created attributable to restoration activities) and GG2 (Jobs created attributable to restoration outcomes). However, not in all cases both pre- and post-restoration data were delivered.

GG1 – Jobs created attributable to restoration activities (Figure 22)

Several case studies were successful with creating jobs attributable to the restoration activities. By far the highest number of jobs was created in CS11 (Emscher basin restoration DE), due to the large spatial and long-term character of this case study.

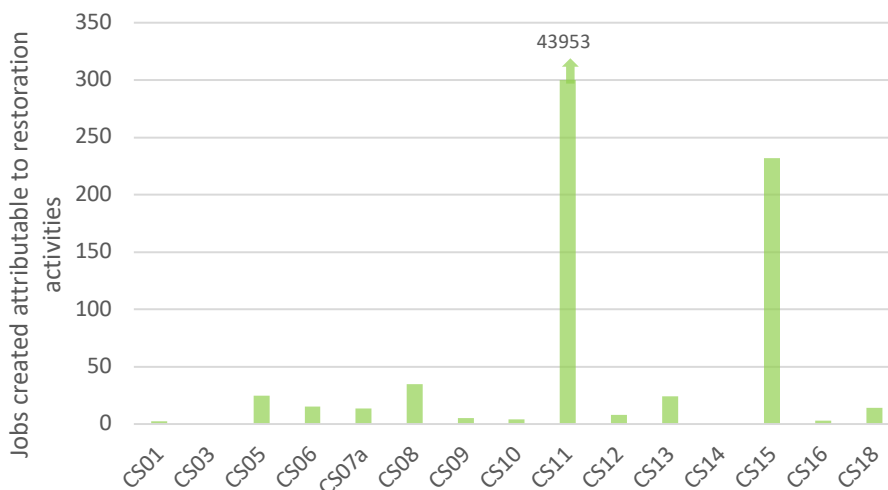


Figure 22 - Jobs created attributable to restoration activities as result of the restoration measures.

GG2 – Jobs created attributable to restoration outcomes (Figure 23)

The case studies were much less successful with creating job attributable to restoration outcomes when compared to jobs created attributable to restoration activities. As with GG1, CS11 (Emscher basin restoration DE) was by far the most successful.

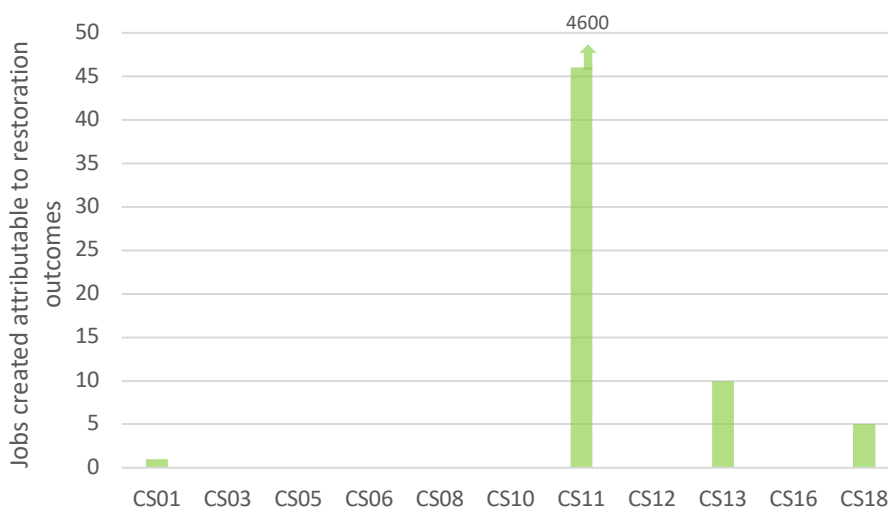


Figure 23 - Jobs created attributable to restoration outcomes as result of the restoration measures..

Assessment of the criterion for individual case studies

An aggregated assessment for the Green Growth criterion for the individual case studies based on an assessment of the reported data is presented in Table 43. Assessment of indicators and the aggregated assessment were done following the approach described in chapter 3.1 of the deliverable.

Table 43 – Assessment of the reported data for the Green Growth criterion: Assessment of individual indicators and aggregated assessment based on all reported indicators. Only indicators with pre- and post-restoration data reported are taken into account. RY – Restoration Year. Numbers attached to faces indicate the number of indicators included in the aggregated assessment.

Case study	Indicator	Description	Assessment	Aggregated assessment
Peatlands and wetlands				
CS01 – Kvorning wetland rewetted DK	GG1	Jobs created (before and after the measure). [RY -2 to +4]	😊	😊 ₃
	GG2	Jobs created (after the measure). [RY -2 to +4]	😊	
	GG10	Increase as result of the measure. [RY -2 to +4]	😊	
CS03 – Beaver river engineering SE	GG1	No jobs created. [RY -2 to +4]	😐	😐 ₂
	GG2	No jobs created. [RY -2 to +4]	😐	
CS05 – Kampinos wetland rewetted PL	GG1	Jobs created (before the measure). [RY -2, 0 (pre)]	😊	😊 ₂
	GG2	No jobs created. [Ry -2 to +2]	😐	
CS06 – Hutovo Blato peatland rewetted BiH	GG1	Jobs created (after the measure). [RY +1]	😊	😊 ₅
	GG2	No jobs created. [RY +1]	😐	
	GG4	Increase as result of the measure. [Ry 0 (pre) to +1]	😊	
	GG5	Increase as result of the measure. [Ry 0 (pre) to +1]	😊	
	GG6	Increase as result of the measure. [Ry 0 (pre) to +1]	😊	
CS12 – Lima floodplain forest restoration PT	GG1	Jobs created (before and after the measure). [RY -2 to +2]	😊	😊 ₁₂
	GG2	No jobs created. [RY -2 to +2]	😐	
	GG3	No changes observed. [RY -2 to +2]	😐	

	GG4	Slight increase as result of the measure. [RY -2 to +2]	😊	
	GG5	Increase as result of the measure. [RY -2 to +2]	😊	
	GG6	No changes observed. [RY -2 to +2]	😐	
	GG7	No changes observed. [RY -2 to +2]	😐	
	GG8	No changes observed. [RY -2 to +2]	😐	
	GG9	No changes observed. [RY -2 to +2]	😐	
	GG10	No changes observed. [RY -2 to +2]	😐	
	GG11	No changes observed. [RY -2 to +2]	😐	
	GG12	Number of participants on scientific or educational activities increased. [RY -2 to +2]	😊	
CS14 – Komppasuo peatland rewetting FI	GG1	No changes observed. [RY – NA]	😐	😐 ₁
Small streams and basins				
CS02 – Deba barrier removal ES	No monitoring data reported.			NA
CS11 – Emscher basin restoration DE	GG1	Jobs created. [RY – NA]	😊	😊 ₃
	GG2	Jobs created. [RY – NA]	😊	
	GG5	Increase as result of the measure. [RY – NA]	😊	
	GG8	Honey production 2021. [RY – NA]	😊	
CS13 – Sorraia river restoration PT	GG1	Jobs created (before and after the measure). [RY -2 to +1 (during)]	😊	😊 ₂
	GG2	Jobs created (before and after the measure). [RY -2 to +1 (during)]	😊	
CS15 – Tzipori basin restoration IL	GG1	Jobs created (before and after the measure). [RY -2 to +4]	😊	😊 ₃
	GG4	Increase as result of the measure. [RY 0 (pe) to +4]	😊	
	GG5	No changes observed. [RY 0 (pe) to +4]	😐	
	GG1	No jobs created. [RY -1 to +2]	😐	😊 ₃

