RECONECT

Co-monitoring and co-evaluation plans for Demonstrators A and B

Deliverable D2.6

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Abstract (for dissemination, 100 words)	The present deliverable discusses the monitoring and evaluation plans of large-scale NBS in demonstration sites (in relation to WATER, NATURE, and PEOPLE) in support of the development of an evidence base on NBS. RECONECT combines 4 Demonstrators Type A (i.e., NBS sites which will be implemented during the project life time) and Type B (i.e., NBS sites which have already been implemented). In this first version of D2.6, demonstrators have focused on describing the monitoring and evaluation procedures in support of the assessment of their NBS performance in achieving a selected number of sub-goals. So far, five demonstration sites are connected to the RECONECT ICT platform and providing real-time data streaming.
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Executive Summary

The present deliverable discusses the monitoring and evaluation plans of large-scale NBS in demonstration sites (in relation to WATER, NATURE, and PEOPLE) in support of the development of an evidence base on NBS. RECONECT combines 4 Demonstrators Type A (i.e., NBS sites which will be implemented during the project life time) and Type B (i.e., NBS sites which have already been implemented). Monitoring and evaluation plans are presented for all 10 sites.

In this first version of D2.6, demonstrators have focused on describing the monitoring and evaluation procedures in support of the assessment of their NBS performance in achieving a selected number of sub-goals. The sub-goals addressed here correspond to those that have been previously selected as relevant to all demonstrators (see also Deliverables 2.3 and 2.5).

So far, five demonstration sites are connected to the RECONECT ICT platform and providing real-time data streaming. These are: Inn River (precipitation and temperature), Tordera River (water level), Portofino (weather data), Ijssel River (water level) and Aarhus (water level).

This report aims to serve several audiences. The first audience is the RECONECT Demonstrators themselves. The document aims to provide a more systematic guidance for Demonstrators through the monitoring and evaluation procedures within a large perspective, i.e. how sub-goals, indicators, data monitoring, impact assessment, and NBS performance in achieving a given sub-goal fit together in RECONECT. In particular for demonstrators A, this report provides an opportunity for uptake of knowledge from Demonstrators B, who have a considerable track record in implementing large scale NBS. The document also serves as a reference for various WP3 activities. In addition, the report also serves as a useful reference for researchers and practitioners beyond RECONECT who are engaged in activities concerning NBS implementation and in particular, activities related to monitoring and evaluate of NBS sites.

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1 Introduction

One of the goals of the RECONECT project is to demonstrate and further upscale large-scale NBS. To support this goal, it is important to develop monitoring and evaluation procedures that can be applied to different types of NBS, their local contexts and settings.

Within the Task 2.6, a co-monitoring and co-evaluation framework is being developed for Demonstrators A and B. There are two kinds of RECONECT monitoring activities within this framework. The first one is monitoring to assess the state of the system (e.g. the general conditions in the NBS area), i.e., baseline monitoring before construction of NBS, and the second one is monitoring to assess the performance of implemented NBS towards the achievement of the project's goals/sub-goals (see also Annex B).

In terms of the NBS evaluation work, RECONECT addresses evaluation of implemented NBS (i.e., Demonstrators A and B) and evaluation of potential benefits from NBS for areas that are subject to hydro-meteorological risk (i.e., Collaborators). NBS for Demonstrators B have already been implemented whereas for Demonstrators A their NBS are planned and will be or are being implemented. In both cases, robust evidence base on the performance of NBS will be ascertained. For Collaborators cases, evaluation consists of screening and selecting those NBS measures that are more suitable to the local setting.

The objective of this report is to present the monitoring and evaluation plans of large-scale NBS in demonstration A and B sites (in relation to WATER, NATURE, and PEOPLE) in support to the development of an evidence base on NBS.

Monitoring and evaluation plans for demonstrators are currently being developed and will be presented in several reports and hence, in several versions of D2.6. This report is the first version of D2.6. In this first version, the focus is on presenting the RECONECT monitoring and evaluation framework and to outline the initial plans for a subset of sub-goals and related indicators. The selection of sub-goals and indicators for this subset has been made based on i) the objectives identified as relevant to their NBS projects and ii) on those indicators that are common, to a large extent, to all demonstration sites. The latter is important in the context of demonstration activities across demonstration sites. As a living document, in next versions of D2.6, the monitoring and evaluation plans for additional sub-goals and related indicators will be further elaborated in order to support the goal of RECONECT in demonstrating and further upscale large-scale NBS.

This deliverable aims to support several audiences. At the first place, it supports the RECONECT Demonstrators by guiding them through the monitoring and evaluation procedures within the context of how sub-goals, indicators, data monitoring, impact assessment, and NBS performance. In particular for demonstrators A, this report also provides valuable information to learn from Demonstrators B, who have a considerable track record in implementing large scale NBS. Other than Demonstrators, this report addresses all other partners within RECONECT. In addition, the report addresses practitioners beyond RECONECT who are engaged with aspects related to the realization of NBS and in particular, with how to monitor and evaluate the performance of NBS towards the achievement of the project objectives.

The following activities have been undertaken in support of this deliverables:

- The RECONECT Indicator Selection Tool which has been developed in WP3. The tool has been used by demonstrators to identify which indicators may be used to monitor the NBS identified impacts for particular sub-goals.

- Indicator assessment methodologies that are being developed and are to be included in D3.5. The indicator assessment methodologies can be used to identify, for a particular selected indicator, which datasets and data processing procedures may be used to assess the indicator.
- D2.3, D2.5, and D2.4. Demonstrators have been requested since the beginning of the project to provide information in relation to their NBS site and to, for example, select relevant indicators. The aim of D2.6, as explained above, has been to guide them in fitting those indicators within the context of demonstrating the benefits of their NBS in relation to WATER, NATURE, and PEOPLE.
- RECONECT ICT Platform. The different types of measured data from Demonstration sites can be connected to the platform. In D2.6 it has been requested to specify whether demonstrators would like to display the data to assess the indicators, as well as the indicator values themselves, in the RECONECT ICT Platform. For the latter, this can be used to identify the functionality that may be needed to assess and present the indicator values in the platform.
- Deliverable D3.1 presents a summary of the model and data gaps based on the information presented in D2.6. Therefore, D3.1 goes hand in hand with D2.6 and when updates are to be made in the latter, these will be reflected in the model and data gaps presented in D3.1
- Task 3.1 “Procurement and installation of co-monitoring equipment” as based on the monitoring plans by demonstrators, the monitoring equipment needed for these activities can be identified.
- Task 3.4 “Data analysis and evaluation of demonstrated NBS”. The monitoring and evaluation plans as presented in this report serve as the basis for the actual analysis and evaluation of the NBS performance in all Demonstrators.

This report is structured in the following way. Section 2 presents the approach proposed for monitoring and evaluation. Section 3, describes information gathered from demonstrators. A summary of the monitoring and evaluation plans for demonstrators A and B is presented in Sections **Error! Reference source not found.** to 13.

2 Monitoring and evaluation approach

In RECONECT, all monitoring and evaluation work is carried out in relation to three categories of challenges i.e., WATER, NATURE and PEOPLE (see also Annex B). Where possible, monitoring data is being, or will be, collected and transmitted through real-time SCADA/telemetry services and also through social science surveys. These data will be used to evaluate the NBS impacts in relation to benefits, co-benefits as well as the negative effects.

Monitoring and evaluation of NBS against the WATER challenges address questions related to hydro-meteorological risks. This includes watershed runoff, river, coastal, and groundwater processes. Also, some interactions with urban areas will be addressed as well.

Monitoring and evaluation of NBS against the NATURE challenges address questions related to habitat structure and the biodiversity of flora and fauna. Implementation of large-scale NBS has the potential to improve habitat conditions, species territorial expansion and colonization of new areas. Species which are known to undergo decline due to combined hydro-meteorological and human pressures, and aspects such as habitat quality/quantity and issues related to decreasing biodiversity are of particular importance in the evaluation of NBS.

Monitoring and evaluation of NBS against the PEOPLE challenge address questions concerning social and economic benefits, with implications for human health and well-being and resilience to impacts from hydro-meteorological events.

The approach to monitoring and evaluation in RECONECT is presented in **Error! Reference source not found.** below.

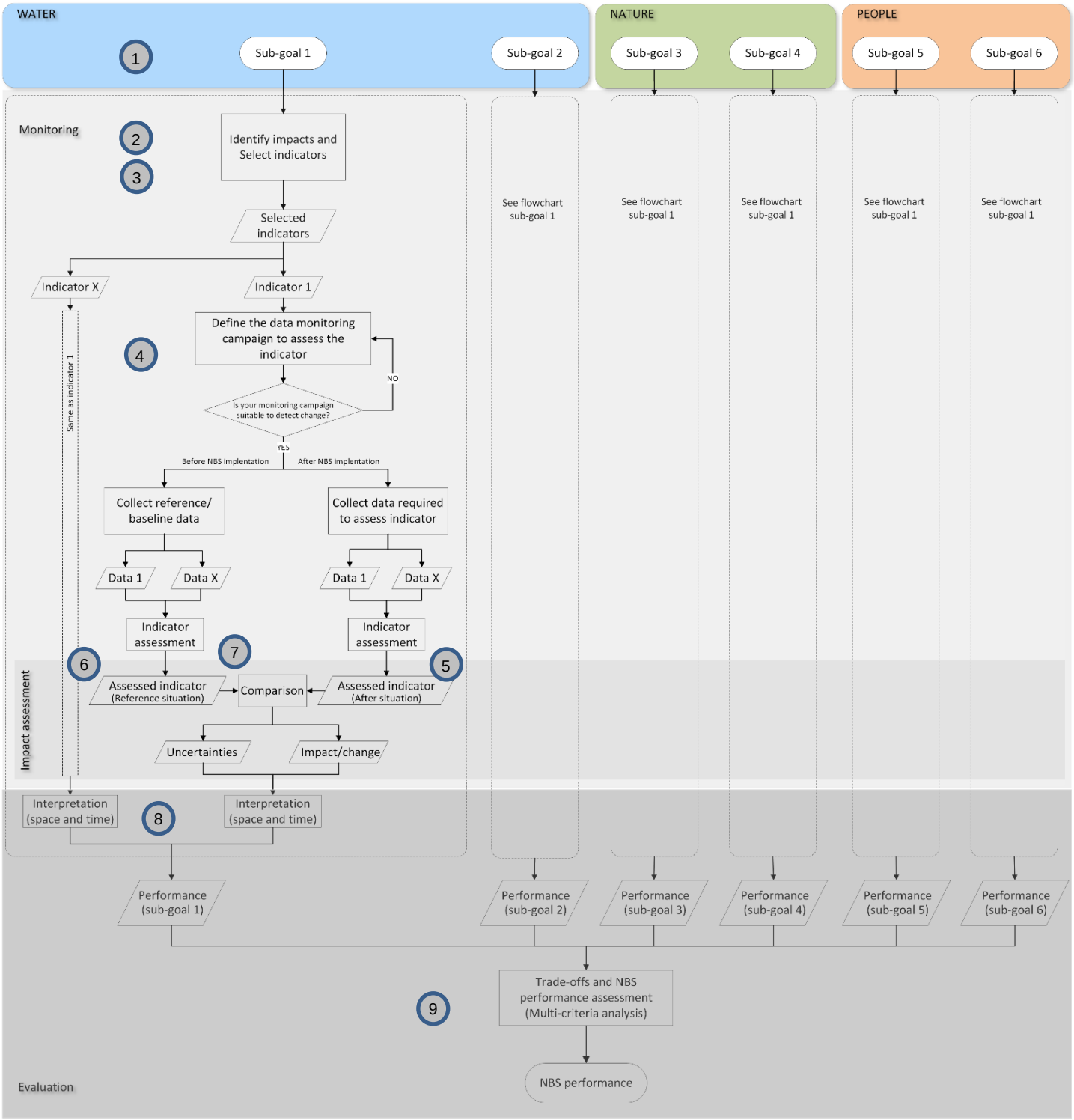

Figure 2.1 RECONECT approach to monitoring and performance evaluation (numbers one through nine refer to step number refer to in the text below)

The approach to monitoring and evaluation in RECONECT consists of the following steps:

1) The first step is to define what the NBS project aims to achieve, i.e. the set of NBS project objectives. In RECONECT, these are also referred to as goals and sub-goals. Goals represent themes/topics within the WATER, NATURE, or PEOPLE challenge area (e.g., water quantity, water quality, habitat structure, biodiversity, socio-economics and human well-being) whereas sub-goals are subthemes within those goals and reflect NBS project objectives (e.g., flood risk reduction within the water quantity goal). The setting of NBS objectives or sub-goals should be made with relevant stakeholders.

2) The second step deals, for each sub-goal, with identification of impacts of the NBS project that are to be monitored by the indicators (see point 3 below). Impacts are the effects/changes attributed to the NBS that are studied by the use of indicators and reflect performance towards achievement of objectives or sub-goals. Note that impacts need to be identified at the appropriate spatial and temporal scales, as this will guide the design of the monitoring and evaluation plan.

   Two types of impacts are distinguished. First, "intended" impacts are the effects/changes that are not only desirable but sought within NBS implementation. Second, we refer to "unintended" impacts as the (usually) negative, unforeseen effects/changes that occur after NBS implementation.

3) This step deals with the selection of indicators needed to monitor each of the impacts, and therefore, to monitor NBS performance towards achievement of objectives or sub-goals. The *"RECONECT Indicator Selection Tool"* developed in WP3 (https://surfdrive.surf.nl/files/index.php/s/NZyWRfEttgIItN0) has been used to select suitable indicators per sub-goal.

   For example, the performance monitoring of a retention pond may be in relation to three sub-goals, i.e. "Flood risk reduction" (WATER), "Increase habitat area" (NATURE), and "Increase in recreational opportunities" (PEOPLE).

   In relation to the achievement of sub-goal "Flood risk reduction" (**WATER**), NBS intended impacts include the reduction of flood hazard and of economic vulnerability. The selected indicators to monitor these impacts could include "flood hazard" (WATER) and vulnerability indicators such as "economic damage cost" (PEOPLE), respectively.

   In relation to the achievement of sub-goal "Increase habitat area" (**NATURE**), an NBS intended impact may be the increase of the habitat size for the species which may be monitored using the indicator "aquatic habitat area" (NATURE). On the other hand, an increase of sedimentation in the pond (unintended impact) may result in the reduction of the aquatic habitat area, hence affecting the achievement of the sub-goal. In this case, a suitable indicator to monitor such impact could be the sedimentation indicator "bed level change" (WATER).

   Finally, intended impacts of the NBS affecting the performance towards achievement of sub-goal "Increase recreational opportunities" (**PEOPLE**) may include the increase of green areas and the NBS attractiveness for recreational purposes. The former could be monitored by the indicator "green area size" (NATURE) whereas the latter, by indicators

related to the number of people that visit or spend time in the NBS area as well as the purpose of those visits (PEOPLE).

As shown above, note that the selected indicators may belong to a challenge area that is different from the one of the sub-goal.

4) This steps deals with the identification of the data/model required to assess the indicator, prepare a sound monitoring campaign for data collection, and collect the data.

   The *"RECONECT indicator assessment methodologies"* for WATER, NATURE, and PEOPLE are being developed as part of WP3 and contain, amongst others, the data that can be used as input for indicator assessment.

   A sound monitoring campaign is of high importance because, if from the data analysis there appears to be no evidence that an impact has occurred, there is the risk that an impact did occur but has remained undetected. There are methods that can be used to choose monitoring campaigns that have the potential to detect a particular impact (e.g. power analysis methods for NATURE sub-goals).

5) The fifth step deals with the assessment of the selected indicator for the situation after NBS implementation. The *"RECONECT indicator assessment methodologies"* for WATER, NATURE, and PEOPLE are being developed as part of WP3 and contain, amongst others, the methods that can be used to assess the indicator.

6) Assess the indicator for the reference/baseline situation. The value of the indicator for the reference/baseline situation is used for comparison with the value of the indicator after NBS implementation, to demonstrate that the sub-goal is being achieved. Values of the indicator for the reference/baseline situation include i) the value of the indicator before implementation of the NBS, ii) a pre-defined value, for example by regulation, and iii) the value of the indicator before and after implementation of the NBS in a control area (area with similar environmental conditions to accommodate for other changes in the indicator value unrelated to the presence of the NBS). For certain impact assessments of large-scale NBS such as those in the NATURE domain, finding a suitable control area is challenging. Ideally, the control area should have similar environmental conditions as the impact area, but be far away enough to be unaffected by the NBS intervention. However, finding such a suitable control area may not be possible. In that case, an alternative approach may be to predict what the situation would be in the project area without implementation of the NBS. This would become the reference/baseline situation to which to compare post-NBS monitoring data and assess impact.

7) Impact assessment: assess impact/change, and related uncertainties, by comparing the value of the monitored indicator after NBS implementation to the one in the reference/baseline situation.

8) Interpret the results to determine NBS performance in meeting the sub-goal (e.g. by comparison to those target values established at the beginning of the project).

9) Evaluate NBS performance taking into account the performance in achieving the different sub-goals including trade-offs. Multi-criteria analysis may be used to take into account the different views on performance by several stakeholders.

