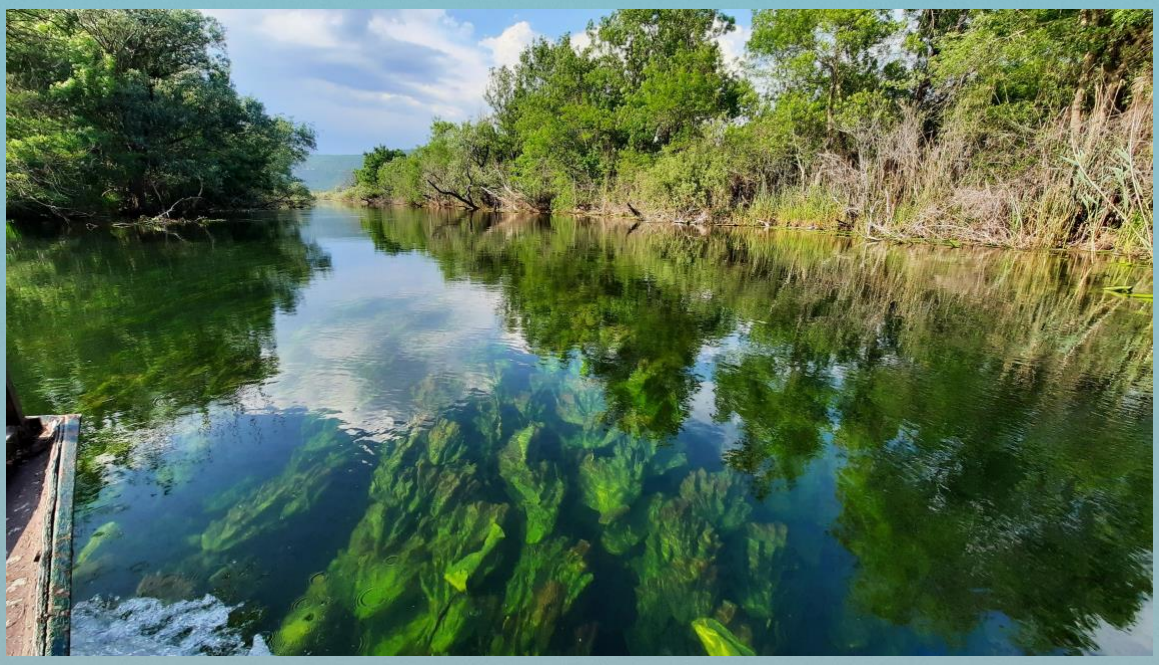
MERLIN



Deliverable D1.2:

New framework for monitoring systemic impacts of freshwater and wetland restoration actions

The MERLIN project (https://project-merlin.eu) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036337.

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Imprint

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MERLIN Key messages

1. Robust demonstration case-studies are needed to evaluate whether improvements in ecosystem condition are translated into improvements in ecosystem services.
2. This research is essential for effectively scaling-up nature-based solutions across Europe and providing the evidence to support transformation agendas in society and industries, and ultimately supporting the ambitions of the European Green Deal.
3. Clear guidance and standardised indicators help monitor the impact of freshwater and wetland restoration measures on European Green Deal goals.
4. These monitoring indicators should include environmental indicators (e.g. for biodiversity, greenhouse gas emissions and water storage capacity) as well as socio-economic indicators such as stakeholder representation, private finance mobilisation and job creation.
5. A combined Before-After-Control-Intervention (BACI) monitoring design is recommended to provide robust evidence and attribute change to the restoration measures.
6. Benchmark (cost or effort) and local/regional context data (e.g. land use, governance) are also needed alongside monitoring of impacts to not just measure what has happened at a site but to understand why it has happened.

MERLIN Executive Summary

A key aspect of freshwater and wetland restoration projects is to monitor and evaluate the broad impacts of restoration actions. This not only includes environmental impacts, such as biodiversity and physical changes to hydrology, but also how restoration measures impact society and the economy. This is particularly important when implementing Nature-based solutions, which are focused on (nature-positive) solutions for societal challenges, such as delivering flood and drought resilience or water quality improvements.

The MERLIN Project aims to demonstrate the benefits associated with restoration of freshwater and wetland ecosystems, specifically measuring the broad scale of impacts in relation to the European Green Deal goals. A shared monitoring framework across restoration case-studies enhances the degree of comparability between case-studies and allows us to understand how the geographical or political contexts and the scale of the restoration measures can affect impact. For all these reasons, **this handbook outlines guidance and standard indicators for monitoring the impact of freshwater and wetland restoration measures on all the European Green Deal goals**.

A number of Green Deal Criteria and associated indicators have been reviewed for monitoring by the case-studies. These cover 13 criteria:

- biodiversity net gain
- climate regulation
- flood resilience
- drought resilience
- health & well-being
- zero pollution
- sustainable food systems (farm to fork)
- sustainable energy
- sustainable transport
- inclusive participation and governance (leaving no one behind)
- circular economy
- financing the transition
- green growth.

For eight of these criteria several indicators have been selected as being **Essential Restoration Variables** that ALL case studies should monitor to measure the impact of their restoration actions and provide consistent results across the MERLIN project. These include indicators for biodiversity (conservation status), greenhouse gas emissions and water storage capacity, as well as socio-economic indicators such as stakeholder representation, private finance mobilized and job creation.

Case-studies are recommended to develop a shared understanding with their stakeholders of what actions and outcomes are needed to deliver the desired impacts (**Theory of Change**) and review where actions need to be strengthened to deliver the intended outcomes for each Green Deal criterion. The monitoring data supports the tracking of progress towards the desired impacts and supports updating of restoration plans.

For some indicators, it may be practically difficult to measure impact. In these cases, the alternative is to record progress in the activities or outputs that you have identified as important to achieve your impacts. For example, for inclusivity in governance it may be difficult without specialist surveys to understand, which people are accessing information on your case study and contributing to decision-making on where and how wetlands and freshwaters are restored. In these instances, documenting how you are making data or information available, and who is invited to make decisions, may provide useful quantitative and qualitative information on how your case study is undertaking activities or producing outputs (such as website design) to enhance inclusion in the governance of restoration programmes.

In terms of monitoring design, a key aspect of measuring impact is **attributing change to the restoration actions**. Ideally this is carried out by comparing the effects observed for a location undergoing restoration (an “Intervention” site) with a “Control” site, unaffected by any restoration measure. It can also be done by monitoring indicators before and after any restoration action. Where possible, **it is recommended a combined Before-After-Control-Intervention (BACI) design is applied**.

The spatial scale of measurement for monitoring is indicator-specific and case-specific. It is expected that case-studies are expected to choose a scale where impact can most be attributed to the restoration action (“signal”), and the effects of other activities in the catchment are minimised (“noise”).

Similarly the temporal scale of response needs consideration, as some indicators are not expected to respond within the time frame of the MERLIN Project, or some indicators measure resilience to infrequent climatic extremes. For these indicators, modelling approaches are provided to predict expected impact.

In addition to the MERLIN indicators of impact, other data are needed to "benchmark" the scale of impact observed. This can include information on implementation effort or extent of resources needed to undertake the restoration. This will be case-specific and very context-dependent, but each case-study provides data that can help understand what quantity of resources is needed for success, e.g. cost per ha of wetland or km of river restored. It is desirable to distinguish resource use between the capital costs associated with the implementation of restoration measures and the operational phase – the annual costs associated with maintenance of the restoration. These **benchmarking measures (cost, effort) are needed to evaluate the cost-effectiveness of all the Green Deal indicators** to calculate benefits per unit cost.

To evaluate what external conditions may support success, restoration projects are also asked to capture information on the context of their case-study including land-use, social and economic settings and the effectiveness of the implementation process (following the IUCN Gold Standard for NbS and associated guidance). One of the most important steps to realise the targets of the MERLIN project (and deliver the European Green Deal) is to upscale restoration and to connect individual measures in a landscape context by designing catchment-scale restoration strategies. Contextual data at both the local scale and catchment-/regional-scale can be useful for developing the upscaling strategy. For some indicators, context could also include documenting the magnitude of drivers or pressures affecting a site as **a key aim for the monitoring is to generate data that allows us to compare across scales in a meaningful way. To not just measure what has happened at a site but to understand why it has happened so upscaling of restoration can be realised**.

The monitoring requirements for each Green Deal Goal (Criterion) are considered in detail, with information provided on the following aspects for each criterion

- Policy background to the goal and targets
- Proposed monitoring design
- Baseline data collection
- Context and benchmarking data
- Data source(s)
- Data analysis and reporting
- Interpretation and limits of application
- Example monitoring strategy

Standardised reporting forms have been produced for each EG Deal criterion and their associated indicators. These reporting forms capture information on each indicator (including method details and units of measurement) as well as key contextual data required to interpret the scale of impact.

The results from monitoring impact will be analysed in relation to the benchmark and context data across all 17 case-studies (or relevant ones) and this will provide valuable evidence to understand how the scale of restoration affects cost-effectiveness, as well as understand how external contexts affect restoration success.

Several of the indicators relate to ecosystem condition or state (zero pollution, conservation status), whereas other indicators are measures of ecosystem services (water storage capacity, greenhouse gas emissions, sustainable farming). The monitoring data collected will, therefore, provide valuable data to examine relationships between state and service indicators, providing **robust demonstration case-studies, that evaluate whether improvement in ecosystem condition is translated into an improvement in ecosystem services. This underpinning research is essential for effectively scaling-up nature-based solutions across Europe and providing the evidence to support transformation agendas in society and industries. Ultimately, this case-study evidence is needed to support the ambitions of the European Green Deal**.

Content

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1 Introduction

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1.1 The European Green Deal Goals

The Green Deal is an integral part of the European Commission's strategy to implement the United Nation's 2030 Agenda and the Sustainable Development Goals (European Commission, 2019[1]). The European Green Deal aims to improve the well-being and health of citizens and future generations with goals related to climate, clean and resource efficient energy, circular economy, zero pollution, biodiversity, food – 'farm to fork', and mobility, i.e. sustainable transport. Based on financing and inclusivity, these objectives form a new green growth strategy that aims to protect the health and well-being of citizens from environmental-related risks and impacts (COM, 2019). Regarding peatlands, floodplains and wetlands addressed by the MERLIN project, this includes increasing resilience to flood and drought risks.

To initiate the transformative change that the European Green Deal promotes, systemic solutions for upscaling and mainstreaming restoration are needed to achieve the ambitious aims of environmental legislation (COM, 2019). Nature-based solutions are indispensable to reach the Green Deal objectives, delivering socio-economic benefits including biodiversity conservation and climate change adaptation and to engage economic sectors in restoration. In general terms MERLIN will address "Key Performance Indicators" (KPIs, hereafter referred to just as "Indicators") for all of the European Green Deal goals and it is expected that most of these will be relevant to all case-studies. MERLIN also has a focus on six economic sectors: agriculture, hydropower, insurance, navigation, peat extraction and water supply.

The main aim of the European Green Deal is to become climate neutral by the year of 2050, so **climate regulation** is a key focus of the MERLIN monitoring, alongside the specific focus of the funding call: the impact on achieving **biodiversity net gain**. Other goals that are widely relevant across the case-studies include **flood resilience**, **drought resilience** and **zero pollution**. The transition to a green economy is a key aspect of the European Green Deal and so indicators of **food sustainability**, **green growth** and **financing** the transition are relevant components of the case study monitoring plans. Ultimately, indicators of **inclusivity** and **health and well-being** to deliver a just and healthy transition are further key elements for monitoring and evaluation across the case studies.

1.2 Indicators for Monitoring Impact in MERLIN

Freshwater and wetland restoration is expected to have a range of consequences, beyond the water systems themselves. These consequences will in some cases be co-benefits to be maximised and in other cases will be disbenefits to be minimised. These interactions will occur with both social and ecologic systems and may, depending on scale, have effects that are significant for landscapes, regions and member-states. Monitoring and evaluation of implemented measures is a key aspect in any restoration programme as it allows the project managers and stakeholders to evaluate the effects of the restoration actions and the progress towards their goals. It also allows restoration programmes to capture and share their learning with stakeholders and the public and re-evaluate the measures undertaken and the need for further actions. In this way, the monitoring and evaluation plans support decision-making and adaptive management.

A key aspect of the MERLIN Project (Task 1.2) is to monitor and evaluate the broad impacts of freshwater and wetland restoration actions as framed by the European Green Deal goals (Table 1). Case-studies are asked to measure all relevant indicators of the Green Deal goals to ensure impacts are measured even when unintended or when trade-offs may occur. A shared monitoring framework across the case-studies also enhances the degree of comparability and between-case-study learning. For all these reasons, this handbook outlines monitoring expectations and guidance for indicators of all the European Green Deal goals, and it is expected that most of these will be relevant to all case studies.

The indicators outlined have been selected to be:

1. Salient and aligned with EU reporting obligations (e.g. Habitats Directive, WFD)
2. Credible - being evidence-based and using recognised, robust methods

[1]European Commission (2019). Communication from the Commission to the European Parliament: The European Green Deal. COM/2019/640 final. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

3. Legitimate (accepted by stakeholders)
4. Practically feasible within the resources of project and partners

Following a review of case study monitoring plans, and a number of discussions with case study leads, a number of criteria and associated indicators have been selected as being *Essential Restoration Variables* that ALL case studies should monitor to measure the impact of their restoration actions (Table 2).

Table 1 - European Green Deal Goals with potential indicators and data sources (taken from Figure 8 in the MERLIN Description of Work).

Criterion	Indicator(s)	Means of Verification
Biodiversity net gain	Conservation status and trends of species and habitat of community interest (Habitats Directive) and/or WFD ecological status	HD and WFD reporting on freshwaters and wetlands
Climate regulation	IPCC emission reporting guidelines on net CO_2 equivalent reductions or storage	Measurement or modelling (IPCC 2019 refinement)
Flood resilience	Flood hazard reduction for people (number) in vulnerable communities or volume (m^3) of additional storage capacity created	Measurement or modelling undertaken for the Flood Directive
Drought resilience	Drought risk reduction for vulnerable communities in (number) of people affected	Measurement or modelling of soil moisture and water storage
Health & Well-being	Increased access to nature-centred recreation and eco-tourism for people (number)	Eurostat Health status
Zero pollution Goals	Reduce nitrate and chemical run-off from agricultural land (% of change)	Measurement or modelling of diffuse pollution loadings
Farm to Fork – Sustainable Food Systems	Sustainable agriculture and aquaculture (ha increase)	Eurostat: organic farming and agri-environmental data
Sustainable energy	Energy savings of using NbS and any increase in renewable energy generation capacity in restored area (kWh)	Renewable scheme data from planning database(s)
Sustainable transport	Measures taken to improve active and public transport (increases in numbers) or renewable energy use (kWh)	Incorporated into restoration plans and local/regional data to evaluate impact
Inclusivity (Leaving no one behind)	Change in access to blue-green space – a) overall, b) for disabled communities, i.e. low employment/high deprivation (% change)	Eurostat spatial data and socio-economic indicators available for small areas/high resolution
Circular economy	Business models adapted according to principles of a circular economy (number); reduced consumption of water and other relevant resources (%)	Business survey and industry data on consumption

Financing the transition	New economic activity (number) company registrations in relevant standard industry classification codes in the region	Company data and postcodes
Green Growth	Employment (% changes) in relevant standard industry classification codes in the region	Eurostat employment data for LAU1

Table 2 - MERLIN Essential Restoration Variables.