CS16 – Upper Scheldt restoration BE - site 1	GG2	No jobs created. [RY -1 to +2]		
	GG12	Scientific or educational activities (before and after the measure). [RY -5, -1 to +2]		
CS16 – Upper Scheldt restoration BE - site 2	GG1	Jobs created (after the measure). [RY -1 to +2]		 3
	GG2	No jobs created. [RY -5, -1 to +2]		
	GG12	Scientific or educational activities (before and after the measure). [RY -5, -1 to +2]		
CS17 – Forth basin restoration UK	GG12	Scientific or educational activities (before and after the measure). [RY 0 (pre) to +1]		 1
CS18 – Ervidel river restoration PT	GG1	Jobs created (before and after the measure). [RY -1 to 0, +2]		 4
	GG2	Jobs created (after the measure). [RY -1 to 0, +2]		
	GG12	No changes in rea of flowering fields. [RY -1 to 0, +2]		
	GG12	Scientific or educational activities (before and after the measure). [RY -1 to 0, +2]		
Large transboundary rivers				
CS04 – Room for the Rhine NL	No monitoring data reported.			NA
CS07a – Danube floodplain restoration AT	GG1	Jobs created (before and after the measure). [RY -3 to +1]		 1
CS07b – Danube sidearm reconnect HU	GG12	Scientific or educational activities (before and after the measure). [RY -4 to 0, +5 to +11]		 1
CS08 – Danube floodplain reconnect RO	GG1	Jobs created (before and after the measure). [Ry 0 (pre), +3]		 2
	GG2	No jobs created. [RY +3]		

CS09 – Tisza floodplain rewetting HU	GG1	Jobs created (during and after the measure). [RY 0 (during), +1, +3, +5, +8]		
	GG4	Impact on number of visitors difficult to assess(narrative). [RY – NA]		
CS10 – CS10 – Blue Belt Germany DE	GG1	Jobs created (before the measure). [RY -2 to +1]		
	GG2	No jobs created. [RY -2 to +1]		

Note: For explanation of assessment symbols see Box 1. For indicator codes see Table 42.

For the majority of the case study a positive impact can be stated. In the most cases this is due to jobs which were created. However, regarding jobs created attributable to restoration activities (GG1) one has to be aware that these jobs are generally limited in time, whereas jobs created attributable to restoration outcomes at least in some case can be assumed to be longer-lasting, and thus creating a certain sustainability. In some cases, a positive impact was also due to improvements related to recreational activities.

Consistency between Theory of Change and reported monitoring data

The alignment between expectations of the Theory of Change and the reported monitoring data across the MERLIN case studies was analyzed for the green deal criteria (Figure 24).

Biodiversity Net Gain and Inclusivity (Leaving no one behind) demonstrated the strongest alignment, with match rates of 94% and 89% respectively, reflecting a strong consistency between planned and delivered data. In general, ecological criteria showed particularly strong alignment, with over 75% matches across all five associated criteria. The two social criteria also displayed high alignment, with at least 78% matches. In contrast, the economic criteria exhibited noticeable lower match rates, with mismatches often accounting for nearly one-third. The lowest overall alignment was observed for Sustainable Transport, where mismatches comprised nearly half of all data points.

For economic criteria, discrepancies often stemmed from data submissions that were not foreseen in the original ToCs—these additional, unanticipated data points made up the majority of mismatches. In contrast, mismatches within the social criteria were exclusively the result of missing data, indicating gaps in delivery rather than overreach. Ecological criteria displayed a more balanced distribution, with mismatches resulting from both missing and additional data, suggesting a more dynamic but relatively well-aligned implementation process.

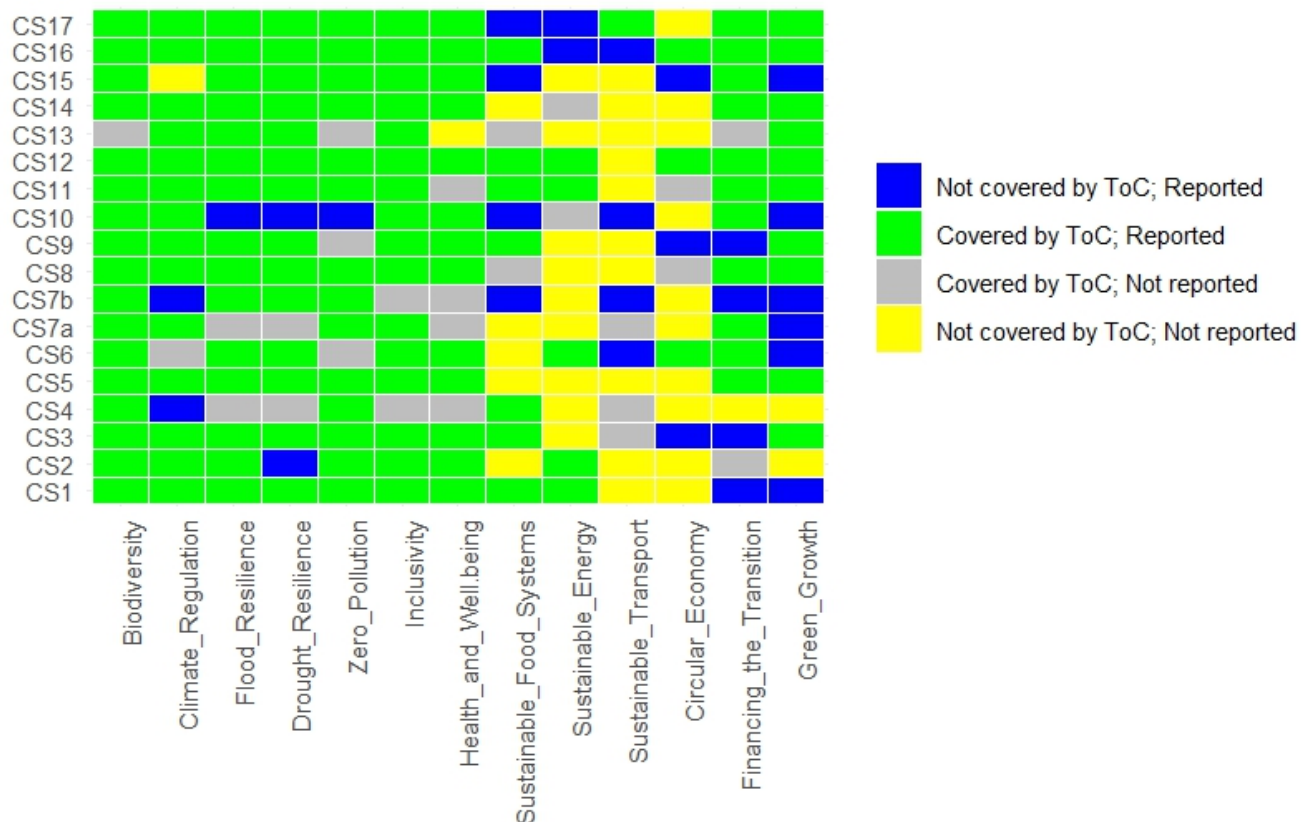


Figure 24 Consistency between Theory of Change and reported monitoring data. Heatmap showing the coherence between the Theory of Change and reported monitoring data across the MERLIN Case Studies (CS1–CS17) and the 13 Green Deal criteria. The colour coding indicates the type of alignment.