3 Information gathering and visualisation

3.1 Information gathering

Following the approach described in Section 2 for steps 1 through 8, the first version of deliverable D2.6 has been developed. In this first version, Demonstrators focus on describing their plans to evaluate the performance of their NBS in achieving a reduced number of sub-goals (see table 3.1).

For the selection of the monitoring indicators and performance evaluation the framework developed within RECONECT has been followed. A brief description of the framework is presented in Annex B**.** Together with the framework a tool to guide the selection of indicators was developed in work package 3 lead by IHE. The tool aims to support selection of specific indicators and variables for different NBS demonstration sites which could be then used for monitoring (baseline and ongoing) and evaluation activities.

The focus for most demonstrators is on a reduced number of indicators per sub-goal.

Table 3.1 Focus sub-goals

Challenge area	Goal	Sub-goal
WATER	Water quantity	Flood, coastal, landslide risk reduction
NATURE	Habitat structure	Increase habitat area (quantity)
	Land cover area	Shifts in land use and land cover
	Biodiversity	Maintain and enhance biodiversity
PEOPLE	Socio-economics	Increase recreational opportunities
		Stimulate/increase economic benefits

To collect information from Demonstrators and produce this first version of D2.6, a template was prepared and discussed with all demonstrators. After a brief introduction to their case highlighting the main goals/sub-goals addressed by the NBS.

For each sub-goal, a brief explanation was requested of the reason why the NBS addresses that particular sub-goal. This is briefly introduced at the beginning of each section / demonstrator case.

To address the different challenges a set of indicator per sub-goal were defined. The tool to guide the selection of indicators developed in work package 3 lead by IHE was applied. The indicators are proposed per sub-goal to provide evidence to the corresponding challenge. Each challenge correspond to a colour, Light Blue for water, Light Green for Nature and Light Orange for People, as presented in table 3.1

For each indicator every demonstrator was asked to describe the (intended and/or unintended) impacts, together with the monitoring question that is answered by the indicator and the monitoring procedure. The monitoring procedure focuses on describing each model and/or data required to assess the indicator, the spatial and temporal scale and the stakeholder responsible for data collection.

For each indicator a brief description about the reference/baseline situation that is used for comparison with the value of the indicator after the implementation of the NBS. It is also indicated how and from where the reference/baseline situation data is obtained and whether the data is available.

Finally, Demonstrators are asked to specify whether the value of the assessed indicator is to be displayed in the RECONECT ICT Platform, which is described in the following sub-section.

The “Evaluation plan” section briefly describes how demonstrators plan to compare the monitored values and reference/baseline values of the indicators to assess the identified impacts and to interpret that the sub-goal is being achieved. They are also asked to reflect on the time scale to which each indicator applies, to which stakeholders the evaluation will be presented, and how often and for how long (also beyond RECONECT) will the evaluation be carried out.

As the evaluation plan is at the sub-goal level, and several indicators may have been described, demonstrators are asked to reflect on them as a whole to answer whether the NBS achieves the sub-goal. This requires to reflect on the possible time scale differences over which the different indicators show that the sub-goal has been achieved or not.

3.2 Visualisation - RECONECT Monitoring Platform

Most of the monitoring data will be displayed at the RECONECT Service Platform (Figure 3.1 and figure 3.2), which is an ICT platform that combines a network distributed data, intelligent tools and standardized web-services, accessible through a centralized catalogue of network services. The platform is hosted by TeleControlNet (https://www.telecontronet.nl), which acts as a backbone for ICT services for data coming from NBS sites. The platform enables to receive both real-time and historical data, their storage, management and display (i.e., analytics). The platform consists of three types of distributed services: 1) data access services, 2) generic NBS network services, 3) tools for analysis feedback.

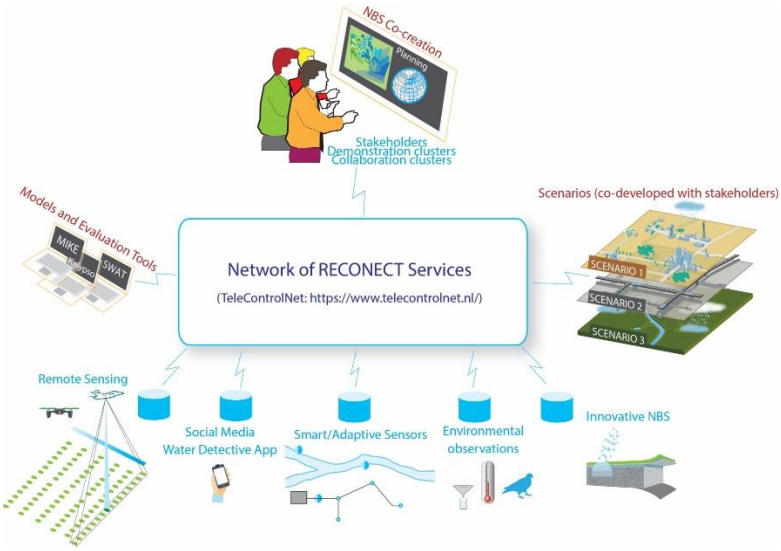

Figure 3.1 RECONECT Service Platform for supporting and displaying monitoring data for Demonstrators and Collaborators cases

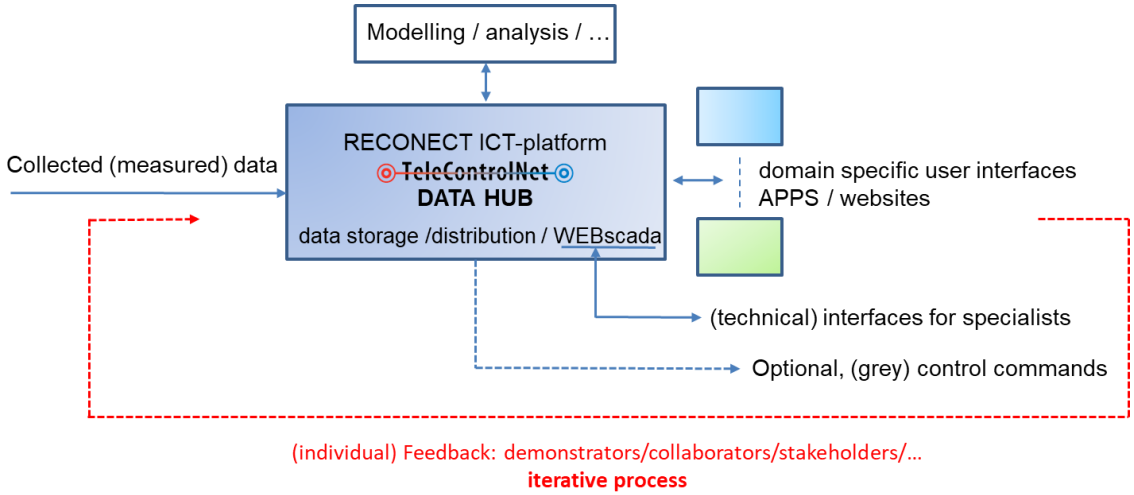

Figure 3.2 Block diagram of the RECONECT Services Platform

Partners and authorized users can access the platform based on their access levels. The platform can be accessed by Login to page https://www.telecontronet.nl (See Figure 3.3).

Figure 3.3 Login page of TeleControNet platform web page

Figure 3.4 shows the main monitoring web page, which consists of RECONECT case studies and characteristics of monitoring services.

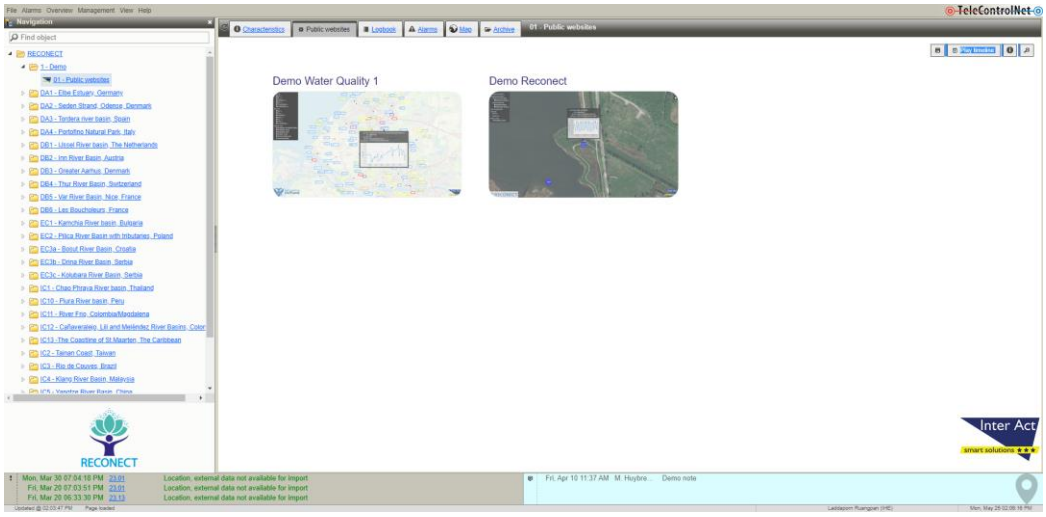

Figure 3.4 The main monitoring web page

Different monitoring data can be displayed on the platform such as precipitation, relative humidity, temperature, wind direction, wind speed, water level and discharge. The information can be displayed in real-time and/or as historical data. Moreover, the data can be shown in different formats such as graphs or bar charts.

4 Elbe “Vier- und Marschlande”, Germany - DA1

4.1 Description of the study area

The network of small rivers and streams of the Dove/Gose Elbe system is located in the southeastern part of the City of Hamburg in the borough of Bergedorf, the largest of seven boroughs of Hamburg. The river system belongs to the complex drainage network of the landscape area Vierund Marschlande, which includes Bille/Schleusengraben and Brookwetterung rivers in addition to Dove and Gose Elbe. The catchment size of the Dove/Gose Elbe river system considered for the RECONECT demonstration is 175 km^2. It is dominated by the natural and agricultural areas (70%).

The two main hydro-meteorological hazards in this study area are:

- Flooding of the marsh area in the Dove/Gose Elbe catchment
- Droughts including the potential failure to provide the required potable water volume for the water supply of the City of Hamburg

In the demonstration area the flood prone areas have been designated as per the EC Floods Directive 2006/60/EC (taken up by the Hamburg and Federal Water Acts). In that sense, the demonstration within RECONECT is in line and will contribute to the implementation of the EC Floods Directive (2006/60/EC). More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5.

4.2 Description of the NBS

The main goal of the demonstration activities in the German Demonstrator (DA1) Vier- und Marschlande is the reactivation and the distribution of the storage capacity upon need of the rivers Bille, Dove and Gose Elbe, their tributaries and trenches (such as Brookwetterung or Curslack) and their flood plains, to create more retention volume for water during flooding. At the same time necessary stable water levels in the rivers can be provided during droughts.

The distribution of the storage volume during flood events will be managed by the RECONECT NBS operation and the real time controlling system. It will make use of the previous studies and rainfall- runoff and hydrodynamic models as well as of the conceptual design of the operation system (mainly developed in the STUCK Project, see Hellmers et. al., 2017) and further developed to be ‘ready-to-use’ by the operators and asset owners.

The improved management of the retention areas in the Dove/ Gose Elbe river system is oriented to reach the following benefits:

- Improved management of the hydro meteorological events being floods and droughts
- Improved ecological condition of the area due to optimised use of the retentions and floodplains
- Improved liveability and social value of the area also contributing to the tourism, that is gaining relevance in the area (Meine & Schruttke, 2018)
- The conversion of grey infrastructure into hybrid solutions by combining the existing grey assets (such as pumping stations) with the RECONECT NBS approach
- The expansion of the existing linear and disciplinary approach (a piecemeal approach to floods and drought management) into a holistic approach

4.3 Goals and sub-goals addressed by the NBS

Table 4.1 presents the challenge area and defined goals and sub goals for the German Demonstrator.

Table 4.1 Challenge area and defined goals and sub goals for the German Demonstrator DA1.

Challenge area	Goal	Sub-goal
	Water quantity (Improved management of the hydro meteorological events being floods and droughts)	A) Flood risk reduction in urban areas and around rivers, lake, water courses, etc.
	Habitat structure (Improved ecological condition of the area due to optimised use of the retentions and floodplains)	B)Maintain and enhance biodiversity
	Socio-economics	C) Stimulate/increase economic benefits

4.4 Indicators to address Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

It is generally agreed that the volumes of precipitation in extreme events will increase under conditions of a changing climate. With these increases in precipitation magnitude and intensity, associated increases in run off, storm water discharges, and flooding are expected more frequently. These concerns are particularly acute in the area of the demonstrator as urban infrastructure, as well as agricultural soils and installations are under threat of being reached by inundations i.e. storm surge floods. From the successful implementation of the NBS it is expected that the risk of the existing urban infrastructure being exposed to threats of floods is reduced.

The German demonstrator area confines protected areas and nature reserves which are subject of a network of protected areas according to the Flora/Fauna/Habitat and Natura 2000 directive. The aquatic communities are being addressed by the Water Framework directive (WFD) (2000/60/EC). In order to reach the goal of the WFD to provide river continuity in the area of study in the past fish ladders at weirs and locks have been installed as well studies carried out to enhance fish passage through dike drainage installations by more fish friendly “smart operation”.

From the NBS is expected that the terrestrial and aquatic communities and biodiversity is at least stabilized or enhanced. The area is subject of regular monitoring activities prescribed by FFH/Flora/Fauna/Natura 2000 Directives and WFD

For the German demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (4.2, 4.3 and 4.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

Table 4.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DA1

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Lowering of the water level	slowing and storing run-off / flood peak reduction	The river water level data collection is related to the existing gauging stations in the river catchment. The information can be seen online (Warndienst Binnenhochwasser Hamburg: www.wabih.de). The data is available since 2001. It consists of 11 gauging stations connected online to deliver real time information. The data is generally collected/store once a day, in case of a flood event it is every 30 minutes. The Ministry of Environment and Energy Hamburg (BUE) is responsible for data collection.	The Water level will determine if the planning (assessed with a Hydrodynamic model) and implementation (measured data) of the hybrid solution is successful. For the base line or reference situation, any recorded flood event before the NBS implementation can be used to compare the situation (intended impact)
	I: Reduction of the inundation time / Flood hazard reduction	Flood hazard	There are 11 gauging stations that deliver the water level in real time (maximum peak of the water level, duration of inundation, etc.) will be used to determine this indicator. Similar to the above monitoring procedure. The Ministry of Environment and Energy Hamburg (BUE)is responsible for data collection.	The Water level will determine if the planning (assessed with a Hydrodynamic model) and implementation (measured data) of the hybrid solution is successful. For the base line or reference situation, any recorded flood event before the NBS implementation can be used to compare the situation (intended impact)
	I: Economical savings from operating the pumping stations	Delay time to peak	The operation of the pumping station is related to the water level, the gauging stations deliver the required information to calculate this indicator, in particular the gauging station at Reitschleuse. The Borough of Bergedorf is responsible for data collection	The storm pumping station Ochsenwerder works when the water level reaches 1,10 m above the sea Level. For the base line or reference situation, any recorded flood event before the NBS implementation can be used to compare the situation (intended impact) In particular the pumping costs per year.
	I: Reduction of the total amount of water	flood peak reduction **pumping stations	The operation of the different pumping stations is related to the water level, it is possible to know the amount of water leaving the system through the pumping stations. In particular the water levels at the gauging stations at the Reitschleuse, Riepenburg, Dove- Elbe and Zollenspieker are required. The information is recorded continuously while in operation. The Borough of Bergedorf is responsible for data collection	For the base line or reference situation, any recorded flood event before the NBS implementation can be used to compare with the situation (intended impact_ which is the reduction of the total amount of water coming into the lower stretch of the Dove-Elbe.

Table 4.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DA1

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
To maintain and enhance biodiversity 	I: Increase in biodiversity of flora and fauna	Species richness and composition	Mapping of the species (count data) along the rivers in the Vier- and Marschlande region in a periodic time after the implementation of the hybrid solution. It will include qualitative analysis (incidence data: species presence- absence) and quantitative analysis (abundance data of each species) by mapping and field visits along the upper part of the Dove Elbe, the lower part of the Dove Elbe, the Gose Elbe and the Neuengammer Durchstich and the Bergedorfer Schleusengraben. The sampling and observations will be defined at regular time intervals for a period which lasts at least for 10 years after implementation of the NBS. The Ministry of Environment and Energy Hamburg (BUE) is responsible for data collection.	The Baseline mapping and sampling already took place and data are available from existing public monitoring programme and sampling provided by obligations delineated by the Natura 2000 Directive as well as the Flora Fauna Habitat Directive and the Water Framework Directive (2000/60/EC). To assess the indicator, detect and assess change of species richness and composition.

Table 4.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DA1

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Stimulate/increase economic benefits	Reduced number of buildings affected by floods	Vulnerability / Economic damage cost	Number of houses affected by floods according to Police/ fire departments as well as insurance companies. The data will be processed from the Police / Fire department and insurance reports. The assessment will include the whole Vier- und Marschlande region and it will be done after each flooding event. The data will be collected form 2017/2018 onwards.	Documentation about the damages caused by floods in houses. The economic damage cost before the implementation of the NBS solution in the area.

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			The Hamburg Agency of Roads, Bridges and Water (LSBG) is responsible for data collection.	