Criterion	Indicator
Biodiversity net gain	• Conservation status of Habitats Directive Annex I listed habitats • Conservation status of species of community interest (Habitats Directive) • Conservation status of Annex I (freshwater/wetland) species in the Birds Directive • Species richness and diversity of native flora
Climate regulation	Greenhouse gas emissions (t CO2-equivalents/ha/yr) Modelled for floodplain wetlands and peatlands using: • Overall extent of wetland-type soils in the study area • Pre- and post-intervention land cover on wetland-type soils • Pre- and post-intervention condition of areas under wetland vegetation • Changes in water table depth in soils and duration and depth of surface water Modelled for surface waters using: • Overall extent and type of water bodies in the study area • Estimates of nutrient and organic matter loads or trophic status and humic type
Flood resilience / drought resilience	• Storage capacity (m^3) of restored rivers and streams (based on surface area of rivers, streams and other water bodies) • Storage capacity (m^3) of wetlands (based on surface area of restored wetlands and floodplains)
Sustainable Food Systems (F2F) and Land Use	• Land cover (ha/type) • Land use (ha/type) primary intended use and any secondary uses • Land tenure (public vs. private land) (ha for each type)
Inclusive Participation and Governance	• Number of visitors to project website • Number of participants in information sessions about the project • Ability to join a formal stakeholder forum/board/working group

	In addition to these measures of engagement we propose surveys are carried out to measure representation within engagement and impact of the engagement.
Financing the transition	• Breakdown of the total restoration budget by funding source and type [%] • Private finance mobilized (€)
Green Growth	• Number of jobs created (attributable in part to restoration activities)

Theory of Change: understanding actions expected to lead to impact

For all Green Deal criteria (and associated indicators) it is recommended that case studies sketch out a *Theory of Change*[2] to help identify the actions needed or outputs from actions that are expected to lead to the intended beneficial outcomes and impact. Developing a shared understanding with your stakeholders of what actions and outcomes are needed to deliver the desired impacts (the *pathway to change*) allows you to review where there are gaps in actions, or where actions need to be strengthened to deliver the intended outcomes. Related to this, it should be clear how your monitoring data help you understand the progress towards your desired impacts and supports decision-making to update restoration plans, or even inform needs for policy development.

For some indicators, it may be practically difficult to measure impact. In these cases, the alternative is to record progress in the activities or outputs that you have identified as important to achieve your impacts. For example, for inclusivity in governance it may be difficult without specialist surveys to understand, which people are accessing information on your case study and contributing to decision-making on where and how wetlands and freshwaters are restored. In these instances, documenting how you are making data or information available, and who is invited to make decisions, may provide useful quantitative and qualitative information on how your case study is undertaking activities or producing outputs (such as website design) to enhance inclusion in the governance of restoration programmes.

1.3 Monitoring design to measure impact

A key aspect of measuring impact on the Green Deal goals is attributing the change to the restoration actions, i.e., evaluating cause and effect. This can be done by monitoring any change in an indicator before and after any restoration action. However, as there may be other changes occurring simultaneously in the environment (e.g. a particularly hot or cold summer) or society (e.g. a global pandemic) that also affect the indicators, then a Before-After approach is not ideal. This is best overcome by comparing the effects observed for a location or region impacted by the restoration action ("Intervention" site) with another "Control" site unaffected by any intervention, or comparison with a location/region where an alternative action is traditionally applied (e.g. a hard engineering solution). Where possible, the evaluation is most powerful if a combined Before-After-Control-Intervention (BACI) design is applied (Downes, 2010[3]).

Spatial scale of impact

A key decision in the monitoring is the scale of measurement for monitoring impact. At what point downstream should social or economic benefits of increased flood resilience be measured? Which communities are relevant to measure inclusivity? Several of the indicators operate at larger scales (i.e., catchments or large landscape projects), while others are specifically designed for the smaller-scale measures to be implemented in the course of MERLIN; their scale of impact is likely to be very different and will be case-specific. As a consequence, the scale at which indicators are applied can differ even within a case study: some indicators might be most relevant for the scale of the entire case study (e.g., for the whole Emscher catchment or the entire area of the Kampinos National Park), while other may just address the local scale at which MERLIN has implemented restoration actions, e.g. a certain river stretch. It is envisaged that biodiversity and climate regulation indicators are measured largely at the local scale where MERLIN measures have taken place. However, there may be opportunities to include evaluation of previous restoration actions across the whole

[2] https://www.theoryofchange.org/

[3] Downes, B.J. (2010). Back to the future: little-used tools and principles of scientific inference can help disentangle effects of multiple stressors on freshwater ecosystems. Freshwater Biology, 55, 60-79.

river basin, such as with the longer-term large river basin case-studies, which can provide further information on how impacts change with increasing scale.

Temporal scale of impact

Some indicators may not be expected to respond within the time frame of MERLIN, for example greenhouse gas emissions and carbon storage, or some indicators may measure resilience to climatic extremes in terms of a return frequency for flood or drought events. For these indicators with expected lags in responses, or measuring expected benefits to resilience, modelling approaches are provided to predict expected impact. This is the case for the approach taken for climate regulation. Alternatively, already finalised restoration measures in the wider case study area (that used the same approach as in MERLIN) could be additionally evaluated to provide evidence of impacts that develop over the longer-term. Where modelling is possible, indicators may consider the expected post-restoration impacts beyond the lifetime of the MERLIN project, not just the immediate results. It is always recommended, however, to consider continuation of the monitoring beyond the MERLIN lifetime.

In conclusion, indicators may be applied:

- To the local area restored by MERLIN, and/or the entire regional case study area or in comparable areas restored previously in a similar way as planned by MERLIN.
- In a before – after design (before and after the restoration), in a control – impact design (comparing a restored to a non-restored area), or in a full BACI design (before – after – control – impact). Alternatively, some indicators may be described as narratives (for expected impacts where monitoring or attribution is difficult).
- Using existing secondary data (e.g., from GIS, or monitoring data from state authorities), using primary data collected by field measurements, or using modelling approaches.

1.4 Benchmarking implementation effort

What the cases uniquely provide is detail of the extent of resources (physical effort, time, cost etc.) needed to undertake the restorations actions. This could include effort often “unrecorded” to enable the restoration actions to be implemented, e.g., the time and costs associated with planning the actions, with seeking legal/regulatory consents, public consultations, community engagement etc.). This will be case-specific and very context-dependent, but each case provides another data point to document and understand what quantity of resources is needed for success, especially if case-studies can characterise the context (see later). From these case-specific data we can derive rates of resource used to achieve success – cost per ha of wetland or km of river restored, number of person months needed per year to maintain actions etc. These *Implementation Benchmarks* will help to frame the conclusions made at regional or pan-EU levels. This is the “cost” part needed for any cost-benefit or cost-effectiveness analysis (addressed in WP3).

The most valuable implementation benchmarks will be those where there is information over time that give a trajectory of costs, i.e., do the costs reduce per ha/km as skills or knowledge in the implementation team improve over time. Or do costs per ha/km reduce as the spatial scale of the restoration action increases? Conversely, if the easiest sites for implementation are restored first, the benchmarking could show that low costs of early “quick wins” are followed by much more costly actions if implementation becomes harder to achieve, or restoration may become less effective as later sites chosen have less impact (e.g. later actions have less storage capacity for floods, more difficult biodiversity targets to achieve, or fewer opportunities for job creation).

These restoration implementation benchmarks provide the best way to make estimates of the direct, local, socio-economic impacts (employment etc.) (Figure 1). This is particularly valuable to estimate the degree to which the restoration activities are undertaken, or how much the restored landscapes are used by local residents. Collecting cost data of the restoration actions will be particularly helpful to identify the future potential for further local or regional upscaling (e.g., for WP2 implementation plans and beyond).

For these implementation benchmarks it is desirable for case-studies to distinguish resource use between:

- Capital Phase (CapEx) – all costs associated with the implementation of the restoration measures (i.e., one-off costs of the MERLIN restoration action)
- Operational or Maintenance Phase (OpEx) – the annual costs associated with maintenance of the restoration following the implementation (i.e., on-going costs after implementation).

The capital phase may last a long time given sometimes it may take many years to implement restoration, and that most restorations are not undertaken catchment- or basin-wide but in a series of smaller scale projects. Yet issues of maintenance and legacy can be significant for some kinds of restoration actions and may explain why some measures are not sustained. Identifying barriers to implementation or upscaling such as property rights and legal issues (e.g., liability, burden sharing) can also provide useful information for evaluating results.

Stopping doing things: a crucial element of some restoration projects may be in not doing things (e.g., not burning peatlands). In these cases, it might be significant to quantify what is saved in cost or time.

For most case-studies these benchmarking measures (cost, effort) will be relevant to evaluating the cost-effectiveness of all the Green Deal indicators to calculate benefits per unit cost, especially:

- Cost of implementing action
- Cost of maintaining restoration
- Costs saved (e.g., costs associated with maintaining the site pre- and post-restoration)

1.5 Context of measures

The WP1 monitoring is also aimed at obtaining the data needed across the other Work Packages: to ensure the monitoring data are relevant and can be reused for these later work package activities. Particularly to provide the data to assess up-scaling potential (WP3) and transformation[4] (WP4). For this reason, we will ask case studies to capture some standard information on the context of their restoration case and evaluating the effectiveness of the implementation process (following the IUCN criteria and associated guidance).

Case studies will be asked to provide contextual data for both the local scale (relevant to MERLIN restoration actions) and catchment-/regional-scale to help evaluate the impacts achieved and serve as input for the national and continental upscaling strategy. The contextual data will also be used in the synthesis analysis to evaluate impacts in relation to environmental, social and economic settings.

Examples of contextual measures that are relevant to many of the Green Deal goals include:

- CORINE land cover (ha and %)
- Protected area status (ha and %)
- Land use (crop and livestock types and densities, fertiliser use, etc.)
- Water use (e.g., for water supply, navigation, hydropower, recreation)
- Local/regional policy or governance contexts
- Local management contexts (e.g., fishery actions in wider catchment)
- Population density
- Deprivation status

Much of this contextual data has been provided or is held by case studies and will be consolidated within the reporting templates or as the synthesis analysis is developed.

For some indicators, context could also include documenting the magnitude of drivers or pressures affecting a site, e.g., the response of wetland or river biodiversity will be influenced by nutrient or disturbance pressures, and it is, therefore, helpful to measure a range of contextual parameters, such as water quality or frequency of disturbance events.

A key aim for the monitoring is to go beyond trying to detect and attribute the effects of very small, or even quite large interventions in noisy, constantly changing, macro-systems. The ambition is instead to generate joined-up data that allows us to compare across scales in a meaningful way. That is to say, what has happened and why it is significant – but perhaps more crucially for MERLIN: what could reasonably be expected to happen in the future?

Ideally, case-studies would assess both the “local” significance of the case and the implications once restoration is scaled up, for example to a whole river basin or even across the EU (WP3&4[5]). Significance will be

[4] the institutional changes required to allow a systemic shift to NbS across economic sectors

[5] WP3 upscaling is spatial, i.e., Pan-EU opportunities for more restoration, with WP4 covering what institutional support is needed.

scale dependent. For example, we could consider land conversion through restoration actions in a variety of ways[6] but the significance of the conversion might only be apparent by setting the amount of land converted in context against another spatial unit: a field, a farm business, or the farmed area in the catchment. Significance might also be judged against how much remains to be restored (T3.1/3.2). This may condition the scale at which we might reasonably expect to find detectable impacts, but also defines the degree of scaling-up or transformative change required. How much of a remaining area or river length is likely to be restorable will also depend on the landscape-context.

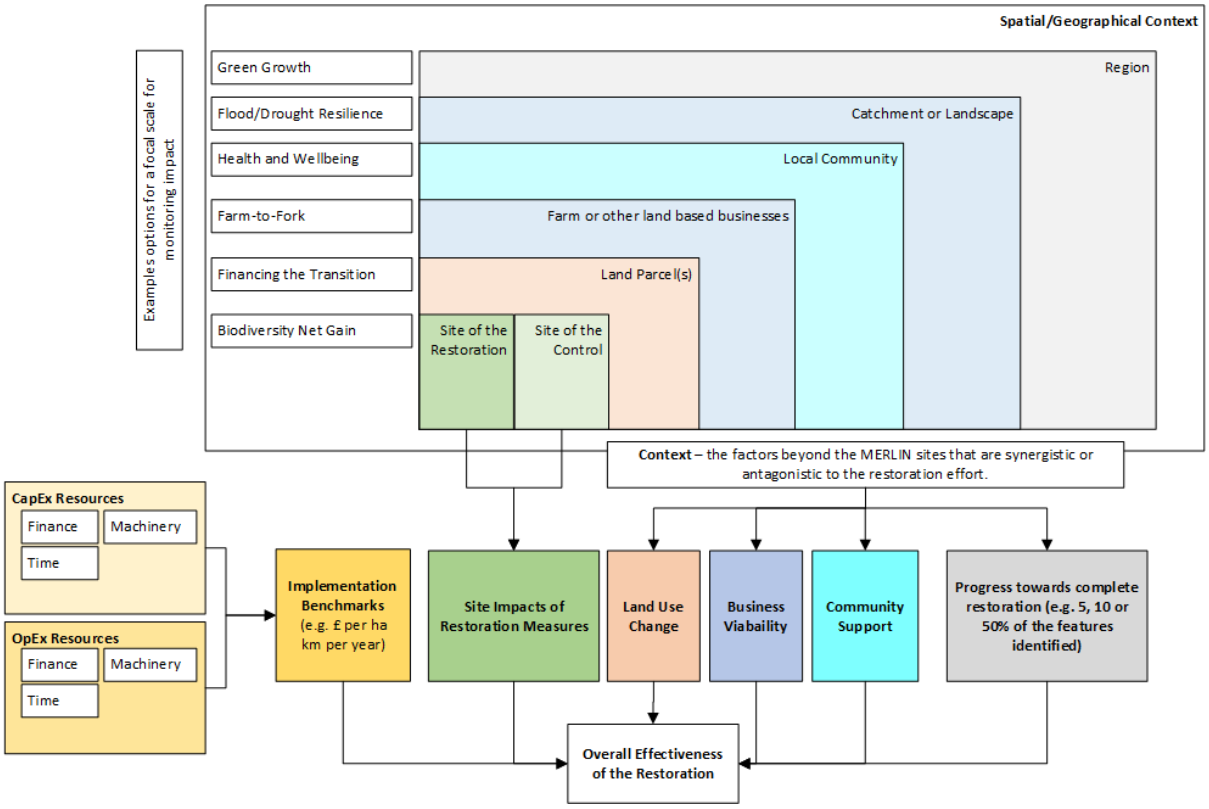

Figure 1 - Overview of monitoring framework to assess impact across scales.

Trends in context – where it is available, details of trajectories in the land and water systems (e.g. land cover classes, land use, land management, water use, etc.) will help set the context of both the need for restoration of aquatic systems and the factors that might be hindering its uptake or success.

1.6 Monitoring the implementation process

As well as monitoring outcomes and impacts, a key aspect of context is monitoring the implementation process. For this purpose, case-studies are expected to use the IUCN Global Standard for NbS[7] to monitor key implementation criteria at the start, middle and end of a project. This will be used to provide additional understanding of gaps in implementation (WP2) and useful context for evaluating the successes and failures of the restoration (WP1 synthesis). Unlike the self-reflectance of the IUCN Self-Assessment Tool, case-studies will need to gather more independent evidence from a broad range of key stakeholders on the strengths and weaknesses defined by the IUCN criteria so as to more robustly evaluate the implementation process. For example, the number of planning meetings with all stakeholders or the efforts made to access (private) funding for restoration actions. It is expected that online surveys of case-study board stakeholders will be the most appropriate method for gathering this evidence, but further guidance will be developed by WP1 and WP2.