Annex 3 – CS09 Tisza floodplain rewetting HU: Demonstration of NbS implementation impact

The MERLIN Monitoring Framework (Carvalho et al., 2022) allows for a broad systemic assessment of the impacts of restoration measures across the 13 EGD policy criteria. At the case study level, such assessments can be important in both assessing the effects of NbS whilst also identifying trade-offs and synergies between different criteria to inform stakeholder discussions and future upscaling opportunities. The MERLIN project was designed to provide an evidence and methodological legacy in this respect; that is, to shape and foster future decision making in NbS planning and upscaling across the 18 MERLIN Restoration Case Studies.

To exemplify this approach, we requested narrative reports to provide context to the aggregated assessment approach used in this report from Case Study Reporting Leads, keeping in mind that at the time of review many case studies were in the process of reflection and interpretation making it a premature request, especially for Implementation Cases. We provide, here, a synopsis from one Restoration Demonstration Case Study where the assessment interpretation was at a more advanced stage: CS09 Tisza Floodplain Rewetting Project, Hungary, from the Large Transboundary Rivers Cluster. In this synopsis we provide an overview of the restoration process implemented and the rationale for the case study, narratives prepared by the Case Study Reporting Leads to provide context to each of the criteria assessed, and an overview of perceived interactions (e.g. synergies and trade-offs) across them, which also considers the perceptions of stakeholders on the impacts achieved.

Description of the Tisza Floodplain Restoration Case Study

The Tisza Floodplain Restoration Case Study is a MERLIN Demonstration Site located near the village of Nagykörű on the Central part of the Tisza River, Hungary; the largest sub-basin of the Danube River Basin. The restoration activities for this Demonstration Case formed part of the LIFE00-NAT-A-7051 Project implemented between 2001–2005. The beneficiary was WWF Austria, the project partner was WWF Hungary. The main aim of this project was to restore and conserve floodplain-related habitats, targeting 5 sites, which are situated along the middle section of the Tisza River in Hungary, within the “Middle Tisza Landscape Protected Area”. Measures were implemented on altogether 392 ha in Nagykörű, Tiszajenő and Tizsakürt. The total budget was 435,326 EUR, the EC contribution was 217,663 EUR (50%). The project was also supported by the Federal Ministry of Agriculture, Forestry, Environment Protection and Water Management of Austria.

The affected active floodplain area is 263 hectares and the restoration focus area, here, the so called ‘Lake Anyita’ is approximately 70 hectares. The Tisza was strongly regulated in the 19–20th centuries when most of the floodplains were cut off from the river creating a landscape dominated by intensive arable farming. The overall goal of the restoration programme was to implement a ‘floodplain farming system’ in the floodway of the Tisza River, near Nagykörű, based on water retention in a designated area of former wetlands. Between 2001–2006, the LIFE00-NAT-A-7051 Lake Anyita Project was implemented with the following restoration objectives: controlled water retention and the rehabilitation of a floodplain meadow that had been invaded by invasive plants due to lack of use through the creation and maintenance of a characteristic and highly biodiverse lowland lake and wetland meadow. This was achieved by constructing a sluice to retain flood water within a low-lying riverbed area creating Lake Anyita (approx. 30–60 ha) and through vegetation management of a floodplain meadow (approx. 15 ha) using physical cutting and the introduction of a native Hungarian Grey Cattle herd. These measures and associated activities have resulted in significant changes in land-cover and habitat type at the site over time (Figure 25).

Changes in land cover before and after floodplain restoration at Nagykörű

CORINE Land Cover categories: Discontinuous urban fabric Non-irrigated arable land Pastures
Complex cultivation patterns Broad-leaved forest Transitional woodland-shrub Water courses and wetlands

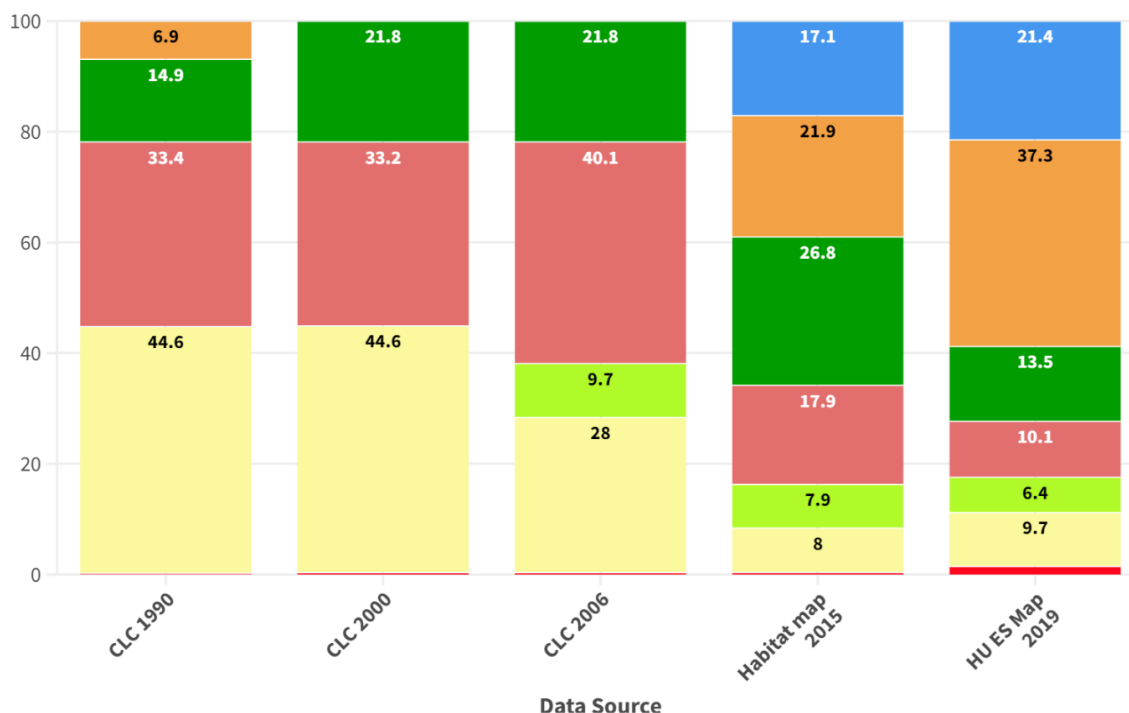


Figure 25 Changes in land cover before and after floodplain restoration at Nagykörű. Figure by Szilvia Ádám.