4.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. In particular the real time data collected in some of the 11 gauging stations can be made available, for instance the water levels. The Ministry of Environment and Energy Hamburg (BUE) is responsible for this data.

4.6 Evaluation plan

Water

Since our indicators are Mitigating and Storing Runoff /Flood Peak reduction, flood hazard, vulnerability, delay time to peak, and flood peak reduction **pumping station, they are closely related to the water level. The gauging stations provide a baseline monitoring; and this gauging stations will continue providing the data to measure the effectiveness of the hybrid solution. The main goal is to keep the water level as low as possible and lower it as fast as possible. As a consequence the affected area is to be reduced as well as the affected houses.

Since every flood event is unique, the complexity and uncertainty to compare all parameters are high. A worst case scenario was used in hydro-numerical models while planning the hybrid solution and the highest water level in each waterbody in the Vier- und Marschlande region is known. The water level from the worst case scenario are not to be reached in order to prove the efficiency of the hybrid solution.

Critical water levels are also known (the maximal water level without damages), the optimal functioning of the hybrid solution would be if these water levels would not be reached.

The indicators will be observed over a flood event and will be presented and discussed mainly with water and local authorities. It is also possible that they will be presented to citizens. The evaluation will be carried out after each flood event to document the effects.

Nature

The assessed indicators will be compared to the baseline before creation of the NBS as well as to reference sites.

Based on the assessed indicators: Species richness and composition in respect to indigenous vegetation and local/national biodiversity targets, Number and type of protected species (species richness), Diversity of species and Restricted-range species (unplanned impact) as well as existing and collected monitoring data the evaluation will answer the following questions:

- How has biodiversity of the area changed over time?
- How valuable is the created NBS in terms of biodiversity?

In order to answer the questions above it is imported to keep in mind that the intrinsic problem of observing natural indicators relies within natural constraints:

- The fact that biological development and successions often require longer timespans before field data show the expected positive impact of the NBS
- The high variability of the biodiversity hinders the observation of the expected positive impact of the NBS.
- Observations require longer time series than the projects life time. For this reason the monitoring of the Demonstrator is embedded in public monitoring programmes which are prescribed by European Directives requirements in order to provide long term trends.

In general it is difficult to use biodiversity development as an indicator to show the immediate effect of an NBS although long term changes might be observable. The more extreme the applied NBS changes the environmental conditions, i.e. the stronger the impact (abiotic conditions, e.g. from still water to tidal waters) changes in the aquatic and terrestrial community become more evident. In the case of the demonstrator Vier- und Marschlande we only expect slight modifications of the abiotic setting, making detecting changes of the biotic setting difficult to detect.

As the NBS is designed in the sense of managing the potential retention volume of the Dove-Gose Elbe system in the case of flood events, observing the development of water levels during flooding makes the NBS´s impact evident or immediately visible.

Biological developments might follow with a natural time lag.

People

The direct economic damage costs are used to calculate the benefits of the application of the NBS by comparing the potential damages of flooding events at the baseline scenario (without the implementation of NBS) with a future situation (where the NBS implemented). From the successful implementation of the NBS it is expected that the risk of the existing urban infrastructure being exposed to threats of floods is reduced.

The NBS implementation could be understood as part of an innovative and future oriented adaptation planning process to cope with the effects of climate change.

The direct damage costs (post flooding) are rather plain to assess using official damage reports and registers coupled with insurance reimbursements of affected clients/households.

The potential damage costs are derived by forecasts using numeric hydrodynamic models which are used for:

- Completion of a vulnerability assessment, and
- Development of an adaption strategy (NBS Implementation).

The economic vulnerability assessment provides an estimate of the degree to which a system insusceptible to and unable to cope with the effects of high precipitation and run off. The vulnerability assessment includes an evaluation of adaptive capacity, which represents the extent to which the effects of flooding can be mitigated with NBS implantation.
The adaptation strategy as part of the RECONECT demonstrator represents a set of actions to be employed to adjust the natural or human systems to mitigate the damage or harm that would result from the precipitation and run-off in the area of study.

It is to stress that in the project the activities are at the beginning to address the issues of socio-economic benefits which are to be expected with the implementation of the NBS (activities under development).It is to stress that in the project the activities are at the beginning to address the issues of socio-economic benefits which are to be expected with the implementation of the NBS (activities under development).

5 Odense, Denmark - DA2

5.1 Description of the study area

The study area of Seden Strand is located approx. 8 km northeast of the Odense city center by the Odense Fjord. The area which will be affected (both nature, urban and cultivated area) covers locally approx. 0,8 km^2 and includes:

- Building and roads: 25 %
- Farmland:50 %
- Nature:25 %

The area surrounding Seden Strandby is primarily used for farming including production of vegetables and grazing with horses.

The present flood protection consists primarily of small, so called 'summer' dikes (op til ca. 1,5 m high), originally build against summer sea flooding to improve farming possibilities in the coastal areas.

The project is governed by storm surges with storm tide in Odense Fjord because of storm from north and northwest causing high influx of water from the North Sea to Kattegat and further into Odense Fjord. For planning use, a rise of 0,30 m of the sea level is expected at 2050 and storm surge will happen more frequently. The project will consider this forecast. More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5.

5.2 Description of the NBS

The demonstration site is situated northeast of Odense at the residential settlement of Seden Strandby. Due to the change in climate, Seden Strandby is threatened by flooding due to the rising sea level. At Seden Strandby this means that 142 private homes are at the direct risk of flooding, as well as up to 66 ha of agricultural land.

Odense Fjord and the surrounding fiord habitats are designated as a Natura 2000 site DK008X075, protected by both the EU´s Bird Directive and Habitat Directive. The status of the Natura 2000-site has to be improved because of a decline of habitats due to cultivation and overgrowth among others.
The main goals of the nature based solution used at the demonstration site are to combine interests which both reduce the risks of coastal flooding of the populated areas, improve and increase the coastal habitats, preserve and improve the open coastal landscape and improve the recreational possibilities in the area.

At Seden Strand this includes:

- Removal of existing low coastal summer dikes and moving them inland to a higher location, which will protect the area against flooding up to 2,25 meter meter (DVR90)[1]

[1] DVR90 is the present height reference system in Denmark. It stands for "Danish Vertical Reference - 1990". It has replaced Denmark's old height system DNN, which stands for Dansk Normal Nul

- Promote rehabilitation of those habitats protected by the EU Habitat Directive (especially salt meadows - 1330) outside of the new dikes
- Focus on habitats related to target species, like the avocet (Recurvirostra avosetta) and the natterjack toad (Epidalea calamita)
- Re-creation of the former steambed and more dynamic flooding regime

In relation to this new pathways and observation towers will also be established, which will enhance the available information in the area.

5.3 Goals and sub-goals addressed by the NBS

Table 5.1 presents the challenge area and defined goals and sub goals for Danish the Demonstrator.

Table 5.1 Challenge area and defined goals and sub goals for the Danish Demonstrator DA2.

Challenge area	Goal (Select Goals from the "RECONECT Indicator Selection Tool")	Sub-goal (Select Sub-goals from the "RECONECT Indicator Selection Tool")
WATER	Water quantity	A) Coastal flood risk reduction
NATURE	Habitat structure	B) Increase habitat area (quantity)
		C) Habitat provision and distribution (quality)
	Biodiversity	D) To maintain and enhance biodiversity
PEOPLE	Socio-economics	E) Increase recreational opportunities

5.4 Indicators to address Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

Regarding coastal flood risk reduction, the nature-based solution at Seden Strand has multi-purpose goals. It shall support the protection of the residential settlement of Seden Strandby and at the same time, as equal parameters, support and improve the coastal habitats. Therefore, the water monitoring in the area will focus both on the effectiveness of the protection against flooding and the effects that changes in hydrology will have on the area.

Considering increase habitat area (quantity), it is expected that removal of 'summer' dikes will change the sea flooding pattern in the area and result in change of the protected habitat size (Atlantic salt meadows). Construction of a stream will also result in a change of the habitat cover in the area and development of riparian habitat.
Changes of vegetation usually take a long time before they are recorded. Therefore, the survey planned during RECONECT will be used to establish a baseline for a future monitoring of the changes.

Regarding habitat provision and distribution (quality), NBS at Seden Strand might possibly result in an extension of habitat cover of Atlantic salt meadows in the area.

In relation with the sub-goal of maintain and enhance biodiversity, the NBS at Seden Strand aims at improving of natural habitats (especially Atlantic salt meadows - 1330) and habitats of species protected by the EU Habitat and Bird Directives. An increase in meadow openness by removal of existing woody vegetation, introduction of management in unmanaged patches of the area, re-creation of more natural sea flooding patterns and the inclusion of depressions will contribute to an improvement of the meadow birds habitats, as well as create habitats for the endangered Natterjack Toad.

Regarding increase in recreational opportunities, the construction of Seden Strand Øst as a nature-based solution. The new construction provides space for the water to move and spread more naturally and thereby leading to the creation of a natural littoral, replacing a former farmed agricultural area, and a path around it. This is resulting in the development of a new recreational area partly open to the public.

For the Odense demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (5.2, 5.3 and 5.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

Table 5.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DA2

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Coastal Flood risk reduction 	I: Flood hazard reduction	Changes in flood risk of areas behind NBS-dikes	The terrain model and measurement of salinity of water in upper ground level data collection is linked to LIDAR data used for modelling, measurements of flooding and measurements of changes in salinity. The LIDAR data is available since May 2020, while the data related to measurements of flooding and salinity is expected to be established in September – November 2020. The spatial sampling coverage is 50 hectares. Regarding Lidar survey, one survey pre- and one survey post NBS implementation are expected. Measurements of seawater level (flooding) will be registered daily. Eurosense is responsible for the Lidar survey, while the measurements of flooding and salinity are Odense Municipality responsibility.	The aims are to establish a digital surface model of the demonstration site (before and after), to show what changes in terrain there will be due to the removal of the existing summer dikes and more frequent flooding, to show at what level the area will be flooded and the amount of time it is affected, and to show if more frequent flooding will have an effect on the salinity of the ground water. For the base line or reference situation, the area is flooded at seawater levels above 0.9 meters (DVR90). The reference/baseline will be obtained before and after implementation of NBS.
	I: More dynamic flooding regime of the area	Changes in area effected by flooding		
		Changes in the salinity of water in the surface, near ground water		

Table 5.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DA2

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: Changes in habitat sizes	Habitat area	Mapping of vegetation for the targeted habitats in the area (shape file) and environmental variables such as terrain elevation (Danish Hight Model), flooding extent and frequency, soil type, salinity, etc. The methodology includes a field survey supported with GIS analysis, to classify habitats and delimit their borders, as well as LIDAR data, measurements of flooding and measurements of salinity. The data will be qualitative, outline of different habitats (2D-Shp-File), and quantitative when habitat areas are obtained from the delineated polygons. The data collection for vegetation mapping will start in June – July 2020. The spatial coverage will be defined by RGB aerial images with a spatial resolution of 12.5 cm GSD; Seden Stand, ca. 27 ha. The sampling frequency consists of a baseline in 2020 (before), verification after NBS implementation, and if needed every 10 -20 years. Regarding environmental variables, the start, frequencies, coverage and responsible are equal to the ones defined for sub-goal of coastal flood risk reduction. During the project time, the responsible for data collection will be Amphi International.	The main aims are to define habitat units in order to assess the habitat size and to help in defining habitat units in order to assess the habitat size. The Baseline mapping and sampling already took place and data are available from existing public monitoring programme and sampling provided by obligations delineated by the Natura 2000 Directive as well as the Flora Fauna Habitat Directive and the Water Framework Directive (2000/60/EC).
Habitat provision and distribution (quality) 	I: Change in location of habitat borders	Location of habitat borders	The data in this case are shapefile with habitat types and environmental variables, such as terrain elevation (Danish Hight Model), flooding extent and frequency, soil type, salinity, etc. Regarding habitat types, the method comprises computation of the habitat patch size and number based on spatial GIS analysis supplemented with field verification of the identified habitat borders. Starting of data collection is expected by June – July 2020. The spatial sampling will be Seden Stand, ca. 27 ha and its frequency includes a baseline in 2020 (before), verification after NBS implementation and if needed every 10-20 years. The responsible for data collection during the project time will be Amphi International.	The purposes are to assess expansion and/or decline of the habitat types and to understand changes in observed habitats. The reference/baseline situation is the situation before implementation in the NBS area (2020) and it is obtained by delineating the habitat borders based on field survey and aerial images before NBS implementation.

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			Regarding environmental variables, the data collection method, start, frequencies, coverage and responsible are equal to the ones defined for sub-goal of coastal flood risk reduction.	
Maintain and enhance biodiversity 	I: Increase in biodiversity of flora and fauna	Species richness and composition	The data required in this case is species count data and environmental variables, such as terrain elevation (Danish Hight Model), flooding extent and frequency, soil type, salinity, land use etc. Regarding species count data, the method includes a field survey (direct observation), terrestrial vascular plants (number and cover of species per plot), and birds (number of breeding, foraging and overwintering species per plot). Also, a statistical power analysis may be required to estimate the spatial and temporal sample effort needed. The following methods will be used for the assessment of the indicator: Menhinick's index (D) or Margalef index (DMg), to calculate species richness, and Jaccard's index of similarity (SI), to detect changes of species composition between years. The type of data is qualitative (incidence data: species presence-absence) and quantitative (abundance data of each species). The start of data collection is expected by June – July 2020 in the case of vascular plants, and April 2019 in the case of birds (also possibly earlier data sets from DOF (Danish Ornithological Society) database). The spatial sampling will be Seden Stand, ca. 27 ha and its frequency includes a baseline in 2020 (before). In the case of vascular plants, in the next field season after NBS implementation, and after 5 and 10 years. In the case of birds, every month during period April- September. The responsible for data collection during the project time will be Amphi International. Regarding environmental variables, the data collection method, start, frequencies, coverage and responsible are equal to the ones defined for sub-goal of coastal flood risk reduction.	The objectives in this case are to assess the indicator, detect and assess change of species richness and composition, and to understand observed species count. The reference/baseline situation is the situation before implementation in the NBS area (2020) and the Odense Fjord as a whole (in the case of birds). The reference/baseline situation is obtained by field verification and possibly from archival data sets for the area as well as whole Odense Fjord in case of birds.

Table 5.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DA2

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase in recreational opportunities 	I: Changes in attractiveness of the NBS area	Number of people that visit or spend time in the NBS area	The type of data required in this case is the number of visitors. The method for counting involves the installation of people or counters/sensors at the access points. The start of data collection is expected in 2021. The frequency of collection is expected to be continuous, with hourly or daily resolution. The Odense Municipality is responsible for data collection.	The aim is to define the number of visitors. The baseline is assumed to be zero visitors since there were no NBS nor recreational activities in the location.
		Enhancing attractiveness of places for living and working, and to visit	The procedure includes a user/visitor survey in combination with the count data. The type of data is qualitative for the purpose of the visit (semi-quantitative for the survey). The method includes a survey on site for out-of-town visitors, and a survey through mail for residents. The visitor characteristics of interest are age, gender, activities undertaken, length of stay, value ascribed, alternative recreational activities. The start of data collection is expected by 2021/2022. The spatial coverage for the on-site survey is 50 ha – (Seden Strand Øst). The frequency of sampling will be 1 survey campaign (including on site and mail surveys). The responsible for data collection are Odense Municipality and DTU.	The purpose is to validate the number of visitors and their purpose, also the value they ascribe to this use and their knowledge about the NBS present in the region. The targets are both residents of the Odense Municipality and tourists. The reference/baseline situation is obtained by estimating the number and activities of visitors before NBS implementation.

5.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. In particular the calculated indicators regarding habitat such as location oh habitats, habitat read and species richness and composition. Also the changes in flood risk of areas behind the NBS-dikes will be integrated with the ICT Platform. Data will be provided from the partners in Odense (Odense Kommune) and Amphi.

5.6 Evaluation plan

Water

Indicator The coastal flood reduction:

- It will be visualized though the Lidar baseline survey showing the before and after NBS situation. This will later on be compared with an after lidar survey.
- The measurements of the amount of flooding and potential changes in salinity will be followed and compared.

- The sub-goals are expected to be achieved if the protection for the residential settlement at Seden Strand by has improved. Furthermore, the sub-goals are expected to be achieved if flooding of the area is happening more frequently and a larger part of the area becomes more saline. This will also be compared with the monitoring done as part of the nature monitoring.

Nature

Indicator habitat area:

- To assess the impact “I: Changes in habitat sizes” the shapefiles created for the indicator “Habitat area” before and after NBS implementation will be compared using GIS operations and the changes in area for the different habitat types will be obtained. Also, characteristics of the vegetation obtained during the field survey will be compared to detect and confirm its development in the desired direction.
- If the area for the different habitat types has increased or vegetation cover develops towards desired habitat types, it will be concluded that the sub-goal “Increase in habitat area” is being achieved. There is no predetermined amount of change (target) that needs to be met.

- Time scale: Development of habitats can take many years. Therefore, it is expected that the assessment of the indicator will be done after RECONECT completion.
- The evaluation will be presented Odense Municipality and stakeholders
- Evaluation will be made every 6-10 years and will follow the national monitoring of the natural habitats within Natura 2000 areas.