[6] Physically – as area (ha's), or in terms of production loss (tonnes), or in revenue terms (income forgone - €) or change in the capital value of land (€)

[7] https://www.iucn.org/theme/nature-based-solutions/resources/iucn-global-standard-nbs?msclkid=b8f6717bcf1511ec85020f193f8d6709

2 Indicators

2.1 Biodiversity net gain

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Background to Green Deal goals

Restoring biodiversity is a key underpinning component of the European Green Deal, delivered through the EU Birds (BD) and Habitats Directives (HD), the Water Framework Directive (WFD) and the EU Biodiversity Strategy for 2030. MERLIN aims to specifically restore the richness and abundance of protected species and habitats and more generally the structure, function and connectivity of freshwater and wetland ecosystems. A number of targets are relevant to the BD, HD, WFD and the Biodiversity Strategy:

- Increase area of protected areas (Natura 2000 or nationally protected)
- Improve the conservation status of habitats in poor and bad conservation status
- Increase the number of habitats with improving conservation trend
- Improve the ecological status of freshwater ecosystems that are in less than good ecological status
- Restore rivers to be free-flowing (barrier-free flow and connections with floodplains)

Proposed indicator(s) and units

To measure impact on these targets, MERLIN case-studies will capture data on all of the following indicators that are relevant to their case-study. The essential MERLIN indicator(s) are highlighted in **bold** and those indicators of relevance to the upcoming EU Nature Restoration Law are underlined.

1. **Conservation status of habitat (Habitats Directive reporting)**
2. **Conservation status of HD Annex II and Annex IV listed species including peatland, wetland and freshwater species in case study area (should be specified from the Annex)**
3. **Conservation status of Annex I listed species in the Birds Directive (focus on peatland, wetland and freshwater species in case study area or nearby landscape)**
4. Total area protected (NATURA 2000 or nationally protected) (ha)
5. Length of river without transversal barriers (km of river length re-connected)
6. Area of floodplain habitat re-connected to river (ha)
7. Ecological status of rivers and lakes in the case study area
8. Normalised EQR of BQE for waterbody (WFD)
9. Presence of invasive non-native species and, if present, any control measures in place
10. Control measures for invasive non-native species

Species listed in the Habitats and Birds directives may not always be the most locally, or regionally, important species. Case studies can, therefore, consider the presence/absence or abundance of other species that are considered important by local or regional stakeholders.

As recovery can take many years, with often a reliance on natural dispersal, it is important that measures are, where possible, continuous data, so the trajectory of change can be evaluated. For example, although a goal is to achieve good ecological status in European freshwaters, it is beneficial to report normalised EQR scores, alongside status class, to evaluate progress towards this goal. Similarly measuring changes in water quality (see Zero pollution indicators) can provide further tracking (and context) of the potential improvements expected in HD indicators and WFD ecological status.

Proposed monitoring design

Case-studies should primarily aim to conduct a comparison of their selected biodiversity indicators, evaluating change between control (or upstream) and restored (or downstream) sites at comparable spatial scales, ideally before and after the restoration action takes place at both the control and restored (intervention) sites.

Baseline data

- Baseline data should specify the stage in restoration (number of years pre- or post-MERLIN restoration actions). Pre-restoration data may be available for sites from land cover maps, HD, BD and/or WFD monitoring. If sites are not protected areas or subject to WFD monitoring then baseline data should still be collected using standard national methods for these directives[8] (HD, BD, WFD), irrespective of the fact the sites are not in protected areas.
- It is recognised that some restoration actions may want to focus on specific habitat or species monitoring (e.g. fish surveys pre-barrier removal; peatland functional groups) and not, for example, all organism groups in WFD monitoring.
- It is recognised that baseline data may not be available pre-restoration. All baseline data should specify the stage in restoration that they relate to (e.g. number of months/years pre- or post-MERLIN restoration action).
- It may be that specific habitat or species data may be more relevant if HD, BD and WFD monitoring are not required (e.g. fish surveys pre-barrier removal; invasive vs native species abundance before action).

Context and benchmarking data

- Local management (e.g. fishery actions in wider catchment)
- Local/regional/national biodiversity policy contexts (e.g. changes in land-use policies)

Data source(s)

- Pre-restoration: secondary data from national nature or environment protection agencies responsible for HD, BD and WFD monitoring – preferably raw data, or EQR of individual metrics.
- Post-restoration: comparable survey methods to pre-restoration using national/CEN standard methods for HD, BD or WFD monitoring or the specific methods used in pre-restoration monitoring.

Data analysis and reporting

Aerial photography or maps of area pre- and post-restoration indicating areas restored.

Standardised HD, BD and WFD methods should be used for data analysis (e.g. calculating HD condition or WFD metric scores). For WFD metrics reporting will focus on EQR (Ecological Quality Ratios) scores and status class of individual biological and chemical quality elements to calculate change in EQR and status class. For WFD metrics the monitoring focus may just be on specific biological quality elements that need to be restored.

Interpretation and limits of application

Some qualitative detail on species restored that are indicative of good quality habitat, or reductions in non-native or invasive species may support interpretation.

Example design (for a case involving river restoration)

- Presence and abundance of HD Annex II and Annex IV in the restored area as compared to a nearby non-restored area.
- Ecological status of a restored river stretch in comparison to a nearby non-restored river stretch.
- Length of free-flowing rivers before and after the restoration was implemented.

[8] National methods for Habitats Directive and Birds Directive can be found here: https://rod.eionet.europa.eu/

2.2 Climate regulation (net zero)

Christopher Evans, Jennifer Williamson

Background to Green Deal goals

The main aim of the European Green Deal is to become climate neutral by the year of 2050. To achieve "Net zero" is a key goal ("climate regulation") of the European Green Deal. It is, therefore, important that the impact of restoration measures on carbon storage and greenhouse gas (GHG) emissions is evaluated in all case-studies, i.e. it is a MERLIN *Essential Restoration Variable*.

Proposed indicator(s) and units

The essential MERLIN indicator is highlighted in **bold**.

- **GHG emissions (t CO2-equivalents/ha/yr)**
- carbon stocks (t C/ha)

To measure impact on these targets, MERLIN case studies will provide monitored or modelled data on changes in GHG emissions (and if available C stocks). Some case studies may have expertise and resources to undertake field measurements of GHG emissions, although it is recognised that emissions may take many years to stabilise after restoration actions. For this reason, we will adopt modelled emissions as a standard approach for reporting the expected impact of the restoration actions. All case studies should carry out a simple standard modelling approach based on land use change, water depth and water quality, using a simple "carbon calculator" spreadsheet (to be provided) for peatlands and for "flooded lands" for floodplain restoration.

To model the essential MERLIN indicator 'GHG emissions' the following variables will need to be measured:

For wetlands:

- Overall extent of wetland-type soils in the case study catchment: including peat, surface water and groundwater gleys (a mottled grey soil resulting from reduction and partial reoxidation of iron oxides following periodic waterlogging) considering that much of this area may now be under agriculture or other land-use
- Pre- and post-intervention landcover on these wetland-type soils (i.e. land-use change)
- Pre- and post-intervention condition of areas under wetland vegetation (surface wetness, vegetation type, any information on active restoration measures)
- Change in water table depth within peat soils

For surface waters:

- Overall extent and type of water bodies in the catchment (rivers, lakes, reservoirs, natural and constructed ponds, ditches)
- Any changes in the extent and hydrological properties of each of these due to restoration (e.g. removal of barriers may reduce area and/or residence time of reservoirs, wetland restoration could reduce ditch extent but may increase the number of ponds)
- Baseline levels of nutrient and organic matter inputs and/or concentrations and/or trophic status in all waterbodies
- Changes in nutrient and organic matter inputs and/or concentrations and/or trophic status in water bodies affected by restoration

Proposed monitoring design

Case studies should primarily aim to conduct a comparison of their selected indicators, evaluating change between before and after the restoration action at the relevant spatial scale. Where field measurements of emissions are being made, a comparison between control and restored sites may also provide suitable data for evaluating impact of the restoration action on emissions.

Wetlands

The IPCC 2013 Wetlands Supplement[9] provides methods to estimate GHG emissions from human influenced wetland areas. In practice, most wetland areas in Europe have been subject to a degree of anthropogenic modification, and the restoration site case studies within the MERLIN project will all sit within this broad classification.

The simplest approach is for case studies to monitor land-use changes and apply emission factors to different land-uses. Emission factors have been developed for human-impacted wetlands on peat, including estimates for the reductions in emissions resulting from peatland restoration. Case studies will use a carbon calculator spreadsheet to record the area of peatland restored and pre- and post-intervention condition state according to the land cover types in Figure 2 below. This will allow estimation of reductions in GHG emissions as a result of the restoration actions using the relevant emission factors. Where country-specific emission factors from the case studies are not available, then factors from areas within a comparable climate zone can be applied. More guidance and training will be provided to case studies to calculate this.

Recent research (Evans et al., 2021) has shown that there is a good relationship between GHG emissions and water table depth on peatlands, with the potential for mean water table depth to provide a proxy for GHG emissions from peatland sites. If case study sites can manage to install equipment, then low-cost methods such as those detailed in 'Eyes on the Bog' (https://www.iucn-uk-peatlandprogramme.org/get-involved/eyes-bog) to monitor peat surface movement and estimate mean water table depth would provide a useful additional resource to compare pre- and post-restoration carbon stocks and GHG emissions even if restoration does not change the deep peat condition category (for example a grassland site where water table levels are raised).

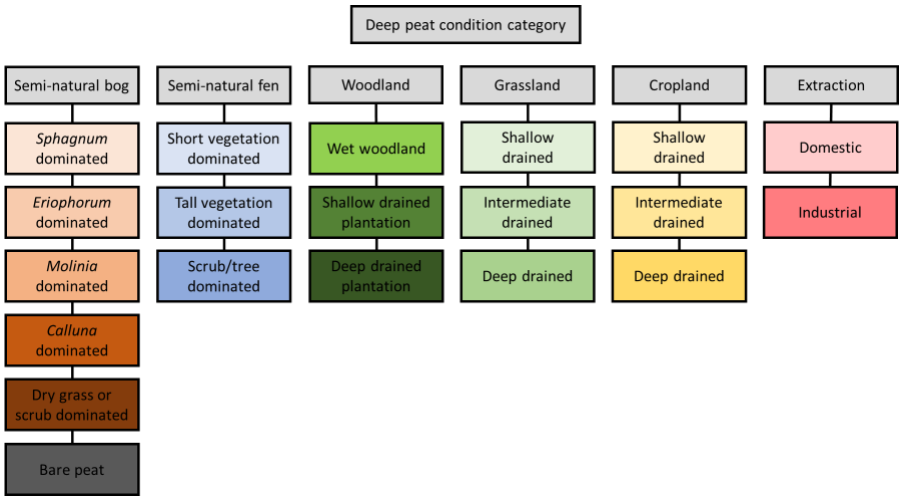

Figure 2 - Classification of land cover types (columns) and more specific communities/drainage states (rows) for selecting emission factors.

Surface waters

The IPCC 2019 update provided emission factors for man-made water bodies for the first time with default emissions based on climatic zone and modified by nutrient status (the more eutrophic a water body, the higher the estimated GHG emissions). If case studies can provide nutrient status pre- and post-restoration, then estimates can be made of changes in GHG emissions resulting from restoration actions.

Baseline data

- Baseline data should specify the stage in restoration (number of years pre- or post-restoration). Pre-restoration data may be available for sites from land cover maps, aerial photography or satellite imagery.

[9] https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/

- It is recognised that baseline data may not be available pre-restoration. All baseline data should specify the stage in restoration that they relate to (e.g. number of months/years pre- or post-restoration).
- It would be useful when assessing baseline data if the project could choose a baseline year so that all sites are reporting on the same number of years.

Data source(s)

- Pre-restoration: land cover maps, aerial photography, satellite imagery.
- Post-restoration: records of restoration activity, areas covered, aerial photography, satellite imagery
- Low cost monitoring data (e.g. 'Eyes on the Bog')

Data analysis and reporting

Aerial photography or maps of area pre- and post-restoration indicating areas restored.

Calculation of pre- and post-restoration GHG emissions using IPCC methods (further guidance and spreadsheet to be provided)

Interpretation and limits of application

If monitoring data is collected, uncertainties associated with emission factor methods should be documented.

Example design (for a case involving wetlands)

- Pre- and post-restoration landcover of different peatland vegetation types (see Figure 1); either mapped or predicted according to the restoration plans.
- Water table depth monitoring

2.3 Flood resilience

Axel Schwerk, Mateus Grygoruk, Tomasz Okruszko

Background to Green Deal goals

This criterion focuses on the increased capacity of natural ecosystems to store water to reduce downstream flooding to communities and to be resilient themselves to climate-driven flooding. This flood risk depends on the level of river restoration and designation of floodplain areas allowed to flood, e.g. by relocating dykes, or by appropriate design of rivers and streams used in agriculture (e.g. creation of double-stage channel or designating wetland buffer zones capable to retain water).

Some of the indicators and respective data important for flood resilience might show overlap with those of other Green Deal goals, as drought resilience, circular economy or supporting indicators of green growth. Therefore, if a site fits both (or even other criteria), the data should be reported for each criterion independently.

Proposed indicator(s) and units

MERLIN case-studies will capture data on one or more of the following indicators. The essential MERLIN indicator(s) are highlighted in **bold** and those indicators of relevance to the upcoming EU Nature Restoration Law are underlined.

1. **Storage capacity (m3) of restored rivers and streams (based on surface area of rivers, streams and other water bodies)**
2. **Storage capacity (m3) of wetlands (based on surface area of restored wetlands and floodplains)**
3. Area of newly designated areas for flooding (e.g., area of floodplain gain in result of dyke relocation; (ha)
4. Area of rewetted wetlands (other than peatlands) (ha)
5. Area of rewetted peatlands (ha)
6. Area discharging runoff to the restored site (ha)
7. Volume of rewetted peat (m^3)
8. Area of restored rivers and streams (ha)
9. Volume of channel retention gained as a result of restoration (m^3)
10. Area of developed wetland buffer zones (ha) / length of developed buffer zone (m)
11. Changes in Flood Risk Management Plans over time

Proposed monitoring design

Case studies should primarily aim to conduct a comparison of proposed indicators in a before-after manner. If a before-after design is not possible, comparisons between control (or upstream) and restored (or downstream) sites may provide suitable data for evaluating restoration success. It is advised to use archival materials (old topographic maps, reports, data and remote-sensing) to document changes of indicators.

Baseline data

- Pre-restoration data available for sites from land cover maps, remote sensing, HD and/or WFD monitoring,
- Systematic (grey)[10] literature review,
- Other specific habitat monitoring and pre-restoration data.

Data source(s)

- Pre-restoration: secondary data from national nature or environment protection agencies responsible for HD and WFD monitoring – preferably raw data, or EQR of individual metrics; (grey) literature review,

[10] Restoration projects are often documented in a grey literature (e.g., reports in national languages, other non-peer-reviewed materials). For the purposes of MERLIN project these materials are of high relevance.

- Post-restoration: comparable survey methods to pre-restoration using national/CEN standard methods for HD or WFD monitoring or those used in pre-restoration monitoring; (grey) literature review.

Data analysis and reporting

- GIS-based approach – map of changes in areas, volumes etc., as relevant for the specified indicators,
- Briefs – data description, bullet-pointed interpretation of indicator values.

Interpretation and limits of application

Quantitative approach is preferred, yet some qualitative interpretations are also welcome if quantitative analysis cannot be performed due to data quality limitations.

Other comments

WGS84 projection is advised when providing relevant geospatial data.

Example design (for a case involving floodplains)

- Area of areas for flooding before and after the restoration measures (either mapped or taken from the restoration plans).
- Volume of channel retention gained (taken from the restoration plans).
- Length of established buffer zones along tributaries before and after restoration.

2.4 Drought resilience

Axel Schwerk, Mateus Grygoruk, Tomasz Okruszko

Background to Green Deal goals

Achieving goals of the Green Deal related to climate forces the EU to work with appropriate hydrological conditions of wetlands (mainly peatlands and mires) as key stocks of continental carbon. Most of these ecosystems in Europe fail to act as carbon sinks due to their degradation caused by dehydration. Additionally, increased capacity of ecosystems to be resilient to climate-driven drought issues depends on the level of river restoration for slowing-down river runoff (meander reconnection), restoration of aquatic habitat variability and rewetting peatlands in river basins. These can then later act as sources of water in critical periods of drought. This is also of key importance for sectors, such as agriculture, hydropower, navigation, or water supply. For this criterion, stakeholder dialogue remains a key for successful increase of river basin resilience to droughts. That is why one should also document the willingness of stakeholders (including authorities and sector representatives from agriculture and industry) to implement water-saving technologies with special focus on documenting groundwater abstraction and rainwater harvesting.