Description of Aggregated Assessment Approach across EDG Criteria

For the purposes of this Demonstration Case Study assessment, a restoration Year Zero was defined as 2006 by which time the major measures outlined above were implemented. So, data reported for indicators that precede 2006 were classed as ‘Before’ and later than 2006 as ‘After’ in the assessments of EDG Criteria. The study leads note that after 2006, grazing and mowing continued in the floodplain meadow and the controlled water retention system was managed until 2016, after which the water management permit of the sluice expired. In 2020, the Nagykörű Municipality took the initiative to have the state buy the Lake Anyita with the purpose of managing water retention in Lake Anyita.

The results of the aggregated assessment are provided (Table 44) alongside an analysis of interactions between them provided by the Case Study Reporting Leads. The measures were assessed as having positive effects on Biodiversity Net Gain, Climate Regulation (with low confidence), Flood and Drought Resilience, Health and Wellbeing, Circular Economies and Financing the Transition. Negative effects were assessed to have resulted from measures implementation for the Farm to Fork Criterion. A range of interactions were identified between criteria and the contexts underpinning these are introduced in the narratives below for relevant EDG Criterion.

Restoration aims and any target goals for criteria including ToC

Between 2001-2006, the LIFE00-NAT-A-7051 project in the Lake Anyita and surrounding area achieved its two main objectives: controlled water retention and the rehabilitation of a floodplain meadow that had been invaded by invasive plants due to lack of use. In the area of about 30 hectares, in a low-lying, riverbed-like area, the water entering with the Tisza flood waves was retained in a controlled manner with a sluice. The conservation objective achieved through water retention was to create and maintain a characteristic and highly biodiverse lowland lake and wetland meadow in the area. In the floodplain flooded for a long period, the near-natural vegetation and water body stabilised in a short period of time, what was important for the protection of aquatic macroinvertebrates, as well as aquatic reptiles, amphibians and birds. Another purpose was to provide spawning habitat for native fish. Fish species of economic importance, such as carp, pikeperch and northern

pike, could naturally reproduce and be returned to the river. It was also important for some Natura 2000 fish indicator species, such as the European Weatherfish, spined loach and European bitterling. In the higher altitude areas, covered with undesirable invasive shrub and tree species, these were cut from about 15 ha, then the site was initially managed with a native Hungarian grey cattle herd, grazing the most problematic false indigo-bush. The aim of grazing and mowing was to create a wooded grassland habitat by leaving the naturally occurring larger willows and native poplars in the area.

Narrative Reports to Supplement EDG Criteria Assessments

We summarise more comprehensive narrative reports for each EDG Criteria provided by the case study reporting leads. The general structure of these narratives outlines the context of the assessment as well as highlighting example interactions between criteria (underlined text). A full assessment of criteria interactions is included in Table 44.

Biodiversity Net Gain

The wetlands, which have been developed for about a decade and a half, have formed zonation, patterns of vegetation and habitats close to natural floodplain conditions. Macroinvertebrate communities have very high densities and diversity, especially for arthropods. Improved spawning habitat for native fish species in flooded meadows has attracted both Natura 2000 species (e.g. spined loach and European Weatherfish) but also invasive species recruitment. Breeding populations of water frogs (*Rana esculenta*-complex), European fire-bellied toads, and the moor frog were established. The habitat supports breeding bird species including the ferruginous duck and mute swan, but the importance a breeding habitat for waterfowl, generally, appear limited.

Climate Regulation

At local scale we estimated the net greenhouse gas balance (NGB) by the process oriented biogeochemical model (BiomeBGC MuSo) for the past/present period.

Floodplain restoration is predicted to have a positive impact on NGB, where wetting increases biomass production and habitat condition leading to reduced greenhouse gas emissions and increased carbon sequestration. However, when in unflooded state, greenhouse gas emissions from the site may increase and the site may become a net carbon source.

Flood Resilience

The main flood protection line of the site runs on average about 25-30 m from the flood-risk area, for a stretch of more than 2 km. Major flooding of the river had previously washed over the summer dyke, which made it impossible to retain water in the area for long periods. The project restored the summer dyke and constructed a sluice to allow control of inflow and release of water, thus preserving the flood protection function of the area. The full capacity of the 263 ha floodplain site is about 10 million cubic metres.

Drought Resilience

The installation of the sluice allowed for controlled water retention following flooding of the Tisza above 600 cm, mainly in the winter-spring period. Between 2004 and 2008, the area was subject to regular, controlled water retention. On average, water was retained in an area of 60-65 ha until the end of the growing season, with the exception of the drought year in 2007, during which this capacity could not be maintained.

Between 2009 and 2018, mainly due to the demands of local farmers, water releases were sporadic and only occurred in the spring-summer period. Since the extremely dry year of 2012, the lake has dried out in summer impacting establishment of marsh vegetation in favour of undesirable species including false indigo-bush (*Amorpha fruticosa*), over about 80% of the site. Regular water retention has reduced the vulnerability of the area to drought but also enhances Biodiversity Net Gain, although the capacity to maintain this function of the sites is dictated by stakeholder demands and extreme weather events

Health and Wellbeing

Restoration increased access to nature and established routes for nature walks in the area. Between 2011 and 2013, the Hortobágy National Park Directorate (HNPD) organised guided tours of the area, mainly in winter and spring. Following the absence of water retention from 2018 and during the long period of no flooding, a route crossing the Lake Anyita bed was established. The improved accessibility of the site requires maintenance and following initial gains, has declined in recent years. There are no known water-related diseases or other water-related health issues reported.

There is perception among some stakeholders that a lack of controlled water retention has led to occasional breeding of mosquitoes (Culicidae) in small, intermittent, warm pools, with some stakeholders calling for pest control in the area.

Farm to Fork (F2F)

Before 2000, lower elevation land use (below 86 mBf; mean sea level above the Baltic Sea) was predominantly arable lands, orchards, gardens and forests. After a flood event in 2000 which breached the flood prevention dyke, arable lands were abandoned and lost through natural succession of vegetation altering the land-use to grassland with shrubs with sporadic flooding. The original elevation of the summer dyke is 87 mBf, the dyke breach was altered through the restoration project to 84.8 mBf. Some orchards and small 'weekend gardens' have remained at higher elevation (above 86 mBf), with lower flood risk.

During restoration, a sluice was built with a channel which allowed regulation of the inundation and exposure of floodplain meadows and pasture for grazing and to retain water in the floodplain for longer periods. Since 2010, the area has been flooded by the riverine floods irregularly and in an uncontrolled manner. Some invasive alien species started to spread (*Amorpha fruticosa*) and the area is undergrazed. After 2016, the permit which allowed control of the sluice expired and so control of water retention was limited. Generally, the restoration project is perceived by stakeholders to have supported more sustainable agricultural practices and has reduced environmental pressures associated with flooding whilst contributing to a reduction in greenhouse gas emissions.