Indicator location of habitat borders:

- To assess the impact “I: Changes in location of habitat borders” the shapefiles created for the indicator “Habitat area” before and after NBS implementation will be compared using GIS operations and the changes of habitat borders for the different habitat types will be assessed.

- If the extension of the different habitat types has changed or/and vegetation is developing towards the desired habitat type in the areas earlier not covered by targeted habitats, it will be concluded that the sub-goal “Changes in location of habitat borders” is being achieved. There is no predetermined amount of change (target) that needs to be met.

Time scale: Development of habitats can take many years. Therefore, it is expected that the assessment of the indicator will be done after RECONECT completion.

The evaluation will be presented to Odense Municipality and stakeholders

Evaluation will be made every 6-10 years and will follow national monitoring of the natural habitats within Natura 2000 area.

Indicator Species richness and composition:

- To assess the impact “I: Increase in biodiversity of flora and fauna” the vascular terrestrial plant species, as well as bird species richness and composition will be compared before and after NBS implementation. Moreover, bird species richness and composition, as well as detected trends will be compared with the whole Odense Fjord area. The frequency of the characteristic/rare plant species occurrence, as well as their cover for Atlantic salt meadows will be also compared.
- If the area will start to support:
    a) less generalists’ and more desired breeding, as well as overwintering meadow/seashore bird species,
    b) more characteristic for Atlantic salt meadows plants than before implementation of the NBS, it will be concluded that the sub-goal “Maintain and enhance biodiversity” is being achieved. There is no predetermined amount of change (target) that needs to be met.

Time scale: the indicator applies to the long-term scale. Changes in vegetation develop over many years. Birds are known as one of the fastest responding fauna groups to the positive alteration of their habitats. But there are also many external factors influencing colonisation of habitats which needs to be considered.

The evaluation will be presented to Odense Municipality and stakeholders.

Evaluation will be made at the end of the RECONECT. Is to be decided when the evaluation will be made after the end of the project.

People

To assess the impact “Changes in attractiveness of the NBS area” the number of visitors and their purpose for visiting, obtained from the monitoring of the NBS area, will be compared to estimates of the numbers and goals from years prior to the NBS implementation.

If the number of visitors, together with the forms of recreation in the area have increased, it will be concluded that the sub-goal “Increase in recreational opportunities” is being achieved. There is no predetermined amount of change (target) that needs to be met.

The impact “Changes in attractiveness of the NBS area” is estimated to be a good assessment of the recreational use of the NBS area overall, as its qualitative estimations could easily overlap with other proposed indicators such as “Number of recreational activities” and “Number of tourists”. Moreover, it is expected that this indicator will be directly connected to an increase in the overall well-being of the population, including positive physical and psychological influences. Finally, links can be drawn between this

impact and the Nature challenge area, as some of the new recreational opportunities expected for Seden Strand are strictly linked to the restoration of habitats and conservation of biodiversity.

Time scale: a shift of “routine” recreational opportunities (e.g. jogging, biking, etc.) to the new NBS area is expected to be identified quickly, in particular in regard to Seden Strand residents. Emergence of new recreational activities (e.g. birdwatching) is also expected, but it’s likely to be identified in a larger timeframe, as it’s dependent on slower mechanisms (e.g. the comeback of wildlife).

Stakeholders include: Odense Municipality, Odense inhabitants, DTU, tourists.

Evaluation frequency and length: Evaluation will be made twice annually. The survey will be done once within the lifetime of RECONECT. However, given the opportunity, the on-site survey could be repeated.

6 Tordera River Basin, Spain - DA3

6.1 Description of the study area

The Tordera River Basin is one of the main watersheds in Catalonia still unregulated. It has a typical Mediterranean rain regime (scarce and highly irregular) and flash floods usually occur. Vulnerable activities are found in flood prone areas as the middle part of the basin is highly industrialized and the delta is a popular tourist spot where different camp sites are located. Besides, the Delta is an important area for agricultural production.

The main hydro-meteorological hazard to be addressed by the implementation of NBS in the Tordera River Basin are floods and flash floods. There are other hydro-meteorological hazards affecting the Tordera River Basin such as coastal (i.e. storm surges) and urban floods that we do not plan to tackle in the context of RECONECT.

More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5.

6.2 Description of the NBS

The main goal to be addressed by the implementation of NBS is the reduction of flood risk in highly vulnerable areas, reducing the impact of floods on economic activities.

On the other hand, part of the Tordera River Basin has been designated as Natura 2000 site, while the river reach where the NBS is intended to be developed has been identified as a highly modified water body with a bad ecological status. In this sense, the second main goal to be attained with the implementation of the NBS is the conservation of the environmental values associated to the area, contributing as well to the improvement of the ecological status of the water body.

6.3 Goals and sub-goals addressed by the NBS

Table 6.1 presents the challenge area and defined goals and sub goals for the Danish Demonstrator.

Table 6.1 Challenge area and defined goals and sub goals for the Spanish Demonstrator DA3

Challenge area	Goal	Sub-goal
	Water quantity	A) Flood risk reduction
	To reflect ecological status and physical structure of habitats	B) Structure of the riparian area
	Habitat structure	C) Increase habitat area (quantity)
	Socio-economics	D) Stimulate/increase economic benefits

6.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

In relation to flood risk reduction, in the forthcoming planning cycle of the EU Floods Directive, the main measure we would like to implement in the Tordera River Delta is to set back the levees along the final reach of the river. This measure will provide more room for the river, increasing its conveyance capacity and consequently reducing the extent of the flooded area and the economic losses associated to flooding.

Regarding structure of the riparian area, the final reach of the Tordera river has been identified as a heavily modified water body with a deficient morphological quality. We expect the implementation of the NBS will help us to improve the morphological quality of the river reach, meeting the objectives set by the WFD.

The morphological quality of a water body is assessed based on two different elements:

i. structure and substrate of the river bed
ii. structure of the riparian area

What we plan is to improve the structure of the riparian area, by setting back the existing levees and restoring the riparian habitats between them.

Concerning increase of the habitat area (quantity), the final reach of the Tordera River has been designated Natura 2000 site, as natural habitats of community interest haven been identified in the area. In this sense, the implementation of the NBS should help to preserve the state of conservation of this type of habitats.

Finally, reduction of flood risk might result, in the long term, in an increase of economic benefits, as damages and economic losses due to flooding are reduced. Consequently, economic activities in, what it used to be a flood prone area, will be developed more securely.

For the Tordera river demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (6.2, 6.3 and 6.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

Table 6.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DA3

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Flood hazard reduction	Flood hazard	The data required in this case includes rainfall time series, discharge time series, roughness, digital elevation model, control structures, geometry of the channel. The collection method for rainfall data comprise a raster dataset of maximum daily precipitation for a given return period, developed based on the statistical analysis of rainfall time series registered by rainfall gauging stations. For discharge data, the collection is performed through a time series of river gauging stations; while for roughness, vector data of land use and land cover, developed from aerial images and DEM: LIDAR data is used. Regarding control structures, topography data and measurements in the field are used; while for geometry of the channel, data is collected using a DEM modified based on the new geometry of the channel and the NBS defined in the feasibility study. Most of the discharge time series start in 2000 (to present time). However, there are data gaps in some of the series. Besides, the river gauging stations are calibrated to measure ordinary flow discharges, so they may not estimate accurately extraordinary flow discharges associated to flooding events. Except for the river gauging stations, the rest of the datasets have been already processed and are available to download in different public web sites. They cover the entire study area. There are four river gauging stations within the Tordera River Basin, that register flow discharge every five minutes. ACA is responsible for the collection of flow discharge data.	The purpose is to predict water depths and flow velocities after NBS implementation for the 3, 10, 50, 100 and 500-year flood. Also, to have input for 2D hydrodynamic model to predict water depths and flow velocities after NBS implementation for the 3, 10, 50, 100 and 500-year flood. For the base line or reference situation, the flood hazard for the 3, 10, 50, 100 and 500-year flood before the implementation of the NBS are used. The reference situation is simulated using the 2D hydrodynamic model.
	I: Reduction in economic vulnerability	Economic damage cost	Data required includes flow depth for the 3, 10, 50, 100 and 500-year flood (output of the 2D-hydrodynamic model); land use cover data; property value data. The flow depth for different return period floods is obtained as an output of the 2D-hydrodynamic model. For land cover, data available in	The aim is to predict water depths and flow velocities after NBS implementation for the 3, 10, 50, 100 and 500-year flood. Besides, damage costs will be calculated as a function of flow depth, type of land use affected and the estimated value of the land use

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			different public websites is used. Regarding property value data, average values for different land use types and for every municipality are available to download from the land registry website. The datasets are already available to download from different public websites. The most up-to-date data available at the time will be used to assess the indicator. The available datasets cover the entire study area. The data is not expected to change significantly during the monitoring phase of the project.	affected. Damages will be calculated for the 3, 10, 100 and 500-year flood. For the baseline, the economic damage cost before the implementation of the NBS for the 3, 10, 50, 100 and 500-year flood will be calculated. The baseline situation is assessed following the same methodology described for the future scenario (NBS implemented), based on the output of the 2D-hydrodynamic models for the current scenario, the current land use cover data and the current property value data.

Table 6.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DA3

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Structure of the riparian area 	I: Changes in land use in the riparian area	Land use in the riparian area	Data required in this case includes land use cover map (shapefile), and habitat cartography (shapefile). The methodology for data collection comprises digitalization of aerial images using GIS tools, in case that official land use and habitat cartography is not available. The data is qualitative, including outline of land use type (polygon shapefile) and quantitative when land use areas are obtained from the delineated polygons. The starting of data collection is year 2000 for aerial images, 1987 for land use cartography, and 2007 for habitat cartography. The datasets cover the entire study area. The sampling frequency is of every year for aerial images, 5 years for land use cartography (last version available from 2017), and in the case of habitat cartography, there is a first version from 2007, updated in 2018. The responsibles for data collection are the Institut Cartogràfic i Geològic de Catalunya (ICGC) and CREAF for Aerial Images & land use cartography, and Servei de Planificació de l'Entorn Natural for habitat cartography.	The purpose is to define land use in the riparian area The reference/baseline situation is the situation before implementation of the NBS. As this is an indicator used in the WFD monitoring programme, the baseline data is already available. The reference/baseline situation is obtained by delineating the natural, agricultural and urban types of land use in the riparian area and by calculating its percentage in relation to the total extension of the riparian zone.
	I: Changes in the extension, structure and quality of the riparian forest	Quality of the Riparian Forest (QBR)	The QBR is a complex indicator that accounts for different elements and characteristics of the riparian forest: percentage of the riparian area covered with vegetation, lateral connectivity of the riparian ecosystem, complexity of the riparian forest structure, diversity of vegetal species in the riparian forest, naturalness of the river channel. This indicator is used in the WFD monitoring programme. All the data needed for its assessment is collected in the field. The data collection covers the period 2009-2015. The spatial coverage includes the water body, which encompasses the study area. The sampling frequency is once every 6 years. Next monitoring campaign will be conducted between 2019 and 2024. The responsible for data collection is ACA.	The aim is to assess the quality of the riparian forest. The reference/baseline situation is the situation before implementation of the NBS. As this is an indicator used in the WFD monitoring programme, the baseline data is already available. The reference/baseline situation has been already assessed and reported in the two previous planning cycles of the WFD (2009-2015; 2016-2021).

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: Changes in area of natural habitats of community interest	Habitat area	The data required in this case includes a cartography (shapefile) of natural habitats of community interest. The type of data is qualitative: type of natural habitat, and quantitative: area covered. The method for data collection comprises the delineation of habitats based on aerial images and field work. The starting year of data collection is 2007. The spatial sampling covers the entire study area. Data was first collected in 2007 and updated in 2018. However, sampling on-demand, might be an option. The responsible for data collection is Servei de Planificació de l'Espai Natural.	The aim is to define the area covered by natural habitats of community interest. The reference/baseline situation is obtained by calculating the area covered by natural habitats of community interest in the study area before implementation of the NBS.

Table 6.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DA3

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Stimulate/increase economic benefits 	I: Reduction in economic vulnerability	Economic damage cost	This indicator has been already defined in Table 6.2, with relation to the "Flood risk reduction" sub-goal. Please, refer to that Table for further details.	This indicator has been already defined in Table 6.2, with relation to the "Flood risk reduction" sub-goal. Please, refer to that Table for further details.

6.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. In particular the calculated indicators regarding flood hazards and the data from the river gauging stations provided by ACA. For example, Figure 6.1 shows the integration of monitoring water level data at the Montseny station in Tordera River, Spain (DA3) which has already been implemented as part of the ICT platform.

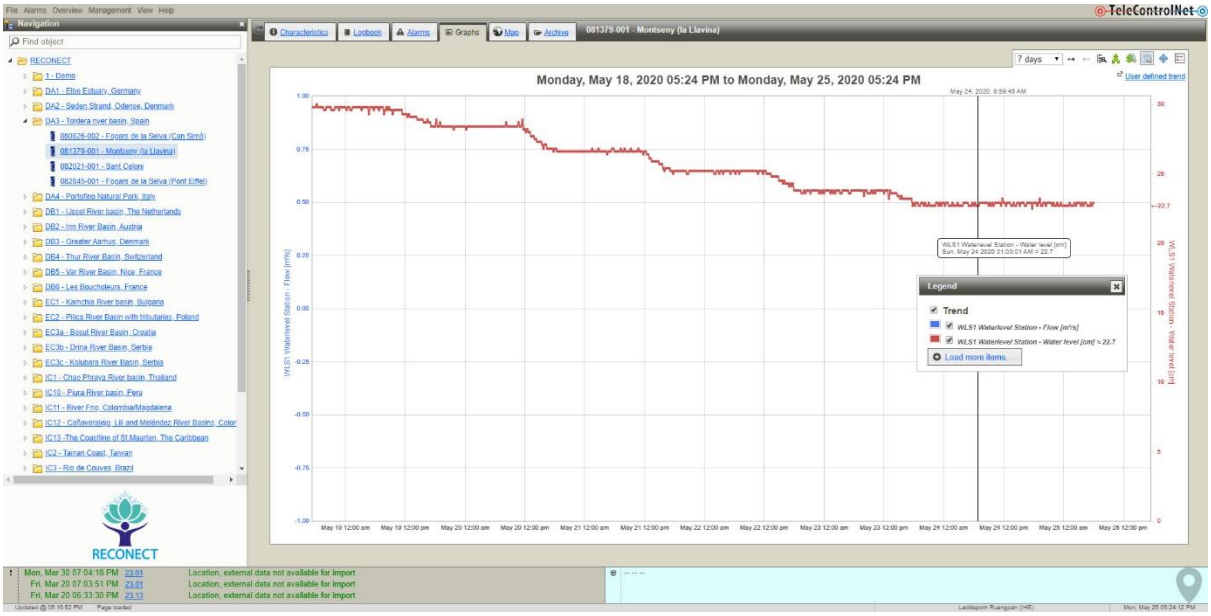

Figure 6.1 Example of monitoring data of water level at Montseny station in Tordera River, Spain (DA3)

The calculated indicators will be displayed in the ICT platform, however the data to assess the indicator will not be accessible through the platform.

6.6 Evaluation plan

Water

- Indicator flood hazard:
    - We will compare the output of the 2D-hydrodynamic model for the current (baseline) and future (NBS) scenarios given different flood events (3, 10, 50, 100 and 500 years return period). In this sense, we will classify flood hazard into three categories (low/medium/high) based on the following hydraulic variables: flow depth (y), flow velocity (v) and the product of the two (v·y).
    - We will calculate the economic damage cost associated to different flood events (3, 10, 50, 100 and 500 years return period), as a function of flow depth, land use type and property/land value for the current (baseline) and future (NBS) scenarios. We will integrate the economic damage cost associated to each flood event (multiplied by its probability of occurrence) throughout the life cycle of the NBS and we will compare the results (present vs future scenario).
    - Flood hazard reduction will be evaluated as the reduction of the area (%) affected by low/medium/high hazard for the different types of land use and

different flood events (e.g. 5% less of agricultural land affected by high flood hazard for the 100-year flood).

Water and People

- Indicator economic damage costs
  - It will be evaluated through a cost-benefit analysis, so we will estimate the economic gain associated to the implementation of the NBS (economic damage cost for the present scenario – economic damage cost for the future scenario – economic cost of NBS implementation > 0).
  - The time scale of analysis for the flood hazard reduction indicator will be that of the flood event.
  - In the case of the economic damage cost indicator, the time scale of analysis will be the life cycle of the NBS.
  - The evaluation will be presented initially to municipalities and key stakeholders.
  - These indicators might be re-evaluated when relevant changes affecting flood hazard and/or damage costs associated to floods will take place in the study area.

Nature

- Indicator Land use in the riparian area
  - To assess the impact "I: Changes in land use in the riparian area" the % of natural, agricultural and urban land use in the riparian area before and after NBS implementation will be compared. Based on these percentages, the quality of the riparian area in terms of naturalness will be assessed, considering three different categories: Less than good; good and very good.