As mentioned in chapter 3.3 (flood resilience), some indicators and respective data are also important for flood resilience.

Proposed indicator(s) and units

MERLIN case-studies will capture data on one or more of the following indicators. he essential MERLIN indicator(s) are highlighted in **bold** and those indicators of relevance to the upcoming EU Nature Restoration Law are underlined.

1. **Storage capacity (m^3) of restored rivers and streams (based on surface area of rivers, streams and other water bodies)**
2. **Storage capacity (m^3) of wetlands (based on surface area of restored wetlands and floodplains)**
3. Area of rewetted wetlands (other than peatlands) (ha)
4. Area of rewetted peatlands (ha)
5. Volume of rewetted peat/ increase in storage capacity (m^3)
6. Area discharging runoff to the restored site (ha)
7. Area of agricultural lands with applied schemes for water retention (ha)
8. Length of rivers gained through reconnection of oxbows (m)
9. Average annual increase of water levels in restored wetlands (m)
10. If feasible (site dependent) – change of groundwater water abstraction by sector over time (e.g. last 20 years) (m^3)
11. If feasible (site dependent) – change of surface water abstraction by sector over time (e.g. last 20 years) (m^3)
12. If feasible (site dependent) – number of households implementing water-saving technologies (no. of people/households)

Proposed monitoring design

Case-studies should primarily aim to conduct a comparison of proposed indicators in a before-after manner. If a before vs after design is not possible, comparisons between control (or upstream) and restored (or downstream) sites may provide suitable data for evaluating restoration success. It is advised to use archival materials (old topographic maps, reports, data and remote-sensing) to document changes of indicators.

Baseline data

- Pre-restoration data available for sites from land cover maps, remote sensing, HD and/or WFD monitoring,

- Systematic (grey)[11] literature review.
- Other specific habitat monitoring and pre-restoration data.

Data source(s)

- Pre-restoration: secondary data from national nature or environment protection agencies responsible for HD and WFD monitoring – preferably raw data, or EQR of individual metrics; (grey) literature review,
- Post-restoration: comparable survey methods to pre-restoration using national/CEN standard methods for HD or WFD monitoring or those used in pre-restoration monitoring; (grey) literature review.

Data analysis and reporting

- GIS-based approach – map of changes in areas, volumes etc., as relevant for the specified indicators,
- Briefs – data description, bullet-pointed interpretation of indicator values.

Interpretation and limits of application

Quantitative approach is preferred, yet some qualitative interpretations are also welcome if quantitative analysis cannot be performed due to data quality limitations.

Other comments

WGS84 projection is advised when providing relevant geospatial data.

Example design (for a case involving floodplains)

- Area of re-wetted peatlands before and after restoration (from field measurements of from restoration plans).
- Average annual increase of water levels in restored wetlands (cm) (measured or modelled).

[11] Restoration projects are often documented in a grey literature (e.g., reports in national languages, other non-peer-reviewed materials). For the purposes of MERLIN project these materials are of the high relevance.

2.5 Health and well-being

Jonathan Hopkins, Kirsty Blackstock, Keith Matthews

Background to Green Deal goals

The European Green Deal emphasises "...improving the well-being of people" as a key aim with action to "Help ensure a just and inclusive transition". Additionally, a key concept of the MERLIN project is to "...demonstrate how restoration contributes to solving societal problems". Given aspirations for 'Green Growth', a key question is which communities and groups are receiving health and well-being benefits from river restoration, including the improved outdoor access and recreation opportunities often associated with enhanced wellbeing. A further question is whether these benefits are accessible to disadvantaged communities (see Glossary for definition). The following indicator(s) are theoretically calculable across Europe and have the potential to generate comparable indicators for multiple case studies (of different spatial extents). Additionally, as the Green Deal Communication notes "Ecosystems provide essential services such as food, fresh water and clean air, and shelter. They mitigate natural disasters, pests and diseases and help regulate the climate", measuring the impact of restoration on the spread of vector-borne and zoonotic diseases could form a separate additional analysis. All these ecosystem services have the potential to deliver health and well-being outcomes, so it is important that where changes in these services are quantified in other Goal indicators their implications for health and well-being are also reported and synthesised under this Goal.

Proposed indicator(s) and units

No essential MERLIN indicators are recommended as the ability to attribute changes in health, and well-being to restoration action is likely to greatly differ between case studies. Indicators are, however, highlighted to stimulate ideas and encourage greater consistency in monitoring between case-studies:

- Length of active travel routes within or connected to the restoration area (km of routes per km^2 of restoration scheme) [This is a readily accessible proxy measure of the potential level of outdoor activity]
- % of active travel routes in proximity to (or within) disadvantaged communities
- Features supporting wellbeing and/or aesthetic attractiveness of the environment (e.g., hiking trails, biking routes, visitor centres, viewing towers), within or connected to the restoration area (number / m2 per km2 of restoration scheme)
- Nature-based activities supporting health & wellbeing
- Features supporting access to restored natural environment
- Changes in occurrence and incidence of emerging infectious diseases or other water-related health incidents (no. of people affected, with a breakdown of numbers between different classes of deprivation)

The indicators could be supplemented/contextualised by additional primary data collection on actual use of restored area in representative communities. It may be important to identify target groups (e.g., current disadvantaged or excluded/oppressed communities). This engagement could also be used to identify place-specific features (or those relevant to groups more likely to use the area) which contribute to wellbeing, or aesthetic attractiveness. Community views on the impacts of restoration on these attributes can also be collected (e.g., via on-site questionnaire surveys). Other social-media and photo-sharing based methods (e.g., Flickr analysis) also have potential to deliver secondary data/information on usage.

More specialist surveys on general well-being and happiness or quality of life are possible but would require recognised experts to gather and attribute to restoration actions (e.g., determining willingness-to-pay through contingent valuation based on choice-experiments). We anticipate the expertise and resources to do this are not within scope of the MERLIN budget and so we have recommended the proxy measure of potential for outdoor access.

In some case studies increasing access may be seen as a conflict to specific conservation interest (e.g., disturbance of bird populations). In these cases a narrative can be provided on why no action was taken to increase access, or actions to mitigate disturbance.

Proposed monitoring design

The monitoring design could vary across case studies and depends on the availability of data on active travel routes over time. Assuming that OpenStreetMap data is available and has been regularly updated, before-after and control-restored comparisons should be achievable. The spatial scale for monitoring would be the site scale: the area covered by the restoration scheme, and the communities which overlap or are within its boundary. For socio-economic and demographic characteristics data may only be available for larger units (neighbourhoods or municipal areas). Where these overlap or are bounded by the appropriate river catchment or wetland area, then data from these sources can be used, to place the magnitude of the contribution of the river restoration into a wider context. In case studies where sites are in very remote areas (for instance, upland peatlands), it may be less straightforward to link cases to widely dispersed communities, in which case these links should be carefully made by alternative measures (e.g., proximity or access points), or not calculated.

Baseline data

Identify the extent of active travel routes, which were established before restoration began, within the area covered by the restoration scheme.

Data sources

Area covered by restoration scheme: the spatial area or boundary of the restoration scheme could be potentially acquired from contractors and agencies involved in restoration within the case study area, or from relevant nation state bodies (e.g., environmental and conservation agencies).

Change in length of created active travel routes: spatial data on the extent of footpaths, cycle paths and similar routes may be available from European or nation state-level sources. If so, assess if this is available for the period prior to the restoration scheme, and the update schedule, to assess whether it is useful for measuring impacts of restoration. Otherwise, OpenStreetMap data is available and regularly updated across Europe, and spatial features (specified by key and value) could be extracted and downloaded using the R package "osmdata". Additionally, data from earlier versions of OpenStreetMap could be extracted by specifying a datetime field. The 'way' or line features which identify active travel routes should be used to extract features: many of these will be consistent across all restoration schemes, but specialist types may exist in some countries.

Features supporting wellbeing and/or aesthetic attractiveness of the environment: OpenStreetMap spatial data (likely to be points or polygons representing these features) is available and could be retrieved in a similar way to that described above.

Disadvantaged communities which overlay the restoration scheme as context for interpretation: the most comparable data on socio-economic and demographic issues is typically available for regions (e.g. NUTS3, LAU1). For the single restoration measures covering very small areas, these regions may be too large to distinguish between communities. There are many types of disadvantages and many nation states in Europe have fine-grained Census data which can be used to measure population change over time, economic activity, levels of wealth and types of deprivation. However, the following datasets appear to be more widely comparable:

- EUROSTAT data for NUTS3 regions: Gross domestic product (GDP) at current market prices by NUTS 3 regions – this could be used to identify poorer regions (via Euro per inhabitant)
- OECD data for small TL3 regions: Regional Labour – Labour indicators, Small regions TL3 (via menu at https://stats.oecd.org/Index.aspx?DataSetCode=REGION_DEMOGR) – could be used to identify regions with low employment rates
- OECD data for small TL3 regions: Life Expectancy and Mortality, large TL2 and small TL3 regions (via menu at https://stats.oecd.org/Index.aspx?DataSetCode=REGION_DEMOGR) – could be used to identify deprived regions
- EUROSTAT data for NUTS3 regions: Population on 1 January by broad age group, sex and NUTS 3 region – could be used to identify shrinking/depopulating regions
- EUROSTAT data for LAU regions: Historical population data from 1961 to 2011 – can be used to identify shrinking/depopulating regions

- Gridded Population of the World (GPW), v4: estimated high-resolution gridded population counts or administrative unit centroids could be used to identify shrinking/depopulating regions

Community perceptions of restoration scheme and recreation: This could be captured through surveys, interviews or focus groups within representative communities (covering a cross-section of communities, including disadvantaged areas), capturing perceptions of the restoration scheme and its impacts and benefits to them: including recreation potential. Any differences in attitudes across social, economic and demographic groups could be identified. Barriers to individuals' and communities' use of outdoor recreation opportunities (which can relate to health, perceptions and changes in individuals' lives; Colley et al., 2016) could be explored with Case Study Boards and within community engagement. This engagement could also identify features created during restoration which are particularly supportive of wellbeing, or which contribute to environmental quality. Community perceptions of key aspects such as a) the accessibility of active travel and recreation opportunities associated with the restoration scheme to different end users (including disabled and older residents); b) the extent of support for the aims of the restoration scheme; c) the perceived distribution of benefits of restoration between local communities and more distant areas, including where end users and visitors are from.

Risk for vector-borne and zoonotic pathogens and diseases: The occurrence and incidence of such infectious diseases at national and regional scale can be gathered from the European Centre of Disease Prevention and Control (ECDC) and might even be available at higher spatial resolution from local or regional public health authorities. In selected and relevant case study areas, the risk can even be estimated by sampling and analysing targeted pathogens.

Data analysis and reporting

Assuming all data are available, the following workflow may be possible:

1. GIS analysis: identify the location of active travel routes which have been created through the restoration scheme (in other words, newly created): dividing the total length of these by the area of the restoration scheme will provide an overall indicator.
2. Data compilation and GIS analysis: identify the disadvantaged communities and their location using regional indicators (linked to regional spatial data) or gridded population data. Thresholds for what counts as a ‘disadvantaged’ community could be defined across the project consistently, or on a case-by-case basis.
3. Identify the newly created active travel routes which are near, or within, disadvantaged communities. Depending on the size of the restoration scheme this could be done through a) GIS analysis, involving intersects/proximity measures (leading to a % indicator); b) a qualitative researcher judgement, based on a mapping of the active travel routes and community characteristics; c) additional primary data collection from local communities.

Spatial analysis of alternative spatial data from OpenStreetMap, representing features supporting wellbeing and attractiveness, would follow a similar workflow, with output metrics relating to numbers or areas of features. Where restoration schemes are not suited to an expansion of active travel opportunities (indeed a reduction in such routes or public access may be desirable in some cases), the analysis of these features could be given more prominence or emphasis in reporting. Additional primary data collection on the actual use of the restored area (as noted within the proposed indicators) should be collected to assess the impact of the restoration on wellbeing and the aesthetic attractiveness of the area.

For risk of emerging vector-borne and zoonotic pathogens, the following workflow can be applied:

1. Field sampling and laboratory analysis of targeted pathogens applying a before-after approach.
2. Independent of whether 1. is possible or not, a GIS-analysis that combines occurrence and incidence of pathogens according to ECDC with occurrence (if available even abundance/density) of reservoir and vector species using IUCN distribution maps and land cover of “risky habitat” including, e.g., the area and connectivity of shallow wetlands and slow-flowing waterbodies.
3. Disease risk is reported for case studies at a 10-graded scale for individual diseases and combined disease risk.

Interpretation and limits of application

This analysis approach has not been run or tested, but it highlights datasets which should or are likely to be available more broadly across Europe, and techniques which could be useful. The approach would need to be tested and refined to assess its feasibility, and consideration of appropriate thresholds of 'disadvantage' (Europe-wide or regional/nation state-based) should be considered. However, the use of more widely available datasets and the creation of rate indicators is positive from the view of creating consistent indicators across countries and at different scales. There is a need to recognise that impacts and benefits of restoration may emerge over longer time periods beyond this project.

Example design

- Change in length of created active travel routes with narrative provided of whether any increase is associated with increasing access for disadvantaged communities
- Changes in disease rates in the restored area compared with a control area, before and after implementation

2.6 Zero pollution

Nadine Gerner, Carl Christian Hoffman, Laurence Carvalho

Background to Green Deal goals

The European Green Deal goals regarding zero pollution are expressed by the EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil', with the major targets to reduce air, water and soil pollution to defined levels by 2030 in order to be no longer considered harmful to health and natural ecosystems. MERLIN will particularly focus on water quality.

In the WFD, the water quality objectives support the protection of aquatic ecology, specifically for the protection of unique and valuable habitats, and also protection of drinking water resources and bathing water[12]. Zero pollution indicators address both surface water and groundwater.

Some of the MERLIN zero pollution targets are interlinked with targets of other Green Deal Goals covered by the project, particularly climate regulation and green growth, but potentially also aspects of the circular economy.

Proposed indicator(s) and units

No essential MERLIN indicators are recommended as the indicators are likely to differ between case-study clusters and target ecosystem types. Key indicators are, however, highlighted below to encourage greater consistency in monitoring between case-studies.

Improvement in surface water quality

The three key indicators for MERLIN are:

1. Surface water chemical status
2. Nutrient concentrations (nitrogen and phosphorus)
3. Dissolved and total organic carbon (DOC, TOC) (for modelling greenhouse gas emissions)

Other possible indicators that may be relevant include:

- chemical/biological oxygen demand (COD, BOD)
- 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
- microplastics
- pathogenic bacteria (E. coli, Enterococci)

Improvements in groundwater quality as a result of the restoration

The two key indicators for MERLIN are:

1. Groundwater chemical status
2. Nutrient concentrations in groundwater (particularly nitrate)

Additionally, salinity/conductivity of groundwater and concentrations of specific and priority chemical pollutants.

Restored wetlands, floodplains and buffer strips

- Sediment transport in streams and rivers
- Nutrient concentrations (nitrogen and phosphorus)
- Suspended solids (inorganic and organic particulate matter)
- Chemical concentrations in soils (e.g. pesticides)
- Modelling water quality (further guidance to be provided)

[12] https://ec.europa.eu/environment/water/water-framework/info/intro_en.htm

In addition to the above indicators, the zero pollution goal includes measures of air quality, which include impacts on nitrous oxide (NOX), particulate matter (PM_{10}), ozone and the number of days during which specific air quality parameters in ambient air (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3 and PAHs) exceed threshold values. These could be relevant to some case-studies.