Inclusivity

The restoration efforts received high media attention during the period of funding for the LIFE project (i.e. between 2001–2006). This included the creation of a project website (www.tiszalife.hu). Highlights in the media included improved aesthetic condition for the public associated with grassland restoration and biodiversity conservation. However, the most popular news stories reaching national media were related to beaver reintroduction in 2004–2005. This media attention and increase in public awareness were important in underpinning negotiations with stakeholders who were initially reluctant to support restoration measures associated with the risk of loss of agricultural land. During the LIFE project (2000–2006), the wider restoration community were engaged through information forums, seminars and conferences were held regularly with the involvement of the municipality, local conservation and water managers. Most of these were held locally, attended by local people and professionals. Several forums and presentations were organised for local stakeholders and farmers during the planning and implementation of the project.

Following cessation of funding, the targeted media attention ceased, public awareness has waned and the maintenance of public engagement materials including wooden information boards has declined. The number of visitors to the site was not recorded, though there were occasional excursions. From 2019, after the termination of the regulated water retention and for other reasons, access to and around the site became difficult, and the number of visitors reduced.

Circular Economy

The LIFE project supported Circular Economy activities by increasing the capacity of the floodplain to store the river's flood waters for use, which would otherwise have been drained. In the upper part of the restoration area, which was not subject to controlled flooding, about 3 ha of hay were grazed and occasionally mown, with a volume of about 5 m³. In 2013, hay from about 10 ha of was harvested in the riverbed for power plant utilisation. In addition, the Grey Cattle herd were used to control invasive vegetation resulting in inputs to the agricultural system through productive land management measures.

These activities improved the water supply to agriculture while increasing biodiversity of the landscape but were limited during periods of limited coordinated management following funding cessation.

Financing the Transition

The funding landscape for the restoration work are outlined in the introduction to this section. WWF Hungary restarted its activities here in 2019 and aims to make landscape rehabilitation based on water retention work effectively in the area again. To this end, it has attracted various sources of funding (e.g. WWF Netherlands, WWF Switzerland, the MERLIN Project, Coca-Cola Foundation, Pancivis Foundation). The long-term goal is to make the management of the area (grazing, maintenance of orchards, ecotourism, processing and trading of local products) profitable for local farmers.

After the LIFE project (2001–2005), the site was not managed in a coordinated way. Private farmers, local on-governmental environmental groups and the local dam keeper operated the sluice. Since 2016, there has been no regular water retention management. Grazing and invasive plant mowing were carried out by private

farmers. Agri-environmental payments partly covered the costs of management. The size of the area managed, and the number of grazing animals decreased after the project, especially in the second half of the 2010s.

Green Growth

Controlled water retention allowed the fish population in the Tisza to increase, and fish stocks increased as a result representing an increase in recreational and commercial potential. However, the area was not used for commercial fishing or angling during the restoration project. Between 2005–2008, this fish stock was harvested for conservation and protection purposes, and fry of native species were released back to the river in autumn by a small number of employed professional fishermen. The quantity of fish caught is not known. At least 70% of the fish caught were of adventive species. However, fish population surveys indicated that the restoration measures resulted in the presence of species important for conservation, including spined loach, European Weatherfish and European Bitterling. Fishing between 2009–2018 was occasional, mainly for research or fish protection purposes.

The average number of people continually employed to manage the grazing for nature conservation measures was 1 person from 2003 to 2024. The number of occasionally employed people was 1–3 person over the same period.

The growth of accommodation and catering for tourism in the municipality since 2002 had no direct link with the project area.

*Table 44 The assessed interactions between criteria based on CS09 reporting team perspectives combining experiences and lessons learned through use of the MERLIN Reporting Framework and stakeholder discussions on perceived impacts of restoration measure effects. **Syn** indicates a positive synergy between two criteria is perceived. **'Trade-off'** indicates where the impacts of one criterion results in a perceived negative effect on another. Where the strength of confidence in the perception of an interaction is weak, the interaction term is preceded by **'W'**. It should be noted that most of the trade-offs are associated with apparent differences of perception across stakeholders. For example, some stakeholders considered the loss of agricultural land during water retention in Lake Anyita as a negative effect, despite the positive effects across multiple criteria resulting from this measure whereas others perceive sustainable land use and habitat creation as a positive outcome. **NR**=not relevant*

Criteria		Biodiversity Net Gain	Climate Regulation	Flood Resilience	Drought Resilience	Health and Wellbeing	Farm to Fork	Inclusivity	Circular Economy	Financing the Transition	Green Growth
	Aggregated Assessment	😊	😊	😊	😊	😊	😞	NR	😊	😊	😊
Biodiversity Net Gain	😊	-	Syn	Syn	Syn	W.Syn	W.Syn	W.Syn / Trade-off	Syn	Syn	W.Syn / Trade-off
Climate Regulation	😊	Syn	-	Syn	Syn	-	Syn	-	Syn	W.Syn	-
Flood Resilience	😊	Syn	Syn	-	Syn	-	Syn	-	Syn	-	-
Drought Resilience	😊	Syn	Syn	Syn	-	Syn	Syn	-	Syn	-	Syn
Health and Wellbeing	😊	W.Syn	-	-	Syn	-	-	Syn	Syn	-	-
Farm to Fork	😞	W.Syn	Syn	Syn	Syn	-	-	Trade-off	Syn	Syn	W.Syn
Inclusivity	NR	W.Syn / Trade-off	-	-	-	Syn	Trade-off	-	Trade-off	Syn	W.Syn
Circular Economy	😊	Syn	Syn	Syn	Syn	Syn	Syn	Trade-off	-	W.Syn	W.Syn
Financing the Transition	😊	Syn	W.Syn	-	-	-	Syn	Syn	W.Syn	-	W.Syn
Green Growth	😊	W.Syn / Trade-off	-	-	Syn	-	W.Syn	W.Syn	W.Syn	W.Syn	-

Implications for the Regional Scalability Planning Process

Consideration of the interactions identified above, and other information, formed an evidence base to inform the preparation of the Regional Scalability Plan (RSP) for the Tisza. Development of the Tisza RSP included input from a Case Study Board and following wider stakeholder workshops supported by the MERLIN Project in 2024. The conclusions of these discussions underpin most of the planned actions in the Tisza RSP.

The Tisza RSP has an ambition to chart a path towards **developing sustainable water management and landscapes in the Tisza Plain, by 2050** (Kajner et al., 2024). A number of linkages and synergies were identified across enabling policy mechanisms that will support this vision including on integrating with basin scale flood alleviation programmes through water management, the review process of the Hungarian National Water Management Plan, the Hungarian 2nd National Climate Change Strategy, linking to the Common Agricultural Policy Strategy Plan, and inputting to WWF Hungary's Tisza 21 Concept. This RSP focuses on the lowlands of the Hungarian part of the Tisza River Basin.