% Land Use	Naturalness of the riparian area			
		Very good	Good	Less than good
	Natural	>= 85	60	< 60
	Agricultural	=< 15	40	> 40
	Urban	0	5	> 5

- Indicator Quality of the riparian forest
  - To assess impact "I: Changes in the extension, structure and quality of the riparian forest", the QBR indicator before and after NBS implementation will be assessed and compared. Five different quality levels will be considered, based on the QBR scoring:

QBR	Quality of the riparian forest
92 – 100	Very good
72 – 92	Good
52 – 72	Not so good
27 – 52	Deficient
0 - 27	Bad

- The quality of the “structure of the riparian area” will be assessed based on the two indicators already described. The target to be met is “good” or “very good” quality. This level could be achieved by scoring “good” or “very good” in the “naturalness of the riparian area (land use)” indicator and “not so good”, “good” or “very good” in the QBR indicator, as shown in the table below:

Naturalness of the riparian area	QBR	Structure of the riparian area
Very good	Very good	Very good
	Good	Good
	Not so good	Good
Good	Very good	Good
	Good	Good

The evaluation will be presented initially to municipalities and key stakeholders.

We will assess the indicators once every 6 years, and until the WFD will be completely implemented. Next monitoring programme will be conducted during the period 2019-2024.

- Indicator Habitat area:
  - To assess the impact “Changes in area of natural habitats of community interest”, we will evaluate the area covered by this type of habitats before and after the NBS implementation, comparing the two values.
  - The sub-goal will be achieved if the area covered by natural habitats of community interest increases or does not decrease after the implementation of the NBS.
  - The indicator will be assessed after the implementation of the NBS. However, as the habitats response to an intervention might take a few years, yearly samplings and evaluations might be considered. In this sense, the evaluation might be carried out periodically, until the impact caused by the NBS has reached a steady state (equilibrium).

The evaluation will be presented initially to municipalities and key stakeholders.

7 Portofino Regional Natural Park, Italy - DA4

7.1 Description of the Study Area

The pilot areas are part of Portofino Park that is located about 20 km East from Genova. The promontory develops in a mountainous territory along the sea, culminating at Monte di Portofino (610 masl). Steep slopes, small catchments and high cliffs are the main morphological features. Slope gradient frequently exceeds 75%.

Land cover is prevalently natural with a concentration of anthropic structures, historical heritages, roads, tourism facilities and houses at the stream's mouths. Dry-stone man-made terraces for agricultural purposes constitute an important human modification present in all the pilot area.

Intense rain event presents a strong spatial variability along the coastal Ligurian zone: in the recent years many flash floods caused high damage often for the concurrent action of flooding and diffuse landslides. The main recent event of this type happened in 2011 in the 5 Terre area. A similar event in 1915 shaped the beach in San Fruttuoso, Site localized in the pilot area. The implementation of the NBS will be crucial in reducing the potential instability of terraced areas, in regenerating wood areas and recovering the highly frequented tracks. More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5.

7.2 Description of the NBS

The Portofino Natural Park is promoting interventions aimed at reducing geo-hazards and vulnerability against climate changes, above all the ones related to extreme rainfall events. The increase of brief and intense rainfall events, as verified analyzing rain gauges data over the last 100 years, tends to foresee a possible growth in flash flood events that, considering the steepness of the slopes and the accumulated loose coarse soil, can determine favorable conditions for triggering increasingly disastrous debris and mud flows. As already happened in the past, the mass movements may affect buildings, infrastructures and cultural heritages and saturate the transport capacity of culverts that are usually present before the streams' mouth.

Therefore, a holistic approach at the basin scale is needed to manage the high hazard in a complex context, where a peculiar geomorphic asset is superimposed by anthropogenic modification, some of which are moving on from more than 1000 years. A basin scale approach is crucial in small mountainous catchments by the seaside and means assessing instability areas, active gravitative processes and the spatial relationships with the stream network and with the risk exposed elements.

Then, in the framework of water quantity goal, landslide risk mitigation is the central sub-goal: shallow landslides, in particular debris/mud flow, are triggered during intense rain events contributing significantly to the flash flooding and then to the risk. NBS are intended to reduce the potential source areas of debris/mud flow, on reducing the availability of potential floating transportation in the stream network, to properly manage running water and to avoid that the eventual solid and floating transportation saturate the transport capacity of culverts. Finally, due to the high yearly number of hikers in the area, proper maintenance interventions are intended to improve footpaths safety and usage.

7.3 Goals and sub-goals addressed by the NBS

Table 7.1 presents the challenge area and defined goals and sub goals for the Italian Demonstrator.

Table 7.1 Challenge area and defined goals and sub goals for the Italian Demonstrator DA1.

Challenge area	Goal	Sub-goal
WATER	Water quantity	A) Landslide risk reduction
NATURE	Habitat structure	B) Increase habitat area (quantity)
	Land cover area	C) Shifts in land use and land cover
	Biodiversity	D) Maintain and enhance biodiversity
PEOPLE	Socio-economics	E) Increase recreational opportunities
		F) Stimulate/increase economic benefits

7.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

The designed NBS is aimed at mitigating the impact of intense rain events on the possible instable areas and reducing the direct and indirect consequent effects of flash flood and debris/mud flow: shallow landslides may affect directly buildings, infrastructures and cultural heritages, but they can even saturate the transport capacity of culverts at the streams' mouth causing flooding and damages. Therefore, several small interventions at basin scale have been designed in order to: improve stability of possible source of debris /mud flow that, in the study area.

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At the edge of restored paths and watercourses subject to intervention, areas suitable for hygrophilous habitats and new ecological niches can be created (order of magnitude square meters). The stopping of erosion phenomena along the slopes, caused by the abandonment of terraces, can encourage the resumption of agricultural activities with the formation of new ecological niches, while generating an improvement in the landscape.

Improving conditions, consolidation and maintenance of trails will increase the general safety conditions and practicability with possible positive effects on hikers frequentation (number of visitors) and the increase safety of visitors to the San Fruttuoso Abbey and decrease possible damage to the Abbey itself.

For the Italian Portofino park demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (7.2, 7.3 and 7.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

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Table 7.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DA4

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Landslide risk reduction	I: decrease landslide risk	Landslide hazard	To determine the indicator a detail digital elevation model is required. This is not yeat available and it will be done as part of RECONECT. LIDAR data analysis allows to precisely detect abandoned terraced areas and assess their volume. The data collection will cover the entire Park territory. The initial data survey will be done in February 2020. A second survey will be performed by the end of the project. The data collection will be conducted by EUROSENSE in coordination with Italian partners. Rainfall time series are needed to assess the possible precipitation threshold level to activate shallow landslides. This data is not available and 3 rain gauges and 2 hydrologic monitoring stations will be installed in the study area as part of RECONECT. Data will be collected starting in February 2020, data will be sample every minute. The Portofino park authority is responsible for the data collection.	Potential slope instability areas before the implementation of NBS. The reference situation is assessed through LIDAR data analysis.
WATER	I: Reduction of the inundation time / Flood hazard reduction	Floating transport in hydrographical network	To assess this indicator data related to Orthophotography and IR is needed to evaluate vegetation conditions. This information is not available in the area and will be collected as part of RECONECT. The Remote sensing data will be collected on the entire Park surface. Two surveys are expected, one at the beginning and the second after the NBS implementation. The initial data survey will be done in February 2020. The data collection will be conducted by EUROSENSE in coordination with Italian partners. Direct survey to quantify the presence of dead trees along the hydrological network. This information is not available in the area and will be collected as part of RECONECT. Direct survey data will be collected along the main streams in the pilot catchments. Two surveys are expected, one at the beginning and the second after the NBS implementation. Direct survey in spring 2020 (due to actual COVID-19 crisis). The data collection will be conducted by CNR-IRPI	Potential dead trees available as floating transportation in the stream before the implementation of NBS. The reference situation is assessed through direct survey and Orthophoto and IR photo data analysis.

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
	I: Economical savings from operating the pumping stations	Vulnerability	To assess the elements/objects expose and vulnerable to the potential risks data regarding land use, roads, buildings/cultural heritage and tourist's presence in the park area is needed. The Analysis will be done with 2018 land use data and control with orthophotography. The presence of tourist is reported yearly and is done directly in 8 access (footpath) monitoring points. For the other data, two surveys are expected, one at the beginning (2018) and the second after the NBS implementation. The data collection will be conducted by the Regione Liguria Authority and the park authority.	The reference situation is assessed through vulnerable elements data. Before and after the implementation of NBS.

Table 7.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DA4

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: increase in riparian habitat U: disturbance of species and alteration of microhabitats at the intervention stage	Habitat area	The determination of the Initial surfaces of the habitat patches that will be expanded is needed. For this purpose spatial GIS analysis (structural classification of terrestrial and aquatic habitats based on aerial images and field survey): data made available by the Park, already collected for other environmental studies. The data will be collected at the 2 intervention areas in Portofino Regional Natural Park. The frequency will be at least 1 time, after the interventions, since the data before the NBS have been collected quite recently. Check: for the specific project purpose every 5-7 years would be advisable. The data collection will start in 2018/06. The Portofino Regional Natural Park is responsible for data collection.	The reference/baseline situation is obtained by field survey before the NBS implementation. Not available yet
Shifts in land use and land cover 	I: resumption of agricultural activities and creation of new ecological niches	Land cover area	To assess the indicator, land cover type and area (square meters) need to be determined. This will be done by using regional land cover Maps; aerial images, and field surveys covering the areas of the small pilot areas in San Fruttuoso and Valle dei Mulini, including stream courses and terraced areas. This will be done 2 times: before and after; check advisable every 5 years. This data collection will start in 2020. The Portofino Regional Natural Park is responsible for data collection.	The reference/baseline situation is obtained by aerial images and field survey before the NBS implementation. Not available yet
Maintain and enhance biodiversity 	I: Increase in selected species (rare, protected)	Species richness and composition	Field surveys to do species count data. The data collection can be Qualitative (incidence data: species presence- absence) and quantitative (abundance data of each species). The following methods can be applied: <u>Direct observation</u> a) phytosociological reliefs; use of square samples survey (plants); b) Point- and mapping count (number of breeding and resting species and individuals observed from monitoring points/transects per plot) - birds d) random search of individuals, eggs and larvae (number of species) - amphibians c) Random search and registration of observed animals, their footprints, excrements and traces. (number of species) The field surveys covering the areas of the small pilot areas in San Fruttuoso and Valle dei Mulini, including stream courses and terraced areas. This will be done 2 times: before and	The reference/baseline situation is obtained by aerial images and field survey before the NBS implementation. Not available yet

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			after; check advisable every 5 years. This data collection will start in 2020. The Portofino Regional Natural Park is responsible for data collection.	

Table 7.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DA4

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase in recreational opportunities	I: Improve safety conditions and practicability of trails I the NBS area.	Number of people that visit or spend time in the NBS area.	Counting the number of visitors by the installation of 8 people counters in crucial points of the Park. Counters are working from the year 2009 and time series are available. The data is recorded continuously and is available since 2009. The Portofino Regional Natural Park is responsible for data collection.	Obtained by estimating the number of visitors before NBS implementation. Partially available.
Stimulate/increase economic benefits.	I: Improve safety of tourists and of the Abbey itself.	Damage to tourist facilities and infrastructure (and number of visitors) Loss of cultural heritage.	Assessing the landslide risk reduction and the number of visitors accessing the cultural heritage. The required data include the llandslide hazard and Floating transport in hydrographical network as indicators in sub goal A) landslide risk reduction and then the cultural heritage, tourist facilities and infrastructure locations, for the pilot areas San Fruttuoso and Valle dei Mulini. The number of visitors at the Abbey. The data collection is punctual and the frequency is continues with daily resolution. The data collection can start in 2020, after the impact of COVID-19 emergency, otherwise data are affected by the restrictions. The Portofino Regional Natural Park is responsible for data collection.	Obtained by estimating the number of visitors before NBS implementation. Partially available.

7.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. Figure 7.1 shows the integration of monitoring weather data Mulini Sam Fruttuoso station, Portofino, Italy (DA4) which has already been implemented as part of the ICT platform.

Figure 7.1 Example of monitoring weather data at Mulini Sam Fruttuoso station, Portofino, Italy (DA4)

Other data that will be captures during the project life span will be made available, for instance the aerial photographs and digital elevation model captured by Eurosense among other data. The Park authority is mostly responsible for data collection and coordination.

7.6 Evaluation plan

Water

Indicator Landslide hazard:

- The high detail DTM analysis comparison will allow to assess morphometric changes, while the precise terraces detection obtained through the reference analysis allow to evaluate the ones to be maintained.
- Even if there is no specific target value, maintenance of terraces reduces the source o possible landslide hazard. Besides, any effect of morphological changes related to slope instability should be mitigated through the spread small interventions at catchment scale, as the ones along the streams.

Indicator Floating transport into the main streams:

- The comparison between survey data before and after will allow to assess the quantity of available floating elements, and then the effectiveness of adopted interventions.

- No specific target is assumed, but the reduction of available floating elements will reduce the hazard.

Indicator Vulnerability:

- The comparison of data before and after will allow to evaluate the eventual change in vulnerability.
- No specific target is assumed and due to the peculiar context, the only possibility in reducing vulnerability is through improving risk consciousness both in residents and people involved in tourist activities and in tourists themselves.

- Time scale: throughout the project life a reduction of landslide hazard and presence of floating transport elements is expected. Reducing vulnerability through raising consciousness is a long-time process that probably will last over RECONECT.
- Some indicators have been collected in order to assess the general situation in terms of landslide hazard and exposed elements, and to point out critical situations. Due to the approach followed in NBS designing, that is small interventions at catchment scale, results must be interpreted in the same way. Then, even indicators follow the same rule and should describe the situation of the pilot areas as a whole. This is particularly true considering the possible direct effect of debris/mud flow on exposed elements and their potential action of saturating culverts transport capacity. Remote sensing data are crucial in identifying areas susceptible as source of debris/mud flow and the related indicator must be interpreted in conjunction with the one related to floating transportation. Then, precipitations monitoring have a critical role in identifying the possible threshold levels for shallow landslides triggering. Therefore, the indicators concur in the holistic approach at catchment scale to mitigate the geo-hydrological risk.
- The evaluation will be carried on after RECONECT project end, if proper resources will be found. It should be performed after every important modification that should occur in the area, and particularly after geo-hydrological events.

Nature

Indicator – Habitat Area
The assessed indicator will allow the comparison between the situation in 2018 (baseline) and the one after the implementation of NBS (using GIS operations and expert surveys) by assessing changes in the extent of the different habitats.

If the size of the habitats after NBS is wider, it can be assumed that the objective has been achieved. There is no predetermined amount of change (target) that needs to be met.

The indicator applies to a time scale of at least five years.

The evaluation will be presented to the following stakeholders: Portofino Park, Portofino and Santa Margherita Municipalities, Regione Liguria.

The evaluation will be carried out once, after the implementation of the NBS.
The observations will be made before the NBS and at the end of the project; then after 5 years from the start of the project it would be advisable to make a new survey.

Indicator - Land use/land cover

The assessed indicator will measure the extent of agricultural land with olive groves or other crops in good condition before and after NBS using GIS operation, aerial photos and surveys.

If agricultural land with olive groves or other crops will be increased after NBS, it can be assumed that the objective has been achieved. There is no predetermined amount of change (target) to be achieved.

The indicator should be applied on a time scale of at least ten years.
The evaluation will be presented to the following stakeholders: Portofino Park, Portofino and Santa Margherita Municipalities, Regione Liguria.

The evaluation will be carried out twice, before and after the implementation of the NBS.
The data collection will be done before the NBS and at the end of the project.

A plan for the evaluation after the RECONECT project has to be decided, but it would be advisable to carry out a new survey every five years after the end of the project.

It will be checked whether it is possible to compare the results with similar ones in terms of size/character.

Indicator - Species richness and composition

The indicator will assess the change in richness and specific structure of sample areas, before and after NBS.

In order to collect data, monitoring will be carried out before and, at least, two years after the end of the interventions.

If more selected species (local/national interest) are found or if a better structure is assessed, the interventions will be positively defined.

There is no predetermined amount of change (target) to be achieved.
Stakeholders include the Portofino Regional Park, citizens, naturalists.
The evaluation will cover a period of at least 4 years: 2020 / 2021, before the implementation of the NBS where data are collected for the first time and, to obtain meaningful data, at least 2 years after the end of the project.

A plan for the evaluation after the RECONECT project has to be decided, but it would be highly desirable.

People

Indicator - Number of people that visit or spend time in the NBS area

To assess the impact “Improve safety conditions and practicability of trails in the NBS area” the number of visitors, obtained from the monitoring in the NBS area, will be compared to estimate eventual modifications from years prior to the NBS implementation.
If the number of visitors, together with the improvement of safety and practicability of trails have increased, it will be concluded that the interventions would have contributed to a

possible positive effect. Many other variables could anyway affect the result, due to the high frequentation of the area. There is no predetermined amount of change (target) that needs to be met.

The possible effects should be considered for at least 5 years, but possibly more, as in the past the hikers frequentation has been substantially constant, and many variables could affect the practicability.

The evaluation will be submitted to the stakeholders: majors and policy makers in the area, together with: open air sport associations, environmental associations, tourist facilities personnel.

The monitoring should be performed over the end of RECONECT project, if proper economic resources could be found.