Proposed monitoring design

Where possible, monitoring should be undertaken using a Before-After-Control-Intervention (BACI) design. This means, case studies should primarily aim to conduct a comparison of their selected indicators before and after the MERLIN restoration action at the relevant spatial scale. If a before vs after design is not possible, comparisons between control (or upstream) and restored (or downstream) sites may provide suitable data for evaluating restoration success.

Baseline data

- Baseline data should specify the stage in restoration (number of years pre- or post-restoration action).
- It is expected that case studies will largely focus on only the most relevant indicators and not all of the proposed indicators.

Data source(s)

Primary data

- Measurements in water/groundwater/soil/air
- Modelling of concentrations/loads/fluxes

Secondary data

- From national nature or environment protection agencies responsible for regulatory monitoring (WFD or HD)
- Wider literature sources (e.g. from previous research studies)

Data analysis and reporting

Examples

- Reduction of nitrate and chemical run-off from agricultural land by X%
- Amount of excess N and P reduced in river loads (in ton total N and ton total P per year)
- Reduction in BOD and COD when water flowing in and out of the restored aquatic ecosystem

Interpretation and limits of application

- Comparison of data from different sources might be limited due to different methods.
- Many pollution indicators (such as nutrient concentrations) might react slowly to MERLIN measures, thus an assessment may only possible through modelling expected impacts.
- Interpretation might be limited due to a lack of pre-restoration data.

Example design (for a case involving rivers)

- Surface water chemical status (using WFD data) of restored vs non-restored river stretches (or before after restoration).
- N and P concentrations in restored vs. non-restored river stretches (or before vs after restoration).
- Modelling of overall P and N fluxes from the catchment to the focus area before and after catchment restoration measures (e.g. using SWAT+).

2.7 Farm to Fork

Keith Matthews, Kirsty Blackstock

Background to Green Deal goals

The Farm-to-Fork (F2F) Strategy[13] states that EU food systems are not sustainable due to negative externalities (e.g., diffuse pollution, or overuse of crop protection products), excessive draw on natural resources (e.g., soil or water) and negative health outcomes from both under- and over-nutrition. There are also inequalities in outcomes for many in the agri-food supply chain especially primary producer farmers.

F2F crucially links the production (farm) and consumption (fork) aspects of sustainability and recognises that we need to be careful not to make EU food systems apparently more "sustainable" by reducing intensity of farming (lower inputs, lower outputs or smaller areas) while still consuming the same and thereby having to import more resources from elsewhere with an implied, but unaccounted for, water, energy and biodiversity footprint.

A key question for MERLIN is how does aquatic restoration interact with farming (or other land use)?

Do farming or other land uses:

- benefit from the restoration undertaken, if so, we need to quantify how;
- limit the potential for restoration, again if so how; or
- get displaced by restoration.

Conversely, how does the context of farming or other land uses encourage, or limit, water or wetland restoration?

Figure 3 – Components of the EU Farm to Fork Strategy.

F2F Objectives

Several of the F2F objectives are shared with other policy domains and are covered in other clusters of the MERLIN indicators. The high-level objective is "*to accelerate our transition to a sustainable food system*" – and that food systems should have the features identified in the table below. Relevant monitoring specific for this goal is highlighted in the first row of the table below. The other objectives of F2F are covered elsewhere by other MERLIN indicator guidance but these are noted here for cross-checking.

[13] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

Table 3 – F2F high level policy objectives.

F2F high level policy objectives	Commentary and Interpretation
Ensure food security, nutrition and public health, making sure that everyone has access to sufficient, safe, nutritious, sustainable food	A complex, compound objective that spans from production via processing and retail to consumption. The types of interventions in MERLIN imply that it is sensible to bound scope for impact monitoring at the 'farm gate'-level and that types and quantities of food commodities might be the focus.
Have a neutral or positive environmental impact	Specific impacts could include changes to a. Soil erosion b. Diffuse water pollution If relevant, both should be covered under reporting of zero pollution indicators.
Help to mitigate climate change and adapt to its impacts	Covered elsewhere in MERLIN by the • Climate Regulation • Drought resilience • Flood-resilience
Reverse the loss of biodiversity	Largely covered by the MERLIN Biodiversity net gain indicators, but could include additional farm production-related indicators, such as pollinator abundance.
Preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade	Supply chain fairness and fair trade. Most of this is considered beyond the scope of MERLIN.

Restoration's interaction with wider primary production or non-food land uses

The focus of F2F is on agriculture (farms) but we need to recognise that relevant land managers for aquatic restoration might not always be farmers with food production as a main aim. We may also need to consider forestry businesses, sport (hunting) businesses or other current land uses (rewilding, conservation etc). Some case studies also have urban/peri-urban contexts where land owners/managers may be municipalities or other non-agricultural entities. Some of the F2F indicators (see the table below) are still relevant in characterising non-food land systems that will interact with aquatic restoration actions. It is possible that these indicators might not be strictly part of F2F indicator but relate to "production" on land that is not covered elsewhere.

Proposed indicator(s) and units

No essential MERLIN indicators are recommended as the indicators are likely to differ between case studies. Potential indicators are highlighted in Table 4. The essential MERLIN indicator(s) are highlighted in **bold**.

Table 4 – Farm2Fork Indicators.

	Indicators	Units	Comments/examples
Farm structure	Farm numbers	count	If more than one land holding is part of the restoration
	Farm size	ha	
	Land tenure	Mix of types	Owned, rented – long or short or annual, communal use
	Land value	€	
Utilisation[14]	**Land cover**	ha per type	e.g. grass
	Land use		e.g. pasture
	Land management		e.g. low intensity dairy
Livestock	Types	Count per type	
	Stocking rate	livestock units/ha	
	Diet	type	forage, fodder, on-farm or bought-in
	Other relevant regimen aspects		where grazed, housing manure management.
Inputs	Tillage	types/seasonality	Per crop or overall
	Fertilizers	tonnage/rates per ha	N, P, & K – artificial and from manures
	Crop protection	types/rates per ha	
	Water use	m^3	Irrigation, other uses, by source, renewable or fossil
	Certification	types	e.g., organic or other certified management
Infrastructure	Labour	hours	family, full, part, seasonal

[14] Need to agree typologies – e.g., via FADN as example

	Machinery	kW/tonnage/€	Power capacity
	Buildings		
	Energy use		Overall and by type
Outputs	Food	Quantity (varies)	By commodity type, tonnage, yield per ha, quality, use[15], value
	Fibre		
	Other		
Diversification	On farm food processing	value (€)	of what, to what, share of business value and time
	Services		tourism/recreation etc.
Farm financial performance	Standard Output	value (€)	varying granularity – enterprise, business or per ha
	Gross margin		
	Net Farm Income		
	Support Payments		by type, noting conditionality

Monitoring Design

Control and restored: possible at site level but note limitations on comparability when including both biophysical and socio-economic characteristics and management preferences of decision makers. Ideally, comparison of control and intervention sites before and after restoration where time series data are available (see data sources).

Spatial-scale

- **Site** – those farms overlapping or adjoining the restoration implementation – direct impacts (core) and (co)benefits or (opportunity) costs to farms.
- **Local** – those farms substantially within the (sub)catchment – **local significance**, e.g., proportions of features restored, any consequences for wider farm systems.
- **Regional** – **extent of need for restoration**, mix of farm systems that **could benefit** or be **barriers** to wider implementation.

It is worth considering the significance of the indicators above at field, farm business and potentially catchment scale if relevant to your case study. The priority for the case study is likely to be at field and farm/business scale, but spatial bounding should be guided by intent, ambition and governance scale. We expect that it is most likely case studies could do a spatial analysis at the site-level. Local-level may also possible but will rely on data availability and GIS/data integration skills. Regional-level may be possible but more likely that this will be limited to a sample/survey or type mix rather than spatially explicit (see data sources).

For the spatial context it is important to know how much "similar" land needing restoration is in the catchment – are we restoring 1%, 10% or 100% and the % of what? The appropriate scale will vary by purpose, but suggestions might be to reflect the ambitions for those doing the restoration – a local group might be satisfied

[15] Consumed or used on farm/sold

with their sub-catchment, others might have a regional/catchment ambition and the % of that is most relevant to them. At higher scales it also becomes a case of saying if the case study is one part of a bigger restoration initiative, e.g., peatland restoration in the Forth catchment is x% of all the restorations nationally but is also y% of more targeted lowland bog restoration (with y a bigger %).

Baseline data

Where agricultural statistics data can be accessed at individual holding or even small area statistics basis then this should give an adequate baseline for F2F indictors with comparability over time. Where this data doesn't exist (or can't be accessed) then qualitative data or narratives from farmers, farm advisors or other experts can be used as an alternative. With such data it is still possible to have an adequate perception of trajectories for F2F indictors.

Data sources

Site level – likely primary data collection from land managers involved in the restoration activity. It may be useful to be specific about which fields within a farm are changed and how this enhances or undermines the whole farm. Primary data collection can potentially be substantially supplemented or replaced by mapping or other data from extension services, such as environmental or agricultural payments agencies and local or member state government. Key data likely to be the Agricultural Census/Farm Structure data that forms the basis of responses to EU Commission/Eurostat.

Local to Regional (incl. catchments) – this is the hardest scale since primary data collection isn't usually feasible within project resources and pan-EU datasets tend to be insufficiently granular – here it may be necessary to make substantial use of member state-level datasets. Issues of GDPR privacy, disclosure and commercial interests can also limit the analysis possible.

For **Regional** and **pan-EU analyses** (largely for WP3 and WP4 focus) many of the F2F indicators are available from Farm Accountancy Data Network (FADN) across the EU but only at NUTS2 granularity. It can be possible to have them derived for smaller units (e.g., NUTS3)[16] but this requires special requests and processing those can take time to set up. The general limitation here is that datasets that include structure, production and management data are typically based on samples not a census and are not spatially explicit. The latter makes within region analysis of combinations of farm types versus environments problematic.

Data analysis and reporting

Generically key decisions are in terms of scale, granularity and the typologies used. Where statistical data sources are available then their embedded typologies[17] should be used but with annotations where classes may be limiting in expressing the likely impact of the restoration on the land use systems[18]. Even when the data itself might not be available then Census takers definitions might be helpful in ensuring consistency within cases over time and comparability between cases. Working across the scales (field, farm, catchment) is the key to interpreting the significance (relative) of any change or impact. Working across scales means being sure that the entities have the same definitions in use. This is important even for apparently simple things like total area, for example is it *utilised* or *utilisable* agricultural area and being aware of any excluded features so definitions in meta-data are essential.

Interpretation and limits of application

See commentary in Data Sources.

Example design

- Change in land cover by crop type
- Change in livestock densities
- Change in fertilizer use
- Change in farm financial performance, including diversification

[16] With some loss of less frequently occurring types due to limits for disclosure

[17] The way real world is represented as classes in the data – i.e., land cover types, livestock species/breeds or farm types based on financial value of their outputs.

[18] For example, with a field just recorded as grass there is a limited amount that can be inferred – with more detail it may be possible to know if it is used part of the year for silage (implying a fertiliser regime) and grazed at other times (ideally, we know by what and for how long, and when – e.g. winter or summer). With less detailed data the uncertainty increases on how land use is, or will, interact with aquatic systems and restoration in particular.

2.8 Sustainable energy

Axel Schwerk, Eva Hernandez Herrero, Miriam Colls, Arturo Elosegi

Background to Green Deal goals

The European Green Deal action towards energy focuses on a clean energy transition. Amongst others, key elements of this strategy are to develop a power sector based largely on renewable sources and to boost energy efficiency.

MERLIN, by aiming to realise innovative and successful peatland, floodplain and freshwater restoration projects. This may offer opportunities to reduce business energy use, for instance, due to improved irrigation systems for farmers with less need for pumping and spraying water. More specifically, increasing hydropower (and associated dam building) is typically known to have negative impacts on biodiversity targets, particularly on the goal for free-flowing rivers and threatened migratory fish populations, such as Atlantic salmon and European eel. MERLIN is generally recommending removal of obsolete dams that are no longer used for hydropower production, or of limited production, as the advantages of dam removal are likely to outweigh any small local gains in energy production. These advantages include enhanced fish migration, improved habitat and enhanced self-purification. Adaptations to small-scale hydropower aimed at minimizing these negative effects might also be possible. In the context of MERLIN, it is important to measure any trade-offs with hydropower (e.g. following removal of small dams), or any consequent changes in energy use related to other sectors (agricultural, water and peat extraction sector) that the restoration actions affect. Evaluating any losses in energy production can be evaluated in relation to benefits to other green deal goals. Objectives related to the clean energy transition are linked to other Green Deal goals, as climate regulation (net zero), zero pollution (air pollution), or Green Growth (net value of energy savings) and potentially trade-offs with respect to the EU Just Transitions Policy.

Proposed indicator(s) and units

No essential MERLIN indicators are recommended as the indicators are likely to differ between case studies. One key indicator is, however, highlighted below to encourage greater consistency in monitoring between case-studies.

Key indicator:

- 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).

Other possible indicators:

- Energy consumption in private households and business as result of NbS implementation, e.g. due to improving irrigation (kWh)
- Changes in active transport (narrative with data if possible)
- 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)

Proposed monitoring design

Case studies should primarily aim to conduct a comparison of their selected sustainable energy indicators, evaluating change between before and after the restoration action at the relevant spatial scale. If a before vs after design is not possible, comparisons between control and restored sites may provide suitable data for evaluating restoration success.

Data source(s)

- Pre-restoration: secondary data from relevant institutions; literature data; (if applicable data from surveys on households, relevant business and stakeholders)
- Post-restoration: secondary data from relevant institutions; planning documents on energy supply; literature data; data from surveys on households, relevant business and stakeholders
- Surveys of active transport

Data analysis and reporting

Standardised statistical analyses and visualisation for reporting of collected quantitative data. Qualitative data may be useful. For example “narratives” of outcomes or expected impacts from relevant stakeholders.

Interpretation and limits of application

Effective results might be shown by some indicators only after a long time period. For example, use of biomass (energy plants) will be possible only after a sufficient plant growth. Thus, some indicators might not show results within the MERLIN time frame. Ecological models (e.g. on plant growth) may work as substitute.

Example design (for a case involving floodplains)

- Amount (tons) of biomass gained from plant production in renewed floodplain habitats (measured or modelled) – converted into potential energy produced (kWh).

2.9 Sustainable transport

Tom Buijse, Axel Schwerk

Background to Green Deal goals

The European Green Deal action towards energy focuses on a clean energy transition. Amongst others, key

The focus of the Green Deal policy area 'sustainable mobility' is on reducing greenhouse gas emissions a.o. by waterborne transport. The interaction between the ecological status and restoration of freshwater ecosystems and inland navigation has many more aspects of which several have much more impact. The interactions encompass, e.g., physical aspects: water bodies are modified to improve their navigability, passing ships causes turbulence and waves, chemical aspects (impact on water quality) and biological aspects (transport mode for invasive exotic species). Thus, navigation is also related to indicators of other criteria, for example non-native alien species as indicator in the context of biodiversity net gain.

Sustainable transport is not relevant for all types of freshwater ecosystems. It is relevant for navigable water bodies for commercial and/or motorised recreational use. In the context of MERLIN several aspect are relevant for individual sectors (WP4), such as navigation and possible insurance (waterborne transport), water supply and agriculture (artificial connectivity between river basins) and hydropower (fish density).

Proposed indicator(s) and units

No essential MERLIN indicators are recommended as this criterion was not considered relevant to many case studies. Indicators can be categorised according to the Driver-Pressure-State-Impact-Response (DPSIR; see: http://fis.freshwatertools.eu/index.php/infolib.html). It has to be respected that there are tight dependencies between physical, chemical and biological impacts that need to be considered/quantified in the analysis. Indicators of relevance to the upcoming EU Nature Restoration Law are underlined.

Physical indicators

The physical impact of navigation is predominantly caused by the combination of the type, size, number and speed of passing ships and the dimension and modification of water bodies and their shorelines.