Today the Tisza runs between flood protection dikes and has no connection with most of its former floodplains. However, there are at least 150,000 ha of deep floodplains (active and morphological floodplains), which could be safely reconnected to the river and used for floodplain farming. The long-term goal is to preserve and develop the natural floodplain river ecosystem along the Tisza River. The target is that water retention based, nature friendly, sustainable floodplain management systems are introduced in the Hungarian part of the Tisza River Water Basin, wherever possible, but at least on 150,000 ha, in order to improve biodiversity and provide benefits for local communities. If the vision is realised, measurable outcomes will include: improved habitat condition and the creation of new semi-natural habitats: grasslands, forests, wetlands. The sustainable use of local natural resources will play a greater role in the livelihoods of people in the region and living standards will improve. Damage from climate change, inappropriate land use and water management will be reduced. Overall, the long-term impact will be to improve the ecological status of the Tisza Region, the livelihoods of its inhabitants and increase their resilience to climate change.

The Tisza RSP proposes 19 Actions designed to deliver ambitions across ten EGD Goals. Of these EGD Goals, Climate Regulation, Biodiversity Net Gain, Drought Resilience, Sustainable Food Systems (Farm to Fork), Inclusivity are classified as primary goals, whereas Flood Resilience, Health and Wellbeing, Financing the Transition, Circular Economy, and Green Growth are classified as secondary Goals.

Narrative Pathways to Impact and monitoring methodologies are presented to support the Actions, alongside high-level targets to 2050. Interactions across these Actions have been identified and are presented within the Tisza RSP (Table 45). The estimated cost of implementing the Actions is €20,450 million, though given the timelines and scale of implementation this estimate has a low degree of confidence and will be subject to managing and monitoring a complex set of interactions across the Actions.

Examples of targets for primary EGD Goals in the Tisza RSP include:

- Climate Regulation. Carbon sinking potential increased in the Hungarian part of Tisza Basin by 15% by 2050.
- Biodiversity Net Gain. Increase the area of floodplain reconnected to the river by 150,000 ha by 2050.
- Drought Resilience. Increase the area of rewetted wetlands (other than peatlands) and the area of agricultural lands with schemes for water retention by 150,000 ha and 120,000 ha, respectively, by 2050.
- Sustainable Food Systems (Farm to Fork). Increase in economic value generated by agriculture in climate adaptation and water retention focus areas compared to previous land use by 40% by 2050. Reduction of intensively farmed arable land and increase in areas used according to environmental conditions (e.g. grasslands, wetlands, forests) by 120,000 ha by 2050.
- Inclusivity. Publish awareness raising materials on a dedicated website attracting 1 million views by 2030 growing to 2 million views by 2050 and engage with the wider public through regular meetings of the Case Study Board (3 times per year) to 2050.

Table 45 - Interactions identified between Actions relating to the delivery of the targets for the primary and secondary EGD Goals as listed in the Tisza RSP (Kajner et al., 2024). CLIM – Climate Regulation; BIOD – Biodiversity Net Gain; DROU – Drought Resilience; F2F – Farm to Fork; INCL – Inclusivity; FLOD – Flood Resilience; HEAL – Health and Wellbeing; FIN – Financing the Transition; CIRC – Circular Economy; GGRO – Green Growth.

Action	To be coordinated with Action #																			
	CLIM	CLIM	CLIM	CLIM	BIOD	BIOD	DROU	F2F	F2F	INCL	INCL	INCL	FLOO	HEAL	HEAL	FIN	FIN	CIRC	GGRO	
	1	2	3	4	1	2	1	1	2	1	2	3	1	1	2	1	2	1	1	
CLIM 1 - Tisza Strategy																				
CLIM 2 – NWRM Pilot Projects																				
CLIM 3 - Water retention in deep floodplains																				
CLIM 4 - Harmonize SECAPs with Tisza Strategy																				
BIOD 1 - Restoration in NWRM pilot sites																				
BIOD 2 - Habitat development in deep floodplains																				
DROU 1 - Analyse the benefits of NWRM																				
F2F 1 – New economic models																				
F2F 2 - CAP and legal framework modifications																				
INCL 1 – Communication and empowering																				
INCL 2 - Strategic partnerships																				

INCL 3 – Case Study Boards																			
FLOO 1 – Harmonizing flood risk management with NWRM																			
HEAL 1 – Increase recreation potential																			
HEAL 2 – Optimizing health effects																			
FIN 1 – Macroeconomic analysis																			
FIN 2 – Bankable projects																			
CIRC 1 – Industrial projects to optimise water use																			
GGRO 1 – Governmental program for local economy development																			

Annex 4 – Questionnaire and questionnaire results for the evaluation of the MERLIN Monitoring Framework

Questionnaire

From Concept to Evidence: Effective Monitoring for Adaptive Management in Nature-Based Solutions

This questionnaire aims to identify challenges, opportunities, and lessons learned during the application of the MERLIN monitoring framework. It will provide evidence-based recommendations for refining and improving its future use. * Indicates a mandatory question

Part 1

Which MERLIN ecosystem cluster does your case study belong to? *

- ☐ Peatlands and other wetlands
- ☐ Small streams
- ☐ Large rivers

Self-Perception

For each question, please use a 1-to-5 numerical scale: 1 represents the lowest or least favorable option, and 5 represents the highest or most favourable option. If you are unable to answer a question, you may skip it and continue with the next one.

1.1 How satisfied are you with the quality of the monitoring data that you provided?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.2 To what extent do the provided MERLIN monitoring data effectively support the assessment and achievement of your project's specific objectives?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.3 How effective is the current monitoring framework in enabling adaptive management for your case study?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.4 Were the available resources sufficient to support your contribution to the data delivery?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.5 How would you rate your overall satisfaction with the MERLIN impact monitoring process?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.6 How appealing do you find this monitoring framework for integration into your organization's standard practices?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.7 To what extent does your organization have the financial and operational capacity to integrate this monitoring framework into its standard practices after the MERLIN project ends?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Overall feedback

A. Institutional Setup

2.1 What institutional resources did your organization utilize to support the MERLIN impact monitoring? *

Please select all that apply

- ☐ Internal Expertise (e.g., staff knowledge in biodiversity, climate modeling, or governance)
- ☐ External Consultants (e.g., partnerships with scientific institutions, NGOs, or industry experts)
- ☐ Technical Equipment (e.g., monitoring devices, drones, software tools, or IoT sensors)
- ☐ Financial Resources (e.g., dedicated budgets or grants for monitoring activities)
- ☐ Access to Databases (e.g., government records, research data, or public environmental datasets)
- ☐ Collaborative Networks (e.g., partnerships with municipalities, other local authorities, or regional agencies)
- ☐ Community Participation (e.g., citizen science initiatives or local stakeholder engagement)
- ☐ IT Infrastructure (e.g., data storage, analysis platforms, or GIS systems)
- ☐ Policy or Governance Support (e.g., frameworks, policies, or institutional buy-in for monitoring)
- ☐ Training and Capacity Building (e.g., workshops or skill development for monitoring activities)
- ☐ I cannot answer this question
- ☐ Other: _____

Comments

B. Resources

2.2 Estimation of the total workload (in hours) for providing MERLIN impact monitoring data.

If you are unable to answer this question, you may skip it and continue with the next one.