Indicator - Loss of cultural heritage due to hydro-meteorological events

To assess the impact “Improve safety of tourists and of the Abbey itself” the number of visitors, obtained from the entrance to the Abbey, will be compared to estimate eventual modifications from years prior to the NBS implementation together with the evaluation of the risk reduction obtained through the NBS implementation.

The number of visitors is essential because of the economic income they ensure to the Abbey management that is mainly used for restoration and conservation activities. Then the evaluation plan will be referred to the sub-goal 6- increase recreational opportunities.
Many other variables could affect the eventual growth in visitor numbers, due to the high frequentation of the area, but improving safety both for tourists and for the cultural heritage itself is not depending on the eventual rise in visitors’ number.

The possible effects should be considered for at least 5 years, but possibly more.
The evaluation will be submitted to the stakeholders: majors and policy makers in the area, together with: open air sport associations, environmental associations, and tourist facilities personnel.

The monitoring should be performed over the end of RECONECT project, if proper economic resources could be found.

8 IJssel River Basin, The Netherlands DB1

8.1 Description of the Study Area

The Ijssel river is a tributary of the Rhine river and has a length of about 125 km. The floodplains of the Ijssel have been in human use for several millennia and dyke construction started at about the year 1200. Land use mainly consists of agricultural activities such as meadows, farmlands and (production) forest, and some farms.

The IJssel River basin project ('Stroomlijn") is implemented under the banner of the 'Room for the River' Programme. The IJssel river is a tributary of the Rhine river and has a length of about 125 km. In 1993 and 1995, floods threatened to devastate surrounding regions of the delta. With ongoing climate change and yearly river floods, sediment is distributed throughout the floodplain, reducing the space that was initially allowed for annual floods.
The main goal of the Dutch Room for the River Program is to give the river more room to manage higher water levels. At more than 30 locations, measures are taken to give the river space to flood safely while at the same time improve the quality of the immediate surroundings. But if the water flows into the floodplains, vegetation can impede the water flow, leading to a raise in water levels and an increase of the flood risk.

8.2 Description of the NBS

The Programma Stroomlijn 'IJssel' is a sub-programme for Room for the river and was aimed at the removal of vegetation (forest, shrubs) which forms a barrier for the discharge of river water. If the water flows into the floodplains, vegetation can impede the water flow, leading to a raise in water levels and an increase of the flood risk. In project 'Stroomlijn' vegetation types are removed / maintained at the river floodplains, and transformed into vegetation types that allow for better water discharge and result in reduced maintenance costs. The project consists of roughly 300 ha of vegetation in a stretch of approximately 130 km's of river, over 350 owners, and 17 local authorities.
The figure below illustrates how vegetation is removed to decrease barriers for the discharge of the river.

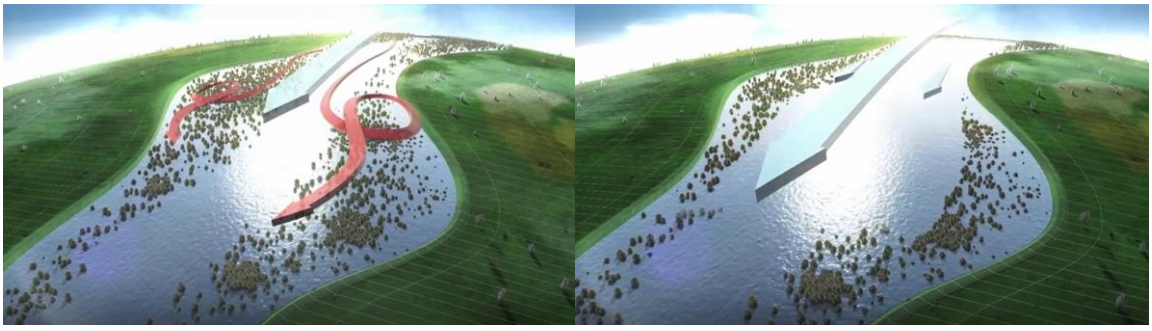


Figure 8.1 Room for the River Ijssel Project.

The last execution of works on the Stroomlijn project took place in February of 2018. The monitoring of the implementation progress took place from February 2015 – August 2018, which included checking whether vegetation was removed properly through drones and photographs before and after the works.

Redevelopment of the vegetation was not monitored, and it is still unclear if Rijkswaterstaat (commissioner) has monitored any results. Within the RECONECT project (which started in 2018), several indicators and evaluation methods are chosen for the evaluation process.

In December 2018, the discharge and floodplain is measured on a plot scale (250 m by 300 m) southwest of Herxen in the IJssel. These measurements will be considered part of the evaluation of the sub-goal Flood risk reduction.

8.3 Goals and sub-goals addressed by the NBS

Table 8.1 presents the challenge area and defined goals and sub goals for the Dutch Demonstrator.

Table 8.1 Challenge area and defined goals and sub goals for the Dutch Demonstrator DB1.

Challenge area	Goal	Sub-goal
WATER	Water quantity	A) Flood risk reduction
NATURE	Habitat structure	B) Shifts in land use and land cover
	Biodiversity	C). To maintain and enhance biodiversity
PEOPLE	Socio-economics	D) Stimulate/increase economic benefits

8.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

Vegetation can form a barrier for the discharge of river water by impeding the water flow which leads to a raise in water levels and thus to increased flood risk. The removal of vegetation (or transformation of vegetation that allows for better discharge) in the IJssel river allows for better water discharge and thus reducing flood risk, which was the main goal of the Stroomlijn project.

The implementation of the NBS (Stroomlijn “vegetation removal” project) has also resulted in changes in the land use and land cover area. The NBS has changed part of the land cover from mainly forest and shrub area to grass- and farmland, because around 30% of the vegetation had been either removed or converted into grass-/farmland. In another 30% the forest is crowned and thicket/shrubs is removed from the reeds, thus forming mainly riverbanks covered with reeds.

The aim of the Stroomlijn project was also to leave a good landscape in its entirety after all the activities, also considering protected plant- and animal species. That is why around 40% of the total area is mainly retained due to ecological restrictions, which may lead to an influence on the number and type of protected species in the project area.

Because the main goal of the Stroomlijn project was to remove vegetation to allow for better water discharge, the implementation of this NBS also caused an unintended (yet potentially positive) impact on biodiversity.

In project 'Stroomlijn' vegetation types were removed/maintained at the river floodplains, and transformed into vegetation types that allow for better water discharge and reduce maintenance costs. The project affected the landscape and land use type along the rivers. In general this should have resulted in lower maintenance cost for land owners. Additionally, as mostly higher vegetation types were replaced by grasslands, the value of the land increased as it could be used by farmers for grazing cattle.

For the IJssel River Basin demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (8.2, 8.3 and 8.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

Table 8.2 Defined Indicators for the Water Challenge component of the RECOECNT NBS implementation and monitoring in DB1

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Reduction of the inundation time / Flood hazard reduction	Flood hazard	1D-2D hydrodynamic model (for example SOBEK) is required to predict the water discharge before and after the implementation of NBS. Quantitative data (including rainfall time series, discharge time series, water level time series, roughness coefficient, vegetation data, digital elevation model, control structures, channel cross section (flood plains), flow velocity) will be used as input for hydrodynamic model to predict water depths and flow velocities, and find relationships between vegetation and discharge. Rainfall and discharge/water depth data are continuously measured at weather and hydrological stations close to the Stroomlijn project. Vegetation coverage in IJssel can be measured through visuals inspections, drones (twice) and satellite data as been applied in the RECONECT project. Rijkswaterstaat, KNMI and Tauw are responsible for data collection.	Baseline of the river IJssel, as part of Room for the river, started in 2006, before implementation of the NBS. Measures have been implemented in the years after and monitored until the start of RECONECT in 2018 and continue during the project connected to the maintenance phase.

Table 8.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DB1

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Shifts in land use and land cover 	I: Changes in land use and land cover	Land cover area	Land cover type and area data are obtained two times before (2006) and after (2021) NBS implementation, through spatial GIS analysis with the use of aerial images and a field verification. Spatial coverage is about 350 ha of the Stroomlijn project (or designated areas where data is readily available). The exact method is still being developed. Data partly available and partly collected by Tauw.	The reference/baseline situation is already obtained based on aerial images before the NBS implementation.
Maintain and enhance biodiversity 	U: Maintain number and type of protected species	Number and type of protected animal species	One field survey for collecting animal species count data by ecologists combined with desk study will take place after the NBS implementation at the sub-areas of the Stroomlijn project. The data before NBS implementation is available. Tauw is responsible for data collection.	The reference/baseline situation is obtained by a desk study of the available data8 from the sub-areas of the Stroomlijn project.

Table 8.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DB1

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Stimulate/increase economic benefits	I: Reduced maintenance cost	Maintenance and management cost of NBS	Twice desk studies at Sub-areas of the Stroomlijn project on available data about maintenance cost of land within the NBS project. The desk study will start in 2020. Tauw is responsible for data collection.	The reference/baseline situation is obtained by a desk study of the available data on maintenance cost of land from the sub-areas of the Stroomlijn project.
	U: Increase of land value	Land and/or property values	Twice desk studies at Sub-areas of the Stroomlijn project on available data about land prices before and after NBS implementation. The desk study will start in 2020. Tauw is responsible for data collection.	The reference/baseline situation is obtained by a desk study of the available data from the sub-areas of the Stroomlijn project.

8.5 Integration with RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. Figure 8.2 shows the integration of historical monitoring water level data at Deventer station in the Ijssel River, the Netherlands (DB1) which has already been implemented as part of the ICT platform.

Figure 8.2 Example of historical monitoring data of water level at Deventer station in Ijssel River, the Netherlands (DB1)

Other data that will be captures during RECONECT will be made available, In particular the calculated indicators, however the data to assess them will not be available in the ICT platform. Tauw is mostly responsible for data collection and coordination.

8.6 Evaluation plan

Water

Indicator – Flood Hazard
Flood hazard assessment on a micro (local) scale (study area in Herxen) will be undertaken using a 1D/2D hydrodynamic model (SOBEK for example). The parameters for this model will include vegetation data obtained before and after the NBS implementation.

Flood risk reduction is achieved when the flood hazard has been reduced after the implementation of the NBS under the same circumstances (discharge, rainfall, etc.).
Collecting the (available) data from relevant sources will take place up until 2021 and the evaluation will be carried out once after data analysis.

The evaluation results will be shared with the RECONECT partners and Rijkswaterstaat (commissioner of Stroomlijn project).

Nature

Indicator Land Cover Area

Shifts in land use and land cover will be evaluated by assessing the changes in land cover in terms of area and patterns (land use) before the implementation of the NBS (baseline) to situation after the NBS implementation. There is no goal in terms of the amount of land cover change over time, but the sub-goal “shifts in land use and land cover” is met when changes in terms of area and pattern occur.

The evaluation will be presented to Rijkswaterstaat (commissioner of the Stroomlijn project).

The evaluation will be carried out once within the RECONECT project. There is no plan on evaluation after the RECONECT project is finished.

Indicator number and type of protected animal species

The assessed indicator (number and type of protected species) will be compared to the baseline before the creation of the NBS.
The evaluation will answer the following question: How has biodiversity of the area changed over time?
Specific targets for the number and type of protected species are not defined (yet).
The evaluation will be presented to Rijkswaterstaat (the commissioner of the project).
The evaluation will cover a period from 2006 start of Room for the river up to 2020 and will be done once during the RECONECT project. There is no plan for the evaluation after the RECONECT project.

People

Indicator Maintenance and management cost of NBS

The assessed indicator “maintenance and management cost of NBS” will be compared to the cost of maintenance of the IJssel river in terms of dredging. Additionally, the changes in price of land before and after the NBS implementation will be analysed.

The evaluation will answer the following question:
- Has the NBS stimulated economic benefits in terms of maintenance cost of the IJssel river?
- How has the land values changed after the implementation of the NBS?

There is no specific target of the reduced amount of maintenance cost or the changes of the land values.

The evaluation will be presented to Rijkswaterstaat (the commissioner of the project) and will cover a period of approximately 15 years (2006 start of Room for the river up to 2018 at the end of implementation).

The evaluation will be done once during the RECONECT project. There is no plan for the evaluation after the RECONECT project.

9 Inn River Basin, Austria DB2

9.1 Description of the Study Area

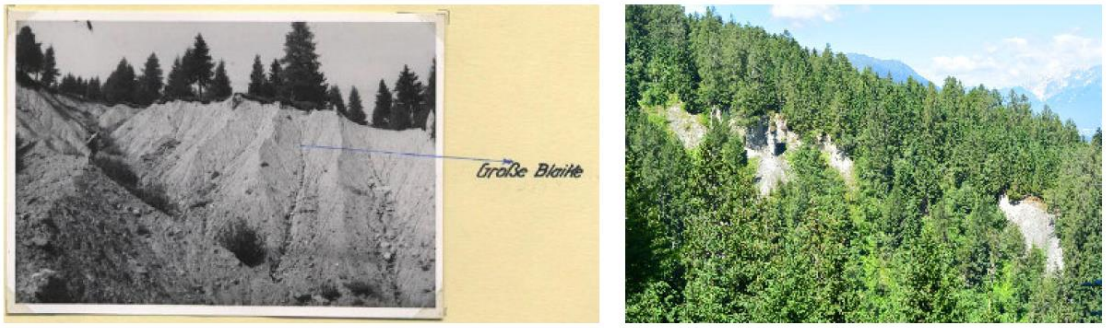
The catchment is located near Innsbruck, Austria, in south-west direction. The overall catchment comprises of the torrential catchments located upstream the municipality of Götzens. From there, the creek is flowing further downstream and contributes to the River Inn which has a catchment area of ~5700 km2 at this location.

The torrential catchment faces (as typical for such type of catchments), convective precipitation events leading to high discharges associated with sediment transport. Downstream of the torrential part, the interactions with the urban sub catchments are the case. Flooding as well as confluence situations result in critical situations and are subject of the investigation. More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5

9.2 Description of the NBS

Focus in this case study is on the upstream part of the Geroldsbach until it reaches Götzens dealing with the interaction of urban and torrential features in alpine environment. This Demonstrator Type B catchment comprises different types of NBS being installed in the torrent since the early 1950ies. The NBS installed over the last decades included:

- Afforestation of high-altitude areas
- Buffer strips and hedges along water courses
- Slope stabilization by means of greening
- Protection forest management



(a) Blaike before 1950 (Stern and Markart, 2010). (b) Blaike june 2017.

Figure 9.1 The catchment, comprises different types of NBS being installed in the torrent. (a) Blaike area, situated in the eastern part of the catchment, before 1950 and (b) Blaike area in 2017

Runoff processes and benefits of long-term NBS are evaluated and demonstrated utilizing a combination of an innovative monitoring technology and modelling approaches. A measurement program is set up for artificial rainfall tests in the Geroldsbach-Götzens catchment to understand runoff behaviour and the benefits of NBS. In addition, climate and land-use scenarios are modelled.

9.3 Goals and sub-goals addressed by the NBS

Table 9.1 presents the challenge area and defined goals and sub goals for the Austrian Demonstrator.

Table 9.1 Challenge area and defined goals and sub goals for the Austrian Demonstrator DB2.

Challenge area	Goal (Select Goals from the "RECONECT Indicator Selection Tool")	Sub-goal (Select Sub-goals from the "RECONECT Indicator Selection Tool")
	Water quantity	A) Flood risk reduction
	Water quantity	B) Landslide risk reduction
	Habitat structure	C) Increase habitat area (quantity)
	Habitat structure	D) Habitat provision and distribution (quality)
	Habitat structure	E) Shifts in land use and land cover
	Biodiversity	F) To maintain and enhance biodiversity
	Socio-economics	G) Increase recreational opportunities
	Socio-economics	H) Stimulate/increase economic benefits

9.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

As NBS, afforestation in the catchment Geroldsbach-Götzens was installed in the torrent since the early 1950ies. One of the main purposes are to reduce the risk of future flooding by handling excess surface waters during extreme events, leading to reduced flood extents. In addition to a reduced risk of flooding, was to reduce the risk of landslides by stabilizing the slopes by means of greening.

The NBS implementation could result in an enlargement of habitat area, shifts in land use and land cover, an increase of biodiversity in the area and an enhancement of recreational opportunities and attractiveness. In this context, we as well evaluate the development of the economic values given in that area.

Habitat provision is a regulating ecosystem service for maintaining populations and habitats and refers to the direct and indirect benefits people obtain from those habitats. Since the implementation of NBS, an evolution can be observed of forest age and distribution.

Land cover indicates the physical land type such as forests, wetlands, impervious surfaces, agriculture, and other land and water types. Land cover change documents how much the different land types for a region, is changed over time. This can be determined

by analysing satellite and aerial imagery, which provides information to understand the current landscape and to see changes over time.

Land cover change gives information on the trend in area of several ecosystems through the trend in extent of related land cover. Land cover change is used to determine NBS development over time such as afforestation.