- Measures to mitigate impact of navigation: NbS, technical, regulations (speed limits) (R). Units: type and size of the measures. See, e.g., Collas et al. (2018) for the benefits of longitudinal training dams.
- Intensity and type of navigation (cargo vessels, passenger ships, sport boats . Units: type of boats per day (P). See, e.g., Zajicek & Wolter, 2019).
- 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.
- Artificial connectivity between river basins (dispersal routes for invasive species). Units: number canals connecting basins (S).

Chemical

The chemical impact of navigation is determined by the level of pollution caused. A development that is ongoing are regulations for the energy source. For recreational navigation, electric boats are more commonly used or even obliged. These boats also make less noise.

- Energy source (amount of reduction of fossil fuel, replacement by electricity) (P)
- Antifouling coating (can be reported by narratives)

Biological

The impact of navigation is on organisms in the main channel, in the shore zone and in adjacent terrestrial and semiterrestrial habitats, which are water dependent.

- Fish density and species composition. Units: species composition and abundance (see: Zajicek & Wolter, 2019) (I)
- Aquatic and shoreline vegetation. Units: species composition and abundance

- Aquatic, semiaquatic and terrestrial animal species. Units: species composition, functional richness or diversity, occurrence or number of habitat specialists species vs. ubiquitous species
- 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
- Exotic species whether or not being invasive (number and relative abundance)

Proposed monitoring design

Proposal: control vs restored sites. Control can either be a degraded or a more natural stretch.

Time series analysis is not often realistic. A comparison along gradients of modification of water bodies and intensity of navigation can be used to quantify impacts if long stretches, or a large amount of single "point measures" are available. If only one (comparably large) measure is at hand, one option is to make qualitative comparisons (lower/higher, yes/no etc.), at least for indicators where no quantitative data are available.

Baseline data

- Monitoring data on the intensity of navigation and on biology and habitats
- Hydromorphological descriptions of the water body

Data source(s)

See above: the proposal is to apply a control – impact approach[19].

Data analysis and reporting

Semi-quantitative correlation between the indicators for pressure (intensity of navigation and modification of water bodies) and biodiversity and habitat diversity. Textual analysis of information provided as narrative.

Interpretation and limits of application

Navigation and the modification of water bodies are not the only pressures affecting the ecological status of freshwater ecosystems. This will complicate to determine any causal relationships.

Other comments

There is quite some literature available on the impact navigation. The question is how monitoring the MERLIN case studies will contribute to generate new insights. The case studies have not been selected for this purpose. An alternative approach could be to collate examples from the case studies about how they mitigate the impact and synthesize this into a narrative.

It would be good to collect qualitative examples of environment friendly navigation. This is not only beneficial for the freshwater ecosystems, but also for the perception of people and as such connected to the indicator well-being. The respective data can be received by help of questionnaires (WP4). Such data might also provide with information regarding improving active public transport.

Example design (for a case involving rivers)

- Changes in intensity and type of navigation after implementation (based on field observations)
- Reduction on fossil fuel (based on surveys)
- Exotic species: increase or reduction along navigation routes (number and/or abundance, from field inventories)

Background information

Collas F.P.L., L. van den Heuvel, N. van Kessel, M.M. Schoor, H. Eerden, A.D. Buijse & R.S.E.W. Leuven 2018. Longitudinal training dams mitigate effects of shipping on environmental conditions and fish density in the littoral zones of the river Rhine. Science of the Total Environment 619-620:1183-1193.

[19] There is French project 'NAVIDIV' specifically focusing on navigation and biodiversity. Astrid Schmidt-Kloiber and Tom Buijse are involved. We should not duplicate what is done there.

Gabel F., S. Lorenz & S. Stoll 2017. Effects of ship-induced waves on aquatic ecosystems. Science of the Total Environment, 601, 926-939.

Söhngen B., J.H.E. Koop, S.E. Knight, J. Rythönen, P. Beckwith, N. Ferrari, J. Iribarren, T. Kevin, C. Wolter & S.T. Maynord 2008. Considerations to Reduce Environmental Impacts of Vessels. Report of PIANC InCom Working Group 27. PIANC, Brussels, p. 90.

Zajicek, P. & C. Wolter. 2019. The effects of recreational and commercial navigation on fish assemblages in large rivers. Science of the Total Environment 646: 1304–1314.

2.10 Inclusive Participation and Governance

Kirsty Blackstock, Laurence Carvalho

Background to Green Deal goals

The European Union encourage greater public involvement in delivering the European Green Deal, with some specific initiatives such as the European Climate Pact, an initiative that helps communities share and implement measures to combat climate change, or the New European Bauhaus, an initiative to establish sustainable communities, inclusive dialogues, and purposeful activities to bring a cultural and creative dimension to the European Green Deal. On 6 October 2021, the European Union also adopted an amendment to the Aarhus Regulation No. 1367/2006 to allow for better public scrutiny of EU acts affecting the environment. More specifically for the European Green Deal, inclusivity in participation and governance is an aspect of the "Finance" topic – including the Just Transition Mechanism which focuses on ensuring a fair and just transition to a green economy. This is a financing tool to alleviate the socio-economic impact of the transition to a climate-neutral economy (away from fossil fuels), to ensure this transformation happens in a fair way, leaving no one behind and particularly support citizens of regions most impacted. Planning and governance of restoration actions need to include cross-sectoral dialogue and citizen participation. In particular, citizen participation in environmental decision-making is needed through all stages of a restoration project to obtain social, political and financial support for the restoration measures (Frantzeskaki and Kabisch, 2016).

Anything specific to MERLIN proposal targets

The original MERLIN proposal considered participation under the topic "inclusivity" and suggested monitoring a change in access to blue-green space (a) overall and (b) for disadvantaged communities. Changes in access to nature are also being considered elsewhere under "Health and well-being" and these consider access by under-represented groups.

Subsequent discussion in MERLIN have highlighted that it might be more relevant to consider other aspects of inclusion in the planning and governance process, to ensure outcomes of greater public awareness and support for the restoration measures. For example, the Aarhus Convention has three pillars "access to information, public participation and access to justice in environmental matters". The last is about the citizen or NGO rights to take a public authority including the EU institutions to court if they fail to implement the environmental laws. However, there is also a connection to ideas of environmental justice – representational justice (ensuring all stakeholders can participate in decisions); procedural justice (the decision process was correctly implemented); and distributional justice (the burden of costs and sharing of benefits are equitable). The Convention on Biological Diversity also has similar principles about distribution of benefits.

Studies of catchment management, conservation and NbS suggest that public/social support and acceptance are important; with participation and governance; knowledge and capacity building; and social justice being identified as important indicator topics by the EC (European Commission DG R&I (2021)).

A just transition to a green economy is important in WP3 (T3.6) and WP4 (T4.2) tasks in MERLIN.

There is a lot of potential for "Inclusive Participation" indicators to draw on data collected as part of the IUCN SAT analysis per case study. This should be further developed. For example:

- Are societal challenges identified? Are rights holders and beneficiaries consulted? Are the most pressing societal challenges for rights holders and beneficiaries prioritised?
- Are human wellbeing outcomes relevant to the identified societal challenges identified? Are there benchmarks in place to monitor impact? Are outcomes and benchmarks assessed at regularly occurring intervals? Are human wellbeing outcomes incorporated into the strategy for the intervention?
- Are the direct and indirect benefits and costs associated with the NbS and who receives them identified? Is this fully documented? Is this verified with key informants? Can "winners" and "losers" be easily ascertained?
- Is there a legitimate feedback and grievance mechanism? Are affected stakeholders consulted for the development of this mechanism? Is this mechanism documented, predictable and transparent? Is this mechanism available and accessible to all stakeholders? Is the mechanism available to stakeholders from before the start of the intervention? Is the mechanism right-compatible? Is the ownership and trust of the mechanism evident? Is the mechanism regularly reviewed and adapted?

- Are indigenous peoples impacted, either directly or indirectly, at any point during the intervention? Does the intervention uphold the right of Indigenous Peoples to Free Prior and Informed Consent throughout the intervention timescale? Is participation based on mutual respect and equality? Are there processes in place to support this throughout the intervention timescale?
- Are the stakeholders who are directly and indirectly affected by the NbS identified? Is their impact and interest in the intervention mapped? Are they involved in all processes of the intervention? Do affected stakeholder accept and feel ownership over the outcomes of the intervention?
- Are decision-making processes being documented? Is this documentation transparent and accessible? Do they respond to the rights and interests of all participating and affected stakeholders? Is specific attention paid to stakeholders subject to extreme inequity?
- Are costs and benefits both at the NbS site and the larger landscape/seascape, throughout the NbS intervention time-scale identified? Are the potential NbS costs and benefits of associated trade-offs explicitly acknowledged? Are they used to inform safeguards? Are they used to inform corrective actions if those safeguards are passed? Is the process of decision-making regarding costs and benefits disclosed to affected stakeholders?
- Are the rights, usage of and access to land and resources as well as stakeholder responsibilities identified? Are they incorporated into a stakeholder mapping analysis? Are they acknowledged and respected? Do they inform the design of the intervention?

Some of these aspects, including how to develop and operationalise a spatial environmental justice approach to transformation will be considered in Task 4.2 so this indicator is very important to help provide some data and examples for that. In WP4 they propose to focus a more detailed analysis of inclusion in CS 2, 4, 7, 8, 9, 13, 17 for this task, but this criterion, inclusion in participatory governance, should be something all case-studies should monitor (see three essential MERLIN indicators below).

Proposed indicator(s) and units

A number of indicators have been proposed on the openness of participatory planning and Governance by the European Commission DG R&I (2021).

All MERLIN case-studies should monitor three essential indicators (in **bold**):

1 Number of visitors to project website

2 Number of participants in information sessions about the project

3 Ability to join a formal stakeholder forum/board/working group

The more comprehensive indicator sets below are activity- or implementation-related indicators that rely on primary data collection by case study partners. Their value would be considerably enhanced where it is possible to additionally comment on their impact – e.g. what changed because of the inclusion achieved. The latter interpretation most likely requires reflection by experts and stakeholders within the case studies, particularly on how implementation has changed relative to initial plans or through phases of longer established projects. For projects in early stages of implementation there are real opportunities to collect information (narrative) on how implementation decisions are influenced by consultations and active participation. Further training could be provided on this if requested.

Public Participation

Level 1 – Public Access to Environmental Information

- Presence of:
  - Project website established with information about the ecosystem, what is being restored and how to get involved (made accessible to support diversity and inclusion)
  - Signage onsite (made accessible to support diversity and inclusion)
- Number of visits to:
  - **Website with information about the ecosystem and what is being restored etc.**

Level 2 - Public Consultation

Including or additional to the Case Study Board (if this is a formal group):

- **Information sessions about the site/project**
- Formal public consultation processes held on measures
- Consultation on measures with case-study board

Level 3 - Public Active Involvement

- **Ability to join a formal stakeholder forum/board/working group**
- Citizen science activities undertaken
- Alignment with existing societal challenges in local area
- Local residents views on the impacts of the NbS on the local area

For all three levels the data collected could be simple yes/no counts or more detailed descriptions, i.e. how many of what type of the 'public' were involved and the trends over time. Beyond this data there is the opportunity to capture impact information on "what has changed" because of the public participation (either qualitatively or in quantified terms). The "what has changed" because of participation can be Instrumental and/or Conceptual. For Instrumental Change this means showing the ways in which the project has evolved over time to better align with the societal challenges as expressed by the participating public(s). For Conceptual Change the opportunity is to assess how attitudes to, or support for, the project by the public has changed (tracking the increase in the perceived salience, credibility and legitimacy of the project).

Access to Justice (links specifically to Aarhus Declaration):

- Have there been any legal actions taken regarding the project or intervention (either to ensure it goes ahead or to try and block it)?
- If so, actions taken by whom? When? On what legal grounds? What was the outcome of the legal action?

Just Transition

For Just Transition there are specific policy instruments that are relevant and link to tasks in other MERLIN WPs:

- Is the intervention (or scaling up plan) **eligible for the** European Green Deal Investment Plan (EGDIP) or specific Just Transition Mechanism funding?

Beyond these instruments there is also the need to consider the local and regional levels of deprivation and the opportunities provided by the restoration work.

- Context - is the Local Administrative Unit or NUTS region classed as a deprived area (and by who) – see the "Health and well-being" section for comments on potential methods to measure levels of deprivation.
- Has the intervention delivered, or does it have the potential to link to 'green jobs' and provision of skills/training/employment in nature-based economy (restoration, environmental data collection, environmental education)? These can be derived by case study partners or their project/delivery contractors' records. This overlaps with the Green Growth indicators, but with an emphasis here on inclusion of under-represented groups.

Proposed monitoring design

Site or local level – it may be possible to do before-after if there is information about the 'start' of the intervention(s) (see below). It may be difficult to compare with a control region in this context.

Baseline data

Dependent on when the intervention was first planned (see above on design and indicator) -suggest measuring process of what additional environmental information is being provided not the outcome (e.g. whether people have more environmental knowledge or understanding). Likewise for participation – are there more public participation opportunities now than before the project? And has there been any legal action (for or against the NbS/restoration intervention) since the project started?

The most difficult thing here will be establishing the 'start' given that often programmes and projects layer over earlier projects or programmes; and may have been talked about or consulted on for several years before any physical intervention was implemented.

Data source(s)

Secondary data sources: project or programme reports and meeting minutes (should be publicly accessible formal documents) for site/local impacts; also web and social media metrics if recoverable from the hosting platform.

Also primary data collection (partners can answer about website/signage/educational use etc.)

Passive ethnographic observations (e.g., is the ground in front of signs well worn, have all the leaflets been taken, is there lots of social media posts tagging the site/project)?

Would be possible to do a field survey but this is time consuming and would need to be repeated to see trends over time.

Data analysis and reporting

Standardised statistical analyses and visualisation for reporting of collected quantitative data. Textual analysis of information provided as narrative.

Interpretation and limits of application

There may be National (Member State) level 'state of environment' indicators that include public attitudes/awareness to the environment but these will not be specific to the intervention. The EU 'barometer' has regular citizen surveys including asking about environmental priorities – these could provide a context to assess how the overall public awareness is changing, that might help with interpreting increased participation or increased accessing of information.

Example design

- Number of visitors to project website
- Number of participants in information sessions about the project with surveys evaluating learning gained of project and further interest in engagement
- Representation in formal stakeholder forum/case-study board
- Representation in citizen science programmes associated with monitoring the status and/or use of the restoration site

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2.11 Circular economy

Axel Schwerk

Background to Green Deal goals

The new circular economy action plan (CEAP) is one of the main building blocks of the European Green Deal. Implementation of a circular economy is pivotal regarding a reduction of pressures on natural resources, improving the jobs market, the climate neutrality target and counteracting biodiversity loss.

MERLIN aims to realize systemic transformative economic changes, based on innovative and successful peatland, floodplain and freshwater restoration projects. Water is one of the most important resources; the restoration of the sites should also support circular economy related issues as principles of reduced water consumption and water-reuse are incorporated into business models.

Circular economy is related to several of the other Green Deal goals. It is an important principle for progressing towards decoupling economic growth from resource use and its impact. Since circularity is a prerequisite for climate neutrality, there is also an interlinkage with climate regulation. Circular economy is also closely related to the zero pollution targets of the Green Deal. Water consumption, water capture and storage and water reuse are unequivocally of significance for flood and draught resilience and thus indirectly relate to the sectors agriculture, hydrology, navigation and water supply (MERLIN WP 4).

Proposed indicator(s) and units

No essential MERLIN indicators are recommended as this criterion was not considered relevant to many case studies.