2.3 Was sufficient funding available to carry out the monitoring?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favorable option, and 5 represents the highest or most favourable option. If you are unable to answer this question, you may skip it and continue with the next one.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2.4 Was adequate technical expertise available to conduct the monitoring?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favorable option, and 5 represents the highest or most favourable option. If you are unable to answer this question, you may skip it and continue with the next one.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Comments

C. Communication**2.5** Did the MERLIN monitoring guidance provide sufficient information to carry out the impact monitoring?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favorable option, and 5 represents the highest or most favourable option. If you are unable to answer this question, you may skip it and continue with the next one.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2.6 Was there adequate communication from the developers of the MERLIN guidance to carry out the monitoring?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favorable option, and 5 represents the highest or most favourable option. If you are unable to answer this question, you may skip it and continue with the next one.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Comments

D. Data Acquisition

2.7 What were the obstacles to implementing the BACI* design for impact monitoring?

Before-After Control-Impact

Please select all that apply

- ☐ Lack of Baseline Data: No data was collected before the restoration began.
- ☐ Absence of Suitable Control Sites: No appropriate unaffected sites could be identified for comparison.
- ☐ Resource Constraints: Insufficient funding, time, or personnel to implement a BACI design.
- ☐ Technical Challenges: Difficulty in designing or implementing the monitoring framework.
- ☐ Spatial Limitations: Control and impact sites were too different or not comparable.
- ☐ Temporal Constraints: Restoration was implemented before a sufficient baseline monitoring period.
- ☐ Stakeholder Opposition: Resistance from local stakeholders or decision-makers to allocate resources for BACI monitoring.
- ☐ Monitoring Complexity: Complexity of integrating BACI with other monitoring frameworks or priorities.
- ☐ Uncertainty of Outcomes: Concerns that the BACI design would not provide clear or actionable results.
- ☐ I cannot answer this question
- ☐ Other: _____

E. Scientific evidence

2.8 How suitable do you consider the MERLIN impact monitoring approach for assessing restoration measures in terms of goals, threats, and adaptations?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favorable option, and 5 represents the highest or most favourable option. If you are unable to answer this question, you may skip it and continue with the next one.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Part 2

In this part of the questionnaire, we will ask for specific feedback on the criteria and related indicators. You will only be asked about items for which you have provided monitoring data.

If you are unable to answer a question, you may skip it and continue with the next one.

Green Deal Criteria**1. Biodiversity Net Gain**

If you are unable to answer a question, you may skip it and continue with the next one.

1.1 How relevant do you consider this criterion for monitoring the effects of your restoration?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favourable option, and 5 represents the highest or most favourable option.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

1.2 What was the source of data you used for monitoring this criterion? *

Please select all that apply:

- ☐ Direct data collection (e.g., site-specific surveys, sensor networks, remote sensing) [please specify below]
- ☐ Existing datasets (e.g., monitoring programs, government databases, reports, open data repositories) [please specify below]
- ☐ Model-based data (e.g., MERLIN templates, other models, interpolations, machine learning outputs) [please specify below]
- ☐ Expert knowledge and estimations (e.g., expert judgment, literature review, historical records, citizen science) [please specify below]
- ☐ I cannot answer this question
- ☐ Other: _____

Specification

1.3 How much effort was required to acquire the necessary data?

Please use a 1-to-5 numerical scale: 1 represents the lowest or least favourable option, and 5 represents the highest or most favourable option.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Comments

... (These three questions were addressed for all 13 Green Deal criteria)

Impact Indicators

You have provided monitoring data for all the indicators listed below.

We would like your assessment of how appropriate the data you delivered are in terms of temporal and spatial scale. *In some cases, for example, the time series provided may not be **sufficient to capture long-term trends** or restoration effects. Similarly, the spatial scale of the data may not fully **align with the expected impact area** of the restoration.*

Based on your judgment, please indicate whether the **temporal and spatial scales of these data are appropriate** for assessing the effects of the restoration by checking the corresponding box. If, in hindsight, you find the temporal or spatial scale inappropriate, simply leave the box blank.

For each indicator, please indicate if you consider the temporal and spatial scale appropriate.

	Temporal Scale:	Spatial Scale:
Habitat status (BD1a)	☐	☐
Habitat trend (BD1b)	☐	☐
Species status (BD2a)	☐	☐
Species trend (BD2b)	☐	☐
Bird status (BD3a)	☐	☐
Bird trend (BD3b)	☐	☐
Area protected [ha] (BD4)	☐	☐

... (***This query was continued for all reported indicators***)

Comments: If you have left any boxes blank, please briefly explain your reasons below.

Questionnaire results

A total of 31 responses were collected for the first part of the questionnaire, while 27 responses were gathered for the second part. In the first part, nine responses were obtained from participants working in peat and wetland ecosystems, fifteen from those involved in small streams and basin environments, and nine from large river case studies. In the second part, eight responses came from peat and wetland case studies, eleven from small streams and basins, and nine from large river case studies.