For the Inn River Basin demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (9.2, 9.3 and 9.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

Table 9.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DB2

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Reduction of surface runoff	Surface runoff reduction	The monitoring procedure is primarily related to the plot scale, assessing the surface runoff generation. Monitoring includes rainfall runoff experiments (plot scale) in the catchments, including permanent installation. The installations are planned to be used to continuously monitor meteorological parameters as well as resulting surface runoff throughout the year. Runoff is planned to be as well measured in side-tributaries to clearly locate the source of flows. Consequently, the foreseen monitoring consists of: • Artificial irrigation (torrential / urban) with runoff measurement at plot scale • Meteorological monitoring (rainfall, temperature, humidity) • Spatially distributed soil moisture sensors at the test plots and in the catchment The hydrological model on plot scale (e.g. Zemokost and WasimETH) to quantify surface runoff and to simulate different scenarios is not yet available. Data are collected since July 2019. Weather data and runoff measurements are sampled every 5 minutes. Continuous monitoring and artificial rainfall runoff tests at plot scale to evaluate runoff processes and the estimation of runoff coefficients. University of Innsbruck and Subcontractor BFW are Responsible for data collection	The surface runoff is tested under different conditions at the plot to better understand the influence of e.g. vegetation and soil conditions on runoff behaviour. The reference situation, before implementation of the NBS, is 1950‘s when the afforestation started. Land cover changes are based on historical aerial imagery and simulated using a hydrological model. Not available yet (obtained in the RECONECT project).
	I: Slowing and storing runoff	Slowing and storing runoff	Friction estimates of land cover types such as grass and forest to assess roughness coefficients for hydrological modelling. Same data is used as 2.1.1 (surface runoff reduction) that is obtained from artificial rainfall runoff tests at plot scale.	Surface runoff and roughness coefficients are evaluated under different conditions at the plot to better understand the influence of vegetation and soil conditions on slowing and storing of runoff.

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			University of Innsbruck and Subcontractor BFW are responsible for data collection	The reference situation, before implementation of the NBS, is 1950‘s when the afforestation started. Roughness coefficient are evaluated at plot scale for different land-uses within the catchment. The resulting coefficients for typical land-uses can be used for the baseline land-use situation when implementation of the NBS started. Not available yet (obtained in the RECONECT project).
	I: Reduction of flood impact	Flood hazard	The catchment Geroldsbach-Götzens is used as a lead catchment, being typical for numerous Alpine catchments with interacting urban and torrential features. In the Geroldsbach-Götzens catchment, the torrential catchment as well as the urban catchment are assessed regarding runoff processes linked to various land use options. Results from the plot scale serve as input for generalizing and upscaling of the findings to catchment scale. Beyond realizing historic and current situations exclusively, land use scenarios for assessing the change over time and potential future land-use scenarios and climate scenarios are to be modelled. University of Innsbruck, Subcontractor BOKU-MET (for downscaled climate projections) are responsible.	Beyond realizing historic and current situations exclusively, land use scenarios for assessing the change over time and potential future land-use scenarios and climate scenarios are to be modelled. The reference situation, before implementation of the NBS, is 1950‘s when the afforestation started. Land cover changes are based on historical aerial imagery and simulated using a hydrological model. Not available yet (to be obtained in the RECONECT project).
Landslide risk reduction 	I: Reduction of the landslide risk	Landslide hazard	Literature-based assessment based on land-use change and corresponding risk of landslides. No own measurements are foreseen. Spatial coverage limited to afforestation site and report/assessments made by stakeholders. The start time is after implementation of NBS (1950’s). UIBK (together with stakeholder WLV) are responsible.	The reference situation, before implementation of the NBS, is 1950‘s when the afforestation started.

Table 9.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DB2

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity)	I: Changes in habitat sizes	Habitat area	Literature-based assessment by experts based on land-use and cover changes (reforestation). It is case specific and the land-use areas are evaluated for today's situation and as well as for the historic situation based on aerial maps. Typical habitats found can be assessed from literature. This assessment is based on results from indicator 6.1.1 Land cover. UIBK and subcontractor BWF are responsible.	The reference situation, before implementation of the NBS, is 1950's when the afforestation started.
Habitat provision and distribution (quality)	I: Changes in habitat boundaries	Location of habitat boundaries	Literature-based assessment based on land-use change and potential assessment of forest age from historic maps. The data is evaluations from above (habitat area bases on GIS analysis) with literature on species for different land-uses. UIBK and BWF are responsible.	The reference situation, before implementation of the NBS, is 1950's when the afforestation started.
Shifts in land use and land cover	I: Changes in land cover	Land cover	Land cover indicates the physical land type such as forests, wetlands, impervious surfaces, agriculture, and other land and water types. Land cover change documents how much the different land types for a region, is changed over time. This can be determined by analysing satellite and aerial imagery, which provides information to understand the current landscape and to see changes over time. The sampling frequency depends on available aerial photographs. UIBK together with subcontractor BFW (support by partner EUROSENSE for data processing) are responsible for data collection.	Since the first implementation of NBS in the 1950ies
To maintain and enhance biodiversity	I: Increase in biodiversity of flora and fauna	Species richness and composition	Attribution of typical development of natural species (density and type) may be based on literature review of potentially existing studies; field assessment (trading-space-for-time) Experts and literature research of earlier studies carried out in the catchment with focus on nature. UIBK is responsible for data collection.	

Table 9.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DB2

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase recreational opportunities 	I: Changes in attractiveness of the NBS area	Recreational quality of the area (including number of people that visit or spend time in the NBS area)	Data (including statistical data on climate, water, nature, infrastructure, socio-demographic data of people, number of overnight stays, etc.) are collected from existing statistical data of the area (e.g. socio-demographic data, GIS data, etc.) and by getting in contact with key stakeholders and experts. No site-specific own data assessment is planned. Data should be collected for different periods e.g. 10, 20 and 30 years ago (depending on available statistical data). UIBK is responsible for data collection and DTU is responsible for evaluation.	Reference situation (1950's) difficult to compare, because of this rather old NBS not many data can be found for this situation. Aim is to use as baseline situation the earliest period when data is available.
Stimulate/increase economic benefits 	I: Increase of property value and building prices	Damage costs and building prices	Qualitative assessment by experts based on existing flooding zones and statistical parcel and building prices. Statistical data (public available on government level) are available. UIBK and DTU are responsible for data collection.	Reference situation (1950's) difficult to compare, because of this rather old NBS not many data can be found for this situation. Aim is to use as baseline situation the earliest period when data is available.

9.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. Figure 9.2 shows the integration of monitoring weather data Precipitation and Temperature) at the Inn River, in Austria (DB2) which has already been implemented as part of the ICT platform.

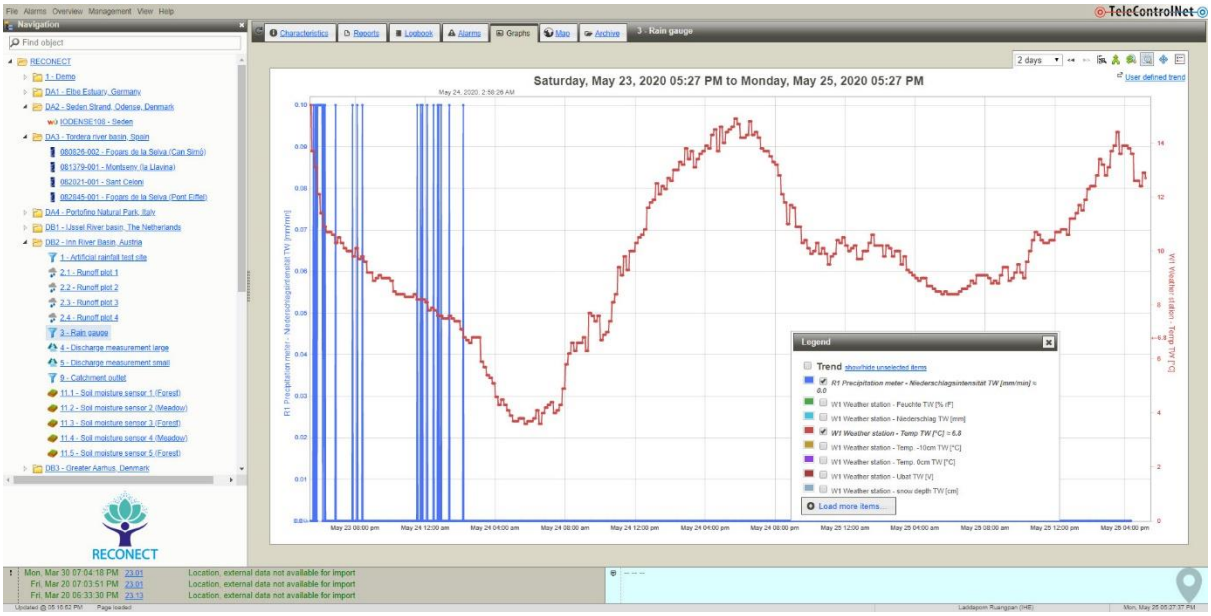


Figure 9.2 Example of monitoring data of Precipitation and Temperature for Inn river basin, Austria (DB2)

Other data that will be captured during RECONECT will be made available, such as measures runoff flows. The University of Innsbruck is mostly responsible for data collection and coordination.

9.6 Evaluation plan

Water

Indicator Surface runoff reduction and flood hazard

Runoff processes and benefits of long-term NBS are evaluated and demonstrated utilizing a combination of an innovative monitoring technology and modelling approaches. A measurement program is set up for artificial rainfall tests in the Geroldsbach-Götzens catchment.

Core of the measurement program is an artificial rainfall runoff test site at plot scale. Three additional rainfall runoff plots will be constructed to test different scenarios under different conditions. The four plots in total can be used to evaluate the different indicators such as the reduction, slowing and storing runoff. At a later stage the artificial rainfall test can also be moved to other locations within the catchment to analyse the different land cover types

and the effect of NBS. Eventually measurements obtained from the rainfall runoff test site serve as input for hydrological modelling.

With the information from the plot scale, a hydrological model of the catchment can be parametrized to evaluate the impact of the NBS on the flood risk. For this also measurements of the runoff at the catchment outlet need to be installed. With means of hydrological modelling different land-use scenarios (before and after NBS implementation) can be tested as well as the potential of NBS to mitigate climate change effects.

As NBS, afforestation in the catchment Geroldsbach-Götzens was installed in the torrent since the early 1950ies (Figure 5). Historic data sets and the evolution of forested and vegetated area are evaluated. Similar urban extends are evaluated for past situations. Both rely on series of aerial photogrammetry being earliest available in the 1950ies and will be used as reference scenario. Beyond realizing historic and current situations exclusively, land use scenarios for assessing the change over time and potential future land-use scenarios and climate scenarios are to be modelled.

Indicator landslide hazard

An upcoming meeting is foreseen with the different stakeholders to discuss on how to assess the risk of landslides and the importance of this indicator related to the water indicators (main focus of the stakeholder).

To assess the impact “Reduction of the landslide risk” a qualitative and literature-based assessment by experts based on land-use change (reforestation) will be made. A comparison should be made for different periods after NBS implementation depending on earliest availability of data.

The impact “Reduction of the landslide risk” is estimated to be a good assessment of landslide reduction of the NBS area overall.

In relation to the time scale to which the indicator applies, as the assessment is based on literature studies, its outcome is depending on available report, research made to date and the stakeholder knowledge.

The stakeholders to which the evaluation will be presented are the Municipality of Götzens and WLV.

The evaluation will be carried out only once within the lifetime of RECONECT for different periods after implementation of the NBS.

Nature

Indicator – Habitat Area

The assessment of the indicator habitat area change is related to the evaluation plan that is mentioned in sub-goal 6 “Shifts in land use and land cover”. Land cover change is quantified by aerial images and can be linked, combined with a literature study, to habitat areas, Historical maps and aerial images (current and past including time before and after the start of afforestation) are available or can be purchased from government agencies for the NBS area.

Since the NBS (afforestation and grassland) investigated within the case study is reacting slowly (in term of decades or even centuries), field investigations or monitoring is not applicable. It is rather, that the land cover assessment and the attribution of habitats are used to identify boundaries and changes in habitat locations.

In relation to the time scale to which the indicator applies, as the assessment is based on literature studies, its outcome is expected to be available in a short timeframe, as soon as the analyses on it have been conducted.

Evaluation will be carried out only once within the lifetime of RECONECT for different periods after implementation of the NBS. Since the process of afforestation is still ongoing it is recommended to evaluate and monitor also after RECONECT.

Indicator - Location of habitat boundaries

Since the NBS (afforestation and grassland) investigated within the case study is reacting slowly (in term of decades or even centuries), field investigations or monitoring is not applicable. It is rather, that the land cover assessment and the attribution of habitats are used to identify boundaries and changes in habitat locations.
From historical maps, aerial pictures and satellite imagery information can be obtained of the evolution of the NBS (afforestation) such as forest age and distribution.

Optional:
Beyond that, attributes such as soil thickness or forest age/forest density can be estimated. Standard methodologies that are used in Alpine regions can be found in books such as Pfadenhauer (1993), Bodenkundlich Kartieranleitung (2005), and Forstliche Standortsaufnahme Begriffe (2016). This method includes fieldwork and making transects. These on-ground observations could support the evaluation of the aerial imagery analysis.

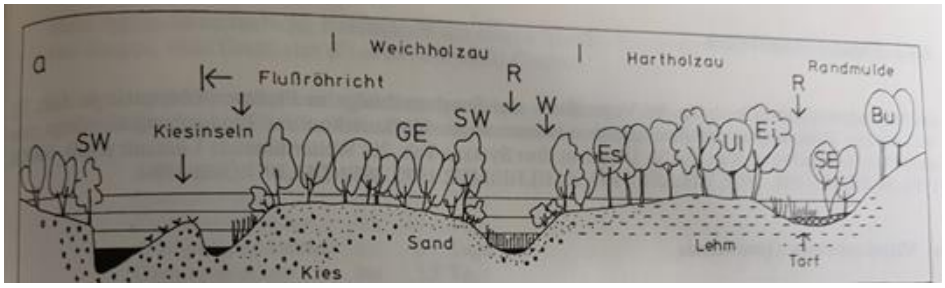


Figure 9.3 Example of a transect with soil type of the upper layer and vegetation (Pfadenhauer, J.. Vegetationsokologie – Skriptum. 1993)

The stakeholder to which the evaluation will be presented is WLV.
The evaluation will be carried out only once within the lifetime of RECONECT for different periods after implementation of the NBS. Since the process of afforestation is still ongoing it is recommended to evaluate and monitor also after RECONECT.

Indicator – Land cover

Evaluation of land cover change in the NBS area based on aerial photos and satellite data. Same data can also be used for the indicator “reduced CO2 emission and carbon

sequestration". This applies to carbon sequestration of trees and the evaluation of development of forest age.

Evaluation of aerial photos over time

Area mapping of forested parts/open parts/grass land over time using different aerial photographs. Using GIS software and programming languages spatial analyses can be carried to estimate the composition of different land cover types over time. The assessment could be conducted for the study area as a homogenous part or divided into specific clusters to look at areas of interest and to understand the dynamics of the afforestation. Example of analysing specific areas of interest within the study area divided into sections can be fund in Pfadenhauer (1993).

Presentation of land cover change

- Histograms of different land cover types based on aerial pictures for different periods. For example, spatial analyses can be carried out with programming languages or GIS software.
- Maps of land cover change over a certain time period. This type output can be produced using GIS software. (Examples see Hu et al., 2019)
- Maps of vegetation and afforestation development over a certain time period. This type output can be produced using GIS software. (Examples see Pfandenhauer, 1993).
- The same data source will be used to assess indicator 4.1.1 Habitat area
- This data can also be used to assess PEOPLE indicator "Value of reduced CO2 emission and carbon sequestration"

Indicator - Species richness and composition

To assess the impact "increase in biodiversity of flora and fauna" a literature evaluation is made of earlier studies focussing on nature in the catchment Geroldsbach-Götzens. A comparison should be made for different periods after NBS implementation depending on earliest availability of data.

Since the assessment will be done on literature data (exact timeframe to be established depending on availability), it is unlikely that the analyses will show a remarkable change in species richness of the NBS area in the latest years.

The impact "Increase in biodiversity of flora and fauna" is estimated to be a good assessment of maintaining and enhancing biodiversity of the NBS area overall.

The results of this assessment are expected to prove useful for other socio-economic sub-goals.

Time scale: As the assessment is based on literature studies.

Evaluation will be carried out only once within the lifetime of RECONECT for different periods after implementation of the NBS.

People

Indicator - Recreational quality of the area

To assess the impact “Changes in attractiveness of the NBS area” an analysis will be made on expert reviews and existing open government statistical data (e.g overnight stays, hotel bookings, tourist/sports related data in general,..). A comparison should be made for different periods after NBS implementation depending on earliest availability of data.

Since the assessment will be done on statistical data from the past (exact timeframe to be established depending on availability), it is unlikely that the analyses will show a remarkable change in the recreational value of the NBS area in the latest years. Instead, it is expected to see a steady presence of recreational activities in the larger timeframe considered, which would confirm its importance in the area. In fact, the sub-goal could be considered as achieved when a stable and good level of recreational quality of the area can be observed over the last decades after implementation of the NBS. However, it is difficult to quantify the role of the NBS alone in this development.

The impact “Changes in attractiveness of the NBS area” is estimated to be a good assessment of the recreational use of the NBS area overall. UIBK will provide data sources and gets in contact with key stakeholders to obtain the available statistical data. Evaluation of the provided data sources will be carried out by DTU.
The results of this assessment are expected to prove useful for other socio-economic sub-goals, as the statistical data will show the level of recreational activities in the area, positively connected to tourism and the development of business; as well as with human well-being.