To measure impact on these targets, MERLIN case studies could capture data on any of the following indicators that are relevant to their case-study:

1. Reduced net water consumption (based on local data on water consumption) (m^3)
2. Water capture (infiltration rate, rainfall storage capacity) (m^3)
3. Water reuse/re-allocation to the environment (local data on water reuse) (m^3)
4. Water reuse projects (number)
5. Sediment reuse (amount of reused material)
6. 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)
7. Municipal staff trained on the circular economy (number)

Proposed monitoring design

Case studies should primarily aim to conduct a comparison of their selected circular economy indicators, evaluating change between before and after the restoration action at the relevant spatial scale. If a before vs after design is not possible, comparisons between control (or upstream) and restored (or downstream) sites may provide suitable data for evaluating restoration success.

Baseline data

- Baseline data should specify the stage in restoration (number of years pre- or post-restoration).
- It is recognised that baseline data may not be available pre-restoration for some indicators. All baseline data should specify the stage in restoration that they relate to (e.g. number of months/years pre- or post-restoration).

Data source(s)

- Pre-restoration: secondary statistical data from local water boards and other institutions; literature data; (if applicable data from surveys on relevant business and stakeholders).
- Post-restoration: secondary statistical data from local water boards and other institutions; literature data; data from surveys on relevant business and stakeholders.

Data analysis and reporting

Standardised statistical analyses and visualisation for reporting of collected quantitative data. Textual analysis of information provided as narrative.

Interpretation and limits of application

Quantitative data might be available for some indicators only at a larger spatial scale; thus complicating the interpretation of the impact of the restoration measure on these data. Interpretation of the results might be also limited due to lack of pre-restoration data for some indicators.

Example design

- Reduction in water consumption after implementation (based on local water board data, or surveys)
- Planned and realised training of staff regarding circular economy (based on survey data)

2.12 Financing the transition

Gerardo Anzaldua, Josselin Rouillard

Background to Green Deal goals

Over the current decade, the European Green Deal Investment Plan (EGDIP) is expected to mobilise at least €1 trillion in sustainable investments that will underpin the achievement of the Green Deal goals. These funds will be primarily financed through the EU budget (an estimated €503 billion for the 10-year period will contribute to climate and environment projects), which is expected to trigger further financial support from national authorities and private actors. MERLIN will contribute to the EGDIP's second main objective, to "create an enabling framework for private investors and the public sector to facilitate sustainable investments". The project will involve the finance and insurance communities in securing the financial sustainability of restoration projects. It will establish communication between investors and restoration practitioners and foster their mutual understanding and collaboration. It will showcase investment opportunities that can generate new cash flows and will create instances for co-designing and piloting locally-adapted financing solutions.

Proposed indicator(s) and units

Two essential indicators are proposed for all case-studies to include (in **bold**):

1. **Breakdown of the total restoration budget by funding source and type [%]**
2. **Private finance mobilised [€/year]**

Additionally, the following indicators may be relevant:

3. In-kind contributions [€/year]
4. Return on Investment (of cash flow-generating measures) [%]
5. Percentage of (upscaling) budget already secured [%]
6. New financial products or solutions designed for the case study [No. and type]
7. New financial products or solutions implemented in the case study [No. and type]

Proposed monitoring design

Indicators 1 to 5 can be calculated for previously implemented measures and compared against measures included in the scalability plans. Proposed indicators 6 and 7 refer to activities that will take place during MERLIN and are thus assigned a baseline of zero.

Baseline data

For the proposed indicators 1 to 4 (and where applicable 5) the baseline should be established by considering the measures implemented before MERLIN. The partners should aim to cover the full extent of the restoration project in question to the best of their possibilities. Alternatively, a representative sample period should be selected and justified for the calculations.

Data source(s)

Review of secondary data sources (e.g. financial plans and similar documentation of the restoration projects) supplemented by interviews to collect additional data and details. Case studies should identify relevant organisation where to obtain the data.

Data analysis and reporting

Standardised statistical analyses and visualisation for reporting of collected quantitative data. Textual analysis of information provided as narrative.

Interpretation and limits of application

Quantitative data might be available for some indicators only at a larger spatial scale; thus complicating the interpretation attributing impact to the restoration measure.

Example design

- Breakdown of the total restoration budget by funding source and type, including private financing [%]

2.13 Green growth

Lars Hein

Background to Green Deal goals

Green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and ecosystem services on which our well-being relies. Green Growth is a key underpinning component of the European Green Deal, as reflected in various policy documents underpinning the Green Deal, as well as the term 'Green Deal' itself. The ecosystem restoration projects of MERLIN aim to contribute to Green Growth. Specifically, the aquatic ecosystems targeted in MERLIN should, following restoration, support local economic development and create additional employment while at the same time leading to an enhanced capacity of the ecosystems to generate ecosystem services. Finding synergies between these two aspects, i.e. enhancing ecosystem service supply that can sustain economic activities, is an important element of restoration.

Proposed indicator(s) and units

The key essential indicator for MERLIN (in **bold**) is

- **Number of jobs created** (attributable in part to restoration activities or restoration outcomes)

MERLIN case studies should also try and capture data on ecosystem services supply prior to and after MERLIN restoration actions, where possible in monetary terms. The focus of the monitoring should be on the ecosystem services that are of most interest to society (and your stakeholders), either locally or nationally. It needs to be noted that local and national interests do not always coincide. For instance, provisioning services generating employment may be of particular local interest, whereas national interests may put a higher value on biodiversity conservation. Since green growth is an overarching aim of the Green Deal, it may encompass many indicators also covered by other Green Deal criteria. Hence, proposed additional service indicators were divided into key indicators and additional "supporting" indicators (those covered by other Green Deal criteria).

Additional service indicators may include:

Recreation

Key indicator(s)

- Turn-over and Gross and Net Value Added of establishments providing recreational services (hotels, camping sites, equipment (e.g. canoe) rental agencies, restaurants, bars).

Supporting indicator(s) covered in the same way or similar by Biodiversity net gain, health & well-being

- Number of people visiting an area (expressed as person-days) on an annual basis
- Number of overnight stays in an area on an annual basis
- Amount of establishments providing recreational services (hotels, camping sites, equipment (e.g. canoe) rental agencies, restaurants, bars)

Flood protection and other hydrological ecosystem services

Key indicator covered under flood and drought resilience indicators

- Change in storage capacity

Provisioning services

Key indicator(s)

- Amount of fish and shellfish harvested, in kg and in euro, per year, by species
- Hectares of reedbeds restored or established
- Amount of reed harvested in kg or bundles
- Other products harvested in kg, by type and by year, including water yield (if relevant)
- Turn-over and Gross and Net Value Added of products harvested in aquatic ecosystems

Carbon sequestration

Key indicator(s)

- Monetary value of the amount of carbon sequestered annually in the ecosystem, ton C/year converted to EURO based on EU ETS carbon price

Other ecosystem services (where relevant)

Key indicator(s)

Indicator of relevance to the upcoming EU Nature Restoration Law is underlined.

- Number or amount of cultural practices taking place in, or dependent upon the ecosystem
- Number of scientific or educational activities taking place in, or dependent upon the ecosystem
- Pollination services provided by the wetland to nearby croplands
- Fishing and hunting in the wetland, expressed as number of fishing/hunting licenses sold and kg of food harvested, by species and by year

Proposed monitoring design

Ecosystem services to be included in the monitoring efforts are to be selected by the relevant local and national stakeholders, for instance by a survey, or during workshops. Case studies should primarily aim to conduct a comparison of their selected indicators before and after the restoration action at the relevant spatial scale. If a before vs after design is not possible, comparisons between control (or upstream) and restored (or downstream) sites may provide suitable data for evaluating restoration success.

Baseline data

- Baseline data should specify the stage in restoration (number of years pre- or post-restoration).
- In addition to job creation, it is recognised that case studies may focus on only some selected ecosystem service indicators.

Data sources

- Pre-restoration: secondary data from national nature or environment protection agencies responsible for ecosystem management; surveys, ecosystem service models, statistical information (e.g. Eurostat)
- Post-restoration: comparable survey methods to pre-restoration monitoring.

Interpretation and limits of application

Quantitative data might be available for some indicators only at a larger spatial scale; thus complicating the interpretation attributing impact to the restoration measure.

Example design

- Number of jobs created (attributable in part to restoration activities or restoration outcomes)

3 Reporting results and synthesis plans

Laurence Carvalho & Axel Schwerk

3.1 Need for standardised reporting

Monitoring and evaluation of the impact of measures is a key aspect in any restoration programme as it allows the project managers and stakeholders to evaluate the effects of the restoration actions and the progress towards their goals. It also allows restoration programmes to capture and share their learning with stakeholders and the public and re-evaluate the measures undertaken and the need for further actions. A shared monitoring and reporting framework across the case-studies enhances the degree of comparability between-case-studies and allows an evaluation of impact in relation to context or scale.

Standardised reporting forms (see chapter 5) have been produced for each EG Deal criterion and their associated indicators. These reporting forms capture information on each indicator (including method details and units of measurement) as well as key contextual data required to interpret the scale of impact.

3.2 Analysing results

Comparable monitoring and reporting of the essential MERLIN indicators allows us to examine the impacts of restoration on each Green Deal goal in relation to contextual settings, scale of intervention or time since restoration (e.g. as shown in Figure 4). Further indicators may be comparable within the clusters of similar case-studies.

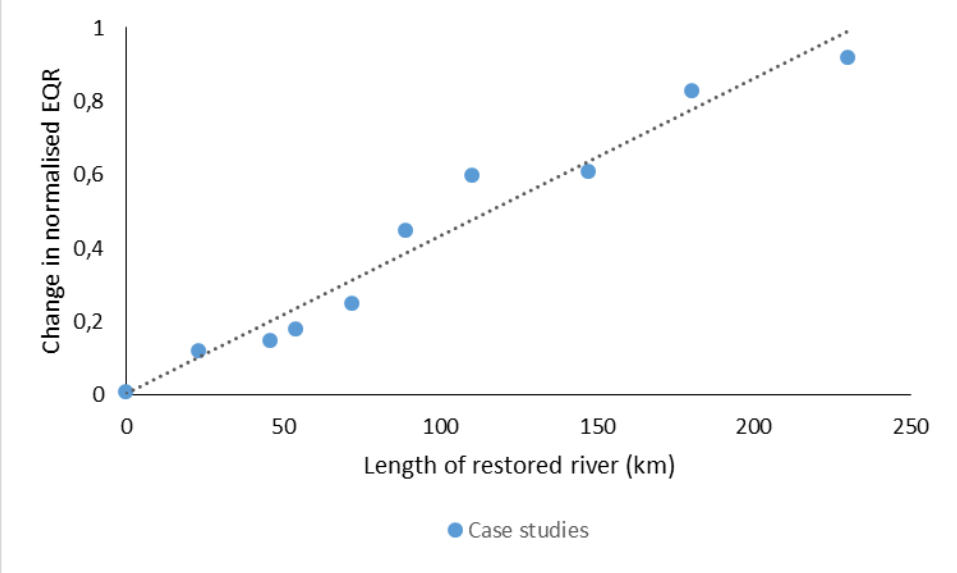

Figure 4 - Theoretical example of comparison of case studies: Change in normalised EQR of an indicator in response to length of restored river (km).

Several of the indicators relate to ecosystem pressures, state or condition, whereas other indicators are measures of ecosystem services (Table 5). The synthesis analysis will examine relationships between state and service indicators. This will contribute to our understanding of how changing status influences the provision of ecosystem services and will be consistent with approaches outlined in the global standard on ecosystem accounts (SEEA EA). The proposed Nature Restoration Law focuses on the improvement of ecosystem condition, so a greater understanding of the relationships between condition and services may help manage towards targets on ecosystem services. Currently these relationships are modelled or inferred, and little empirical evidence exists to underpin the assumptions on these relationships. Ultimately the monitoring data collected in MERLIN will be important evidence from real-world restoration case-studies, to evaluate whether improvement in ecosystem condition is translated into an improvement in ecosystem services.

Table 5 - MERLIN indicators classified into indicator groups for pressures, state (condition) and service.

Indicators of Pressure	Indicators of State (Condition)	Indicators of Service
Sustainable Food Systems (e.g. crop area, livestock density)	Biodiversity (e.g. conservation status, ecological status)	Climate regulation (e.g. greenhouse gas emissions)
Sustainable energy (e.g. renewable energy production)	Zero pollution (e.g. nutrient status)	Flood resilience (e.g. water storage capacity)
Sustainable transport (e.g. intensity and type of navigation)	Sustainable transport (e.g. bank condition, barrier density)	Drought resilience (e.g. water storage capacity)
		Sustainable energy (e.g. renewable energy production)
		Sustainable Food Systems (e.g. crop area per ha, livestock numbers per ha)
		Health & Well-being (e.g. number of features supporting wellbeing, incidence of disease)
		Green Growth (e.g. green jobs created, pollination services)

Several of the indicators described in chapter 2 are also of relevance related to the upcoming Nature Restoration Law (NRL). These are in particular:

- Biodiversity net gain criterion
  - Conservation status of HD Annex I listed habitats
  - Conservation status of HD Annex II and Annex IV listed species
  - Conservation status of Annex I listed species in the Birds Directive
  - Length of river without transversal barriers
  - Area of functioning floodplain re-connected to river
- Flood resilience/drought resilience criteria
  - Area of rewetted wetlands (other than peatlands)
  - Area of rewetted peatlands
- Sustainable transport criterion
  - Barriers per river km
  - Artificial connectivity between river basins
  - Degree of lateral connectivity to floodplains
- Green Growth criterion
  - Pollination services provided by the wetland to nearby croplands

Using these indicators, the synthesis analysis could also evaluate the impact of the restoration measures on the relevant goals of the proposed EU Nature Restoration Law.

4 Glossary

Axel Schwerk, Gerardo Anzaldua, Levin Scholl

Aarhus Convention

”The Aarhus Convention establishes a number of rights of the public (individuals and their associations) with regard to the environment. The Parties to the Convention are required to make the necessary provisions so that public authorities (at national, regional or local level) will contribute to these rights to become effective” (https://ec.europa.eu/environment/aarhus/index.htm, accessed 17.03.2022).

Asset

Anything tangible or intangible that holds or generates economic value (EIB 2020). Assets of a restoration project could include machinery, cash, data, land(-tenure), expertise, and access to natural resources. Moreover, ecosystems providing services (i.e. ecosystem services) are thought of as natural assets (see natural capital).

Asset Investment

Investments to purchase or improve an asset, while expecting the asset's value (e.g. productive or cost-saving properties) will return the investment, ideally with a profit.

Bankable project

A project that convincingly demonstrates to satisfy the needs of investors, including criteria such as cash flow generating activities, sufficient collateral, success probability of the project, proof of concept and proven track record, among other things (WWF 2020).

Baseline

“’Baseline’ refers to measurements of key conditions (indicators) before a project begins, from which change and progress can be assessed” (https://issat.dcaf.ch/download/152421/3160687/Baseline Assessments.pdf, accessed 06.04.2022).

Before-After-Control-Impact (BACI)

“Non-randomized methods that can employ a variety of statistical tests. BACI approaches include time and impact factors, with a control site and a comparably impacted site, both represented by data before and after the impact” (Seger, K.D., Sousa-Lima, R., Schmitter-Soto, J.J., Urban, E.R. 2021: Editorial: Before-After Control-Impact (BACI) Studies in the Ocean. Frontiers in Marine Science 8, 787959. Doi: 10.3389/fmars.2021.787959).

Biodiversity

The number and types of plant and animal species that exist globally or in a particular area. Biological diversity is often understood at three levels: the diversity within species, the diversity between species and the diversity of ecosystems.

Biodiversity offsetting

The activity of compensating the (presumably unavoidable) destruction of a particular habitats through the restoration, improvement or creation of a similar habitat.

Blended Finance

The strategic use of public and philantropic funds to attract private capital and enable profit-driven investments in revenue generating activities (Earth Security 2021, OECD 2018).

Capital expenses (CAPEX)

The amount of money that is allocated or spent on one-off and upfront on new assets (investments), such as land property, machinery, buildings, patents, etc. (also see Assset Investment).