Part 1

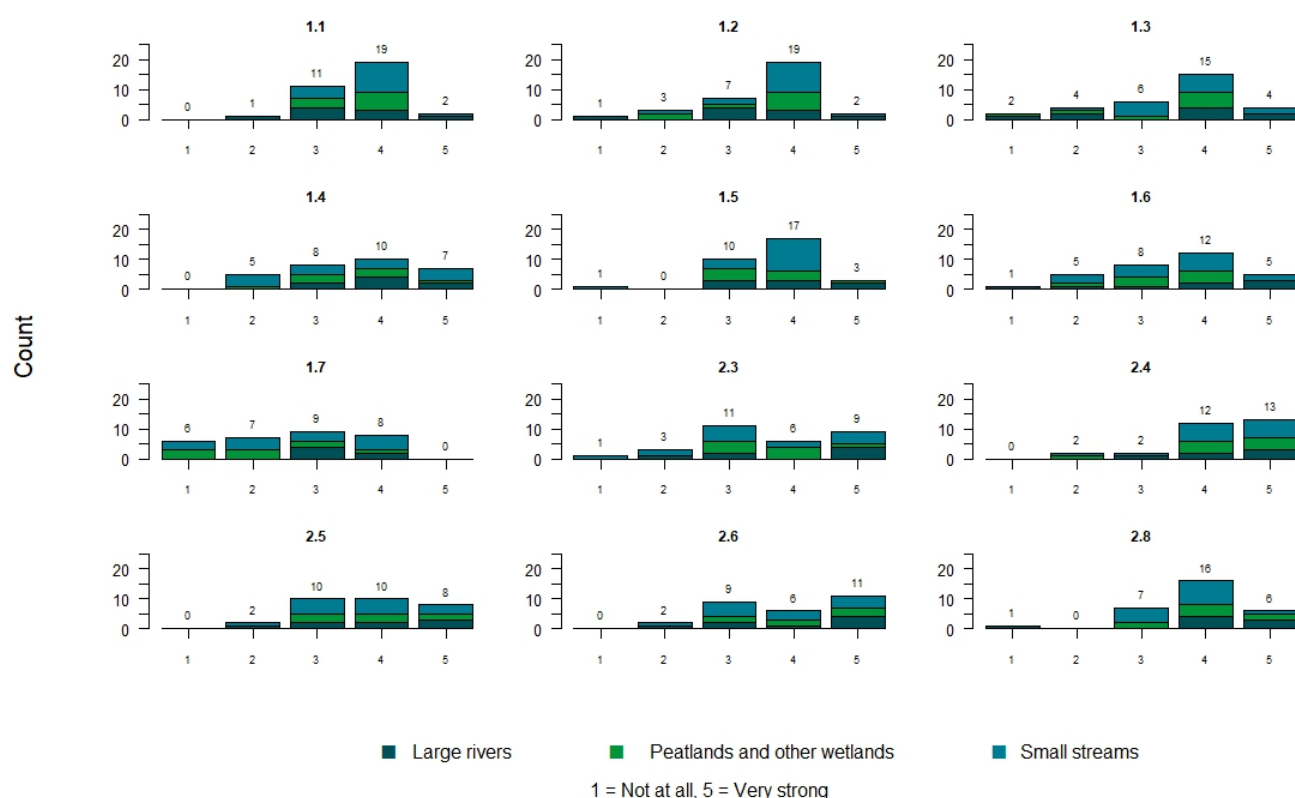


Figure 26 Breakdown of responses to all Likert scale questions from the first part of the survey. The numbering of the individual plots corresponds to the numbering of the respective questions (see Questionnaire Part 1). A total of 31 participants completed the questionnaire, providing insights into the perceived impact of these landscape types. The y-axis represents the total count of responses for each rating.

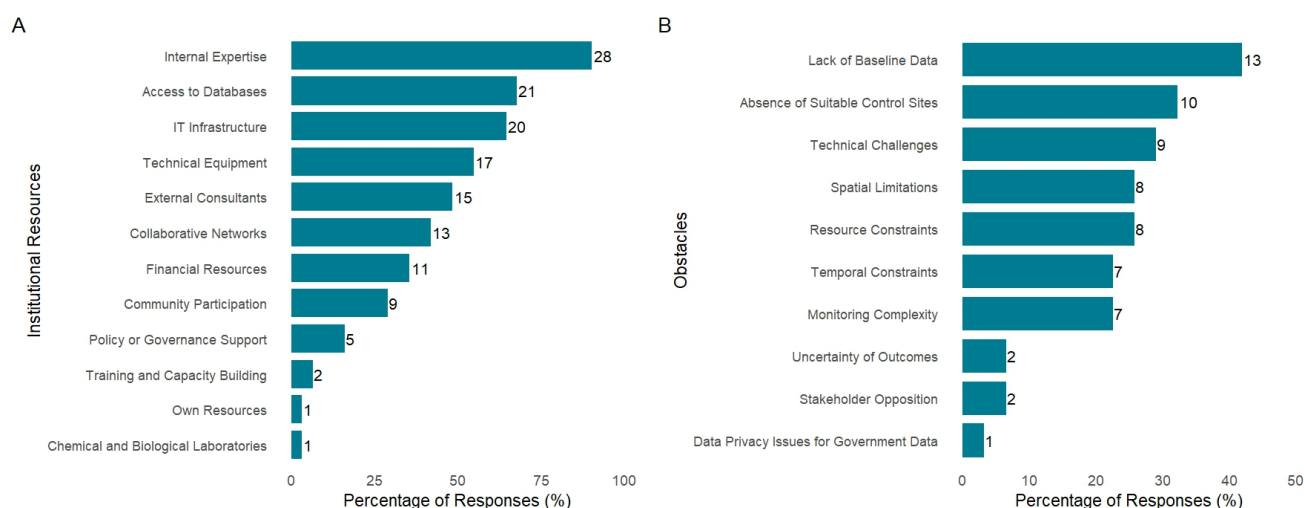


Figure 27 Distribution of answers to multiple-choice questions from Part 1 of the questionnaire. Panel A corresponds to Question 2.1 and shows the institutional resources available for supporting implementation monitoring. Panel B corresponds to Question 2.7 illustrating reported obstacles to implementing a BACI monitoring design. Multiple answers were possible per respondent. In total, 31 individuals completed the questionnaire.

Part 2

Table 46 - Average relevance of the green deal criteria for monitoring the effects of restoration and effort to acquire the necessary data based on the opinion of the case studies (Based on questionnaire questions “How relevant do you consider this criterion for monitoring the effects of your restoration?” and “How much effort was required to acquire the necessary data?”).

Criterion	Relevance [ø]	Effort [ø]
Biodiversity	4.6	3.8
Climate Regulation	3.7	3.8
Flood Resilience	3.9	3.4
Drought Resilience	3.7	3.6
Zero Pollution	3.9	3.5
Inclusive Participation and Governance	3.2	3.3
Health & Well-Being	2.9	2.8
Sustainable Food Systems (Farm to Fork)	3.2	3.4
Sustainable Energy	3.2	3.0
Sustainable Transport	2.7	2.4
Circular Economy	3.0	3.1
Financing the Transition	3.3	3.1
Green Growth	2.9	3.0

Table 47 Positively rated Indicators. The table shows selected indicators that received at least three responses and for which ≥75% of respondents rated either the temporal or spatial scale as adequate. Listed are the associated Green Deal criterion, indicator code, description, as well as the respective percentages, and number of responses. The indicators are grouped into thematic categories.

Criterion	Indicator Code	Indicator Description	Temporal [%]	Spatial [%]	Responses
Space and Structure of the System					
Biodiversity	BD5	Free-flowing river re-connected [km]	33	89	9

Biodiversity	BD6	Area of floodplain re-connected [ha]	33	100	9
Flood Resilience	FR3	Area of newly designated areas for flooding [ha]	58	92	12
Flood Resilience	FR4	Area of rewetted wetlands (other than peatlands) [ha]	100	89	9
Flood Resilience	FR5	Area of rewetted peatlands [ha]	75	75	4
Flood Resilience	FR9	Area of restored rivers and streams [ha]	50	79	14
Flood Resilience	FR10	Volume of channel retention gained as a result of restoration [m ³]	100	100	4
Drought Resilience	DR2	Storage capacity [m ³] of wetlands	67	89	9
Drought Resilience	DR9	Average annual increase of water levels in restored wetlands [cm]	75	100	4
Visitor and Participation Structure					
Inclusivity	IG2	Total number of participants in information sessions about the measures	59	82	17
Inclusivity	IG10	Do local residents feel positive about the MERLIN NbS and their local area impacts?	70	90	10
Green Growth	GG4	Number of people visiting an area on an annual basis	80	100	4
LULC (Land Use and Land Cover)					
Farm to Fork	SFS5	Utilisation: Land cover	92	92	13
Farm to Fork	SFS6	Utilisation: Land use	83	75	12
Other					
Health and Wellbeing	HWB6	Changes in occurrence and incidence of emerging infectious diseases or water incidents	14	83	7
Sustainable Transport	ST7	Fish density and species composition	20	100	5