Time scale: As the assessment is based on statistical data, its outcome is expected to be available in a short timeframe, as soon as the analyses on it have been conducted.

Stakeholders include: Municipality of Götzens, WLV
Realisation is done by UIBK together with DTU.

Evaluation will be carried out only once within the lifetime of RECONECT for different periods after implementation of the NBS.

Indicator - Damage costs and building prices

As no information on flooded or protected areas is available (like simulations from a 2D model) an alternative solution to evaluate sub-goal “Stimulate/increase economic benefits” would be the evaluation of indicator “Land and/or property value”. To assess the impact “Increase of property value and building prices” a qualitative assessment is made of statistical parcel and building prices in the flood zones and municipality. A comparison should be made for different periods after NBS implementation depending on earliest availability of data.

The sub-goals should be achieved when an increase of property value and building prices can be observed in the flood risk areas close the NBS over the last decades. However, it still is difficult to differentiate between the contribution of the NBS and other (conventional) flood protection measures.

The impact “Increase of property value and building prices” is estimated to be a good assessment of the economic benefits in the area. This is also linked to the water indicator flood hazard. UIBK will provided data sources and contact persons of the existing available data. Evaluation of the provided data sources will be carried out by DTU.

Time scale: As the assessment is based on statistical data, its outcome is expected to be available in a short timeframe, as soon as the analyses on it have been conducted.

Stakeholders include: Municipality of Götzens
Realisation: UIBK together with DTU

Evaluation will be carried out only once within the RECONECT for different periods after implementation of the NBS.

10 Greater Aarhus, Denmark - DB3

10.1 Description of the Study Area

The demonstration site is situated north of Aarhus, the second largest city in Denmark and consists of 2 interconnected areas: a) an artificial lake Egå Engsø created in the valley of the river Egå with app. 50 ha of wet meadows surrounding the lake and b) the suburb residential area Lystrup, lying on a hillslope north of the lake in the catchment of the river Egå.

The main hydro-meteorological hazards that Egå Engsø handles, is river flooding. Besides that, the area is protected from high coastal water level with a dike and a lock with a pumping station further downstream. The main hydro-meteorological hazard that Lystrup handles, is flooding from excess rainwater during heavy rainfalls. One of the sub-projects handles extreme waterflow in the minor watercourse 'Ellebækken'.

More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5

10.2 Description of the NBS

The main purpose of establishing the wetland "Egå Engsø" was to reduce the nitrogen and phosphorus supply to the Aarhus Bay (caused by agriculture and wastewater discharges) in order to reduce eutrophication of the coastal ecosystem. By creating a ca. 110 ha shallow lake directly on the river, it was expected that 32,9 t N and 0,9 t P would be captured annually in the lake (Kristiansen et al. 2014).
The expected reduction of the nitrogen was equal to 36% of the Egå river nitrogen discharge and almost 6% of the total nitrogen emission by Aarhus Municipality in 2006 (556 t) to the Aarhus Bay (Hinge-Christensen 2003, Aarhus Kommune 2010).

Another purpose for establishing the "Egå Engsø" was to improve the natural conditions in the Egådalen (the valley of Egå) and to provide also the basis for recreational utilization of the area.

It has also transpired that the "Egå Engsø" reduces flood risk from the river Egå to the low laying residential area located downstream, along the coast of the Aarhus Bay, functioning as a retention basin. In addition to numerous positive impacts, one unintended negative impact has been identified. The NBS construction poses a serious problem for the migratory fish (trout), which 'get lost' in the lake on their way from the river Egå to the sea. Monitoring by DTU Aqua, carried out from 2009 to 2011, has confirmed the average loss of 83% of migrating young trout in the lake in comparison to 0% before establishment of the Egå Engsø.

The main purpose for the climate adaptation measures in Lystrup was reduction of flood risk to the residential area. Since the Egå Engsø lake's holding capacity will be reduced if the water level in the lake is already high, i.e. due to a heavy rainfall event, the delayed water runoff from the Lystrup area helps also to maintain the holding capacity of the Egå Engsø.

Another purpose was to increase biodiversity of the created terrestrial and aquatic habitats, as well as to increase stakeholder involvement of the inhabitants in maintenance as well as recreational utilization of the area.

10.3 Goals and sub-goals addressed by the NBS

Table 10.1 presents the challenge area and defined goals and sub goals for the Danish Demonstrator.

Table 10.1 Challenge area and defined goals and sub goals for the Danish Demonstrator DB3.

Challenge area	Goal (Select Goals from the "RECONECT Indicator Selection Tool")	Sub-goal (Select Sub-goals from the "RECONECT Indicator Selection Tool")
WATER	Water quantity	A) Flood risk reduction
	Water Quality	B) Improve coastal water quality
		C) Improve water quality in rivers/watercourses, lakes/ponds
NATURE	Habitat structure	D) Increase habitat area (quantity)
		E) Habitat provision and distribution (quality)
		F) Shifts in land use and land cover
	Biodiversity	G) To maintain and enhance biodiversity
PEOPLE	Socio-economics	H) Increase recreational opportunities

10.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

One of the purposes in establishing Egå Engsø was to prevent future flooding by handling excess surface waters during extreme events by reduction in flood peak downstream and as well as delay time to flood peak. This reduces the risk of flooding of residential areas downstream during extreme events, as well as increases the preparedness time for eventually emergency effort to take place.

The main purpose for the climate adaptation measures in Lystrup was reduction of flood risk to the local residential area. Since the Egå Engsø lake's holding capacity will be reduced if the water level in the lake is already high, i.e. due to a heavy rainfall event, the delayed water runoff from the Lystrup area helps also to maintain the holding capacity of the Egå Engsø.

The main purpose of the construction of Egå Engsø lake was to reduce the nitrogen load to the Bay of Aarhus. The reduction was based on a one-off effect in connection with the change of agricultural land to nature and a long term effect based on the natural conversion of nitrate to free nitrogen in wetlands.

The construction of Egå Engsø lake, which replaced a former intensively farmed agricultural area, as well as application of flood risk reduction measures in Lystrup resulted in the development of both aquatic and terrestrial semi-natural habitats.

Habitat provision is a regulating ecosystem service for maintaining populations and habitats and refers to the direct and indirect benefits people obtain from those habitats. Assessment of the structural and functional quality of the habitats created by NBS gives understanding of the quality of natural assets as basis for multiple human uses.

Expansion and/or retreat of crucial habitats linked to the ecosystem services provided by those habitats (e.g. mediation of flows, metabolism of matter, habitat provision, recreation, etc.) gives also the possibility to assess potential for qualitative benefits of NBS linked to the People challenge area.

Land use and land cover are direct indicators of the impact of anthropogenic economic and non-economic activities. The construction of Egå Engsø NBS has changed land cover from intensively farmed arable fields to semi-natural habitats of the lake and surrounding meadows. The primary land use has shifted, from agriculture to recreation and provision of habitats. Application of the flood control measures in Lystrup resulted in the creation of aquatic habitat in retention basins, increasing diversity of habitats present in the residential area.

Creation of the lake Egå Engsø together with surrounding wet meadows also resulted in increasing biodiversity of fauna and flora in the area.

For example a survey of the area in 2007, one year after creation of the lake, has confirmed presence of 33 breeding bird species related to the aquatic habitat with total of 415 breeding pairs. Grabes, ducks, waders and gulls represented 85,8% of the total number of the breeding pairs in the Engå Engsø . In August 2009 the lake has been placed as 10th on the list of the most bird- rich localities among the 69 new or restored lakes over 10 hectares in Denmark, with 199 breeding bird species.

The construction of the NBS Egå Engsø caused also unintended impact on biodiversity. The NBS poses a problem for the migratory fish (trout), which ‘get lost’ in the lake on their way from the river Egå to the sea. DTU Aqua’s monitoring carried out from 2009 to 2011 has confirmed the average loss of 83% of migrating young trout in the lake in comparison to 0% before establishment of the Egå Engsø. The construction of Egå Engsø, which replaced a former intensively farmed agricultural area, and a path around it resulted in the development of a new recreational area open to the public.

For the Greater Aarhus demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (10.2, 10.3 and 10.4) includes the monitoring procedure to collect the required data. A brief description about the way to define the base line or reference event is also included, the evaluation will be done against those past recorded events.

Table 10.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DB3

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Flood peak reduction	Flood peak	Statistical analysis and/or dynamic river model is used to find relationships between (rainfall), discharge, lake water level and reduction of flood peaks and assess the benefits in relation to reducing the risk of downstream flooding. Monitoring data are rainfall time series, discharge time series, water level time series, and digital elevation model. Rainfall data is available since 2019 from one rainfall station near the project area localities. Hydrometric data (five stations in the rivers and outlets from the retention ponds) at Egå Engsø is available since 1988 and expected start June 2020 for Lystrup area. Rainfall data is collected hourly and hydrometric data is collected every 15 minutes (water level and generated discharge). Aarhus Vand A/S is response for rainfall data collection. Orbicon A/S on behalf of Aarhus Municipality is response for hydrometric data collection at Egå Engsø. Tender is response for hydrometric data collection in Lystrup area.	Rainfall time series, discharge time series, water level time series, digital elevation model are used as input to statistical analysis and/or dynamic river model in order to find relationships between (rainfall), discharge, retention volume and reduction of flood peaks. The reference situation is based partly on data before the implementation of the NBS and partly on data in “control area” (upstream hydrometric stations). It is available for Egå Engsø but not yet available for Lystrup area (to be obtained in the RECONECT project).
	I: Prolong the time to flood peak downstream	Delay time to peak	Statistical analysis and/or dynamic river model is used to find relationships between (rainfall), discharge, lake water level and reduction of flood peaks and assess the benefits in relation to reducing the risk of downstream flooding by increasing the preparedness time for eventually emergency effort to take place. Monitoring data are rainfall time series, discharge time series, water level time series, and digital elevation model. Rainfall data is available since 2019 from one rainfall station near the project area localities. Hydrometric data (five stations in the rivers and outlets from the retention ponds) at Egå Engsø is available since 1988 and expected start June 2020 for Lystrup	Rainfall time series, discharge time series, water level time series, and digital elevation model are Input to statistical analysis and/or dynamic river model in order to find relationships between (rainfall), discharge and delay time to peak. The reference situation is based partly on data before the implementation of the NBS and partly on data in “control area” (upstream hydrometric stations). It is available for Egå Engsø but not yet

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			area. Rainfall data is collected hourly and hydrometric data is collected every 15 minutes (water level and generated discharge). Aarhus Vand A/S is response for rainfall data collection. Orbicon A/S on behalf of Aarhus Municipality is response for hydrometric data collection at Egå Engsø. Tender is response for hydrometric data collection in Lystrup area.	available for Lystrup area (to be obtained in the RECONECT project).
Improve Coastal water quality 	I: Reduce the nitrogen load to coastal waters	Pollution in coastal waters	Results from an intensive investigation in 2015 will be presented. This data is available since 2015 DCE - Danish Centre For Environment And Energy is response for data collection.	The baseline situation is total nitrogen load to Lake Egå Engsø and total nitrogen load out of Egå Engsø. The immediate reduction in nutrient load due to transformation of land in the project area, the baseline will be the estimated load from agricultural use of the area before the construction of the lake and the load from natural areas based on standard values.
Improve water quality in rivers/watercourses, lakes/ponds 	U: raised water temperature and reduced dissolved oxygen concentration	Temperature and dissolved oxygen concentration	Rainfall time series, discharge time series, water level time series, digital elevation model, temperature and dissolved oxygen concentration are used to describe the consequences on temperature and dissolved oxygen concentration. Rainfall data is available since 2019 from one rainfall station near the project area localities. Hydrometric data (five stations in the rivers and outlets from the retention ponds) at Egå Engsø is available since 1988 and expected start June 2020 for Lystrup area. Rainfall data is collected hourly and hydrometric data is collected every 15 minutes (water level and generated discharge). Aarhus Vand A/S is response for rainfall data collection. Orbicon A/S on behalf of Aarhus Municipality is response for hydrometric data collection at Egå Engsø. Tender is response for hydrometric data collection in Lystrup area	The reference/baseline situation is obtained by control station in river inlet to Egå Engsø and a control station in a relevant area in Lystrup. The reference data is not available yet.

Table 10.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DB3

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: Changes in habitat sizes	Habitat area	Shapefile with habitat types that defines the aquatic and riparian habitat units is used to define habitat units in order to assess the habitat size, which is based on aerial images, supplemented with field verification. The results have been post-processed using morphological operations (erosion and dilation) and finally adjusting the contours manually. The data are collected two times: before (2006) and after (2019) implementation. Verification is needed every 15-20 years. Environmental variables are collected as described in WATER sub-goal. During the project lifetime, EUROSENSE, AMPHI are response for data collection and after the project lifetime, Aarhus Municipality will be response for data collection.	Environmental variables such as: size of the lake (max/min/average), terrain elevation (Danish Digital Elevation Model), water level at the inlet and outlet of the lake, flooding extent and frequency, soil type, etc. The reference/baseline situation is obtained by delineating the aquatic and riparian habitat units based on aerial images (and using other environmental variables) before implementation.
Habitat provision and distribution (quality) 	I: Changes in structure and function of habitats	Location of habitat boundaries	Type of habitat will be obtained from spatial GIS analysis (structural classification of terrestrial and aquatic habitats based on aerial images and field survey) before and after NBS implementation at Egå Engsø (ca. 420 ha) to define units in order to assess changes in their pattern. Number and size of the habitat patches are collected by automatic or manual computation of the habitat patch size and number based on spatial GIS analysis supplemented with field verification of the identified habitat borders (if needed) and Max. Depth limit of the aquatic vegetation is obtained from Field measurement during aquatic vegetation survey. Tha data at Egå Engsø are collected once every 10-15 years since August 2007. Environmental variables will be collected from existing data sets and data which is going to be collected for indicators related to the 'Water' challenge. During the project lifetime, EUROSENSE, AMPHI are response for data collection and sub-contractor performs mapping of aquatic vegetation. After the project lifetime, Aarhus Municipality will be response for data collection.	The available reference/baseline situation is obtained by the same methods as specified above.

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Shifts in land use and land cover	I: Changes in land use and land cover	Land cover area	Land cover type and area is used to define units in order to assess changes in their area and pattern, which will be obtained from spatial GIS analysis with the use of aerial images. Automatic and manual classification of land cover classes and computation of the area. The data were collected at Egå Engsø (2006) and Lystrup (2014) and will be collected after NBS implementation. Aarhus Municipality is response for data collection.	The available reference/baseline situation is obtained by the same methods as specified above.
Maintain and enhance biodiversity	I: Increase in biodiversity of flora and fauna	Species richness and composition	Species count data is required to assess the indicator, detect and assess change of species richness and composition. The data have been collected from direct observation and statistical data analyses since 2007 (Egå Engsø) and 2020 (Lystrup). Sampling frequency is variable, depending on the species group. Meteorological data (precipitation and wind speed) to estimate detection probabilities and correct collected species count (fauna) will be collected from weather data reports for local or reginal area in May-June 2020. Environmental variables will be collected from existing data sets and data which is going to be collected for indicators related to the 'Water' challenge. Aarhus Municipality, sub-contractor chosen in procurement procedure and AMPHI are responsible for species count data collection and surveyors are responsible for Meteorological data collection.	Egå Engsø: The reference/baseline situation is the situation 1 year after implementation of the NBS (2007) and for birds also before implementation of NBS (2006). Lystrup: the reference/baseline situation is before implementation of NBS.
	I: Increase in biodiversity of flora and fauna	Number and type of protected species	Species count data is required to calculate indicator, detect protected species presence-absence (species richness). Data for vegetation, invertebrates and birds have been collected during field surveys since 2007 (Egå Engsø) and 2020 (Lystrup). Sampling frequency is variable, depending on the species group. Amphibians will be collected from detection of eDNA of Triturus cristatus – Crested Newt (presence-absence) in water samples with qPCR method in May-June 2020. Environmental variables will be collected from existing data sets and data which is going to be collected for indicators related to the 'Water' challenge. AMPHI is responsible for Amphibians data collection.	Environmental variables: e.g. depth of the lake (average/min/max, 0,5 m intervals), size of the lake, Secchi depth, total phosphorus concentration (TP), total nitrogen concentration (TN), chlorophyll a, alkalinity, elevation (Danish Hight Model), flooding extent and frequency, soil type, etc. The reference data is available.

Table 10.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DB3

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase recreational opportunities 	I: Changes in attractiveness of the NBS area	Number of people that visit or spend time in the NBS area	Number of visitors will be calculated using installation of 6 people counters at the access points of the path around Lake Egå since 2020. Assessment for each of the counters how many of the total visitors will be counted at each location. The number is calculated continuously, with hourly or daily resolution. Also manual sampling of NGO usage of NBS area for recreational purposes. Aarhus Municipality is responsible for data collection.	Baseline is assumed to be zero visitors, there was no NBS nor recreational activities in the location. The reference data is not available yet.
		Enhancing attractiveness of places for living and working, and to visit	The model will be developed in accordance with the template outlined in the PEOPLE indicator methodology report. User/visitor survey in combination with the count data (qualitative and quantitative) are used for the purpose