Carbon credits

Carbon offsets that are tradable.

Carbon offsets

Certificates that testifying and attribute carbon offsetting to their owners.

Carbon offsetting

The activity of compensating (presumably unavoidable) carbon emissions by reducing or avoiding carbon emissions elsewhere, e.g. by sequestrating carbon in moors or planting trees.

Cash

Actual spendable money.

Cash-flow

The flow of actual spendable money that is transferred into- and out of an enterprise or a project.

Collateral

An asset that can be seized from a borrower who fails to repay debt (e.g. a loan) to compensate the lender (EIB 2016).

(Commercial) revenues

Incomes generated by the regular operation of a particular business, e.g. the sale of carbon credits or other commercial products and services.

Commodities

Homogenous and standardized products, e.g. raw materials, that are traded at a more or less uniform price on (virtual, global) markets, where multiple buyers and seller interact according to market dynamics (The Economist 2017).

Cost-Benefit Analysis (CBA)

An analysis of the social-economic costs and benefits of a particular project or activity, including opportunity costs, intangible costs and benefits, risks, and externalities, to support strategic decision making (Le Coent et.al. 2021).

Crowdfunding

A funding model, in which many private individuals donate (often small) amounts to a specific cause that would otherwise not receive sufficient funding. Donations are often motivated by small rewards or out of intrinsic values. Crowdfunding is pre-dominantly facilitated by specialized online platforms (Baroni et.al 2019).

Debt financing

Allocating financial resources for a specific purpose through lending. Examples include loans or bonds. Loans are based on an agreement between two parties (a lender and a debtor) and are normally repaid over time in fixed (monthly) installments that also include an interest. Loans that finance sustainable projects can be called green loans. Bonds are used by large entities (e.g. governments, municipalities, corporates) to generate large sums of funding from many different lenders simultaneously (Fernando et.al 2022). So called green bonds generate funding for "sustainable" activities, while so called climate bonds generate funding for climate change mitigation and adaptation.

Diversification

The process of widening the basis of one's dependency to reduce the risk of relying on a single, failable entity, e.g. customers, suppliers, revenue streams, assets, etc.

Enabling conditions

Settings conditions or circumstances that lay the institutional, infrastructural, and policy foundation for asset investments (e.g. by generating incentives to invest in a particular activity), usually with no immediate expectation of financial rewards (Shames et.al 2014).

Disadvantaged Communities

There are many types of disadvantages including economic activity, levels of wealth and types of deprivation. However, the following datasets provide the most comparable data on socio-economic and demographic issues available for European regions (e.g., EUROSTAT data for NUTS3 and LAU1 regions or OECD data):

1. Population on 1 January by broad age group and sex – could be used to identify shrinking/de-populating regions
2. Gross domestic product (GDP) at current market prices – could be used to identify poorer regions (via Euro per inhabitant)
3. EUROSTAT data for LAU regions: Historical population data from 1961 to 2011 – can be used to identify shrinking/depopulating regions
4. OECD data for small TL3 regions: Regional Labour – Labour indicators, Small regions TL3 (via menu at https://stats.oecd.org/Index.aspx?DataSetCode=REGION_DEMOGR) – could be used to identify regions with low employment rates
5. OECD data for small TL3 regions: Life Expectancy and Mortality, large TL2 and small TL3 regions (via menu at https://stats.oecd.org/Index.aspx?DataSetCode=REGION_DEMOGR) – could be used to identify deprived regions

Driver-Pressure-State-Impact-Response (DPSIR)

"The causal framework for describing the interactions between society and the environment adopted by the European Environment Agency: driving forces, pressures, states, impacts, responses (extension of the PSR model developed by OECD)" (http://glossary.eea.europa.eu/terminology/concept_html?term=dpsir, accessed 06.04.2022).

Ecological quality ratio (EQR)

"Ecological quality ratios (EQR) shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. The ratio shall be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero" (EU Water Framework Directive, 2000).

Ecosystem services

The benefits that people obtain directly or indirectly from ecosystems – the goods and services provided by nature. These can be divided into *provisioning services* (food, water, wood, raw materials), *regulating services* (pollination of crops, flood and disease control, water purification, prevention of soil erosion, sequestering carbon dioxide), *cultural services* (recreational, spiritual and educational services) and *supporting services* (nutrient cycling, maintenance of genetic diversity).

Equity (financing)

Equity is the ownership of assets. In equity finance, an investor inserts cash or capital into a business in return for an ownership share of the business (i.e. buying a part of the business). Equity investors are motivated by financial returns, which they anticipate either in the form of dividends (i.e. a share of the yearly profits) or by re-selling the equity with a surplus after its value has increased (also called capital gains) (EIB 2020).

European Climate Pact

"The Pact is an EU-wide initiative that invites people, communities and organisations to connect and share knowledge, learn about climate change, develop, implement and scale up solutions. As an open and inclusive initiative, the Pact will evolve and grow thanks to the creativity, needs and ideas of those becoming part of it" (https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-pact_en#ecl-inpage-646, accessed 06.04.2022).

Financier

A person or entity tactically allocating financial resources for a specific purpose by means of lending, investing, or through grants. Commercial financiers expect a profit in the form of capital gains (an increase in the value of their equity share), dividends (a share of profit), or interests (for debt financing).

Financing

Tactically allocating financial resources for a specific purpose. Internal financing involves the allocation of internal financial resources, while external financing involves a contractual relationship with a financier (NAIAD 2021).

Financing Instrument

An instrument that is used to finance projects or businesses, e.g. loans, grants, etc. (NAIAD 2021). cy swaps.

Funder

A person or entity providing funding.

Funding

The total sum of money available to a specific project. Also, the activity of providing all or parts of that money (Naiad 2021).

Floodplain

Part of the river valley that can be exposed to flooding from river (note - some floodplains have dykes; parts of the valley beyond dykes, which is now not flooded due to dykes, can also be part of the floodplain).

Freshwater

Water with less than 0.5 ‰ mean annual salinity (EU Water Framework Directive, 2000).

Grant

A sum of cash handed out to financially support a particular purpose without expecting re-payment, generally by governments or philantric organizations to support the provision of otherwise underprovided non-market goods (Shames et.al 2014).

Greenhouse gas (GHG)

“Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation” (United Nations Framework Convention on Climate Change, 1992).

Green infrastructure

Strategically created natural and semi-natural areas, designed and managed to allow nature to deliver a range of valuable ecosystem services (such as clean air and water), in both rural and urban settings.

Guarantees

An agreement in which a third party (e.g. the state or the EU) guarantees to cover any outstanding debt or financial obligation, if a debtor fails to repay a lender (EIB 2020).

Habitat banking

Habitat banking is a centrally coordinated and managed approach to biodiversity offsetting at the local or regional level (often based on public policy and mandate).

Impact investors

Investors (individuals or organizations) that accept higher risks or lower profits for investing into projects and businesses that create a positive broader social or environmental outcomes (Shames et.al 2014).

In-kind contribution

A non-monetary donation, e.g. by providing labor, expertise, machinery or other forms of support for free or below market rates (Connectology 2022).

Institutional investor

Professional investment companies (e.g. banks, pension funds, mutual funds, etc.) that pool funds from clients or members to invest large sums across a variety of different businesses and projects (Shames et.al 2014).

Investment

The allocation of capital to mechanisms, inputs, labour and capacity building that aid the process of ecosystem recovery with the expectation of scaling up efforts in terms of number and size of ESR projects, and generating ecosystem service returns.

Investment track record

An investor's track record outlines past accomplishments and performance to establish credibility and indicate success rate to potential project partners (Financial Pipeline 2014).

Just Transition Mechanism

"The Just Transition Mechanism (JTM) is a key tool to ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no one behind. It provides targeted support to help mobilise around €55 billion over the period 2021-2027 in the most affected regions, to alleviate the socio-economic impact of the transition" (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en, accessed 17.03.2022). Just transitions should include representational justice (ensuring all stakeholders can participate in decisions); procedural justice (the decision process was correctly implemented); and distributional justice (the burden of costs and sharing of benefits are equitable). The Convention on Biological Diversity has similar principles about distribution of benefits.

Landscape

According to the European Landscape Convention, "'Landscape' means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe Landscape Convention, 2000). In ecology the term ecological landscape is sometimes used, which can be defined as a set of interdependent ecosystems creating the ecological system of the highest order (Andrzejewski, 1992). A landscape is a mosaic of natural and/or human-modified ecosystems, with a characteristic configuration of topography, vegetation, land use, and settlements that is influenced by the ecological, historical, economic and cultural processes and activities of the area. Both the mix of land cover and use types that make up the larger mosaic, including agricultural lands, native vegetation, and urban areas (landscape composition); and the spatial arrangement of different land uses and cover types (landscape structure) contribute to the character of a landscape. Depending on the management objectives of the stakeholders, landscape boundaries may be discrete or fuzzy, and may correspond to watershed boundaries, distinct land features, and/or jurisdictional boundaries, or cross-cut such demarcations. Because of the broad range of factors a landscape may encompass areas of 100s to 10,000s square kilometers.

Lender

Any actor who lends out money, often in return for interest payments by which the re-payment exceeds the initially borrowed amount of money.

Market

A physical or virtual place that facilitates the trade of commodities among multiple sellers and buyers, following the dynamics of supply, demand, and market prices.

Natural capital

Assets that stem from ecosystems, natural cycles and processes, and biotic organisms (World Forum on Natural Capital).

Nature-based Solution (NbS)

"Actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits. They are underpinned by benefits that flow from healthy ecosystems and target major challenges like climate change, disaster risk reduction, food and water security, health and are critical to economic development" (https://www.iucn.org/theme/nature-based-solutions/about, accessed 17.03.2022).

New circular economy action plan (CEAP)

"The new action plan announces initiatives along the entire life cycle of products. It targets how products are designed, promotes circular economy processes, encourages sustainable consumption, and aims to ensure that waste is prevented and the resources used are kept in the EU economy for as long as possible. It introduces

legislative and non-legislative measures targeting areas where action at the EU level brings real added value" (https://ec.europa.eu/environment/strategy/circular-economy-action-plan_pl, accessed 06.04.2022).

New European Bauhaus

"A creative and interdisciplinary initiative that connects the European Green Deal to our living spaces and experiences" (https://europa.eu/new-european-bauhaus/index_en, accessed 17.03.2002).

Off-the-shelf-instrument (OTSI)

A set of instruments to fund and finance restoration projects. WP3 will be providing specific and detailed guidance documents tailored at restoration managers.

Operational expenses (OPEX)

Re-occurring, regular expenses associated with the day-to-day operations of a particular business, such as expenses for labor, energy, raw materials, management, etc.

Payment for ecosystem services (PES)

A transaction in which the beneficiary of an ecosystem service compensates the provider of the ecosystem service.

Payments for health outcomes

Transactions where the beneficiaries of the health benefits provided by the natural environment pay for the outcomes (Esmée Fairbairn Foundation 2020).

Payments for NFM outcomes

Transactions where the beneficiaries of NFM benefits provided by the natural environment pay for the outcomes (Esmée Fairbairn Foundation 2020).

Payments for water quality outcomes

Transactions where the beneficiaries of the water quality benefits provided by the natural environment pay for the outcomes (Esmée Fairbairn Foundation 2020).

Peatland

Place, where peat is accumulated (note - including both natural peatlands, which are called mires, and drained peatlands, which cannot be called mires).

Private investors

"Local farmers and businesses, private sector companies, impact investors and institutional investors such as banks and pension funds. Development Finance Institutions (DFIs) can be categorized between public aid institutions and private investors. Corporate Sector Responsibility departments of private companies can be involved in ESR projects through integrated landscape management and offset schemes" (Shames et.al 2014).

Public investors

"Government institutions whose main aim is to allocate capital to projects with the expectation of financial or other returns in the future. involves any government or state funds, including aid" (Shames et.al 2014).

Retail investor

"A retail investor, also known as an individual investor, is a non-professional investor who buys and sells securities or funds that contain a basket of securities such as mutual funds and exchange traded funds (ETFs)" (Investopedia 2021).

Supply Chain (management)

The organization of sequential steps, in which a single (leading) firm manages the logistics of sourcing raw or interdemiary goods, and of marketing its final products and services (Feller et.al 2006).

Sustainable development

Even if originating already earlier, a widely recognized definition of sustainable development was formulated in the so-called Brundtland report (Brundtland, 1987) as "sustainable development is development that meets the

needs of the present without compromising the ability of future generations to meet their own needs". The 2030 agenda for sustainable development (UN General Assembly, 2015) aims at "achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner", thus highlighting the economic, social and environmental pillars of sustainability.

Upscaling

Implementing restoration measures and NbS on larger scales addressing technological, social, governance and financial processes. This may entail:
- The replication of promising restoration measures at many other places
- At a catchment scale, smartly positioning individual restoration measures so that they act in a synergistic way
- The restoration of large areas (e.g. large wetlands) which can act as hotspots for biodiversity and ecosystem services (ESs) and positively impact the surrounding areas
- At a continental scale, strategically identifying sites for restoration based on their suitability, the envisaged large-scale effects and on efficiency.

Upscaling potential

Regional potential for more restoration (large scale, PAN-EU); the process to implement restoration measures and NbS on larger scales addressing technological, social, governance and financial processes.

Value Chain

The full range of value-adding activities and processes by different economic actors within a sector (e.g. design, extraction of raw materials, transport, storage, processing, export, branding, packing, wholesale, retail) to produce a final product or service (Feller et.al 2006).

Wetland

"Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Convention on Wetlands (Ramsar Convention Secretariat, 2013), article 1.1).

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5 Appendix: Example Reporting Form

Case-study No:	
Habitat type	
Site Name/Code:	
Site type (Con./Int.)	
Site type (Dem./Impl.)	
Contact name	
Contact email	

			Years Since Restoration	-1	0	1	2
			Restoration stage	Pre	Pre	Post	Post
			Date of measurement (DD/MM/YYYY)				
IndicatorCode	**Short Indicator Name**	**Specific Indicator**	**Unit**				
BD1	Condition of habitat	habitat <code>	HD category				
BD2	Condition of species	<species name>	HD category				
BD3	Condition of bird species	<species name>	HD category				
BD4	Total area protected	Area of habitat <code>	(ha)				
BD5	Length of free-flowing river	<Name of river>	km of river length re-connected				
BD6	Area of connected floodplain	<Name of river>	(ha)				
BD7	Ecological status of waterbody	Status class of <name o	WFD status class				
BD8	nEQR of BQE	nEQR of <BQE> of <Nan	nEQR				
BD9	Presence of invasive non-native	<name of invasive spec	(yes/no/% relative abundance)				
BD10	Control of invasive non-native s	<name of invasive spec	(yes/no/% area treated)				
BD11	Other	<describe your indicato	depends on indicator				

Figure A1 – Biodiversity indicators reporting form: data reporting page.

Reporting Form data sources and methods	*Explain how you generated the biodiversity data and/or source of information (web site, report reference).* *Ensure when data collected is clear (e.g. DD/MM/YYYY) or if over a period, state the relevant period.* *If an indicator was not used, please put N/A in the cell.*
BD1: Condition of habitat	
BD2: Condition of species	
BD3: Condition of bird species	
BD4: Total area protected	
BD5: Length of free-flowing river	
BD6: Area of connected floodplain	
BD7: Ecological status of waterbody	
BD8: nEQR of waterbody	
BD9: Presence of invasive non-native species	
BD10: Control of invasive non-native species	
BD11: Other	

Figure A2 – Biodiversity indicators reporting form: methods reporting sheet.

Short synthetic summary of results
A short summary of the main findings; where more than one indicator has been evaluated discuss any synergies and discrepancies between the results for the individual indicators; highlight if there are any implications for upscaling (MERLIN WP3) or transformation (MERLIN WP4).

Figure A3 – Biodiversity indicators reporting form: summary reporting sheet.

The full set of MERLIN reporting forms is available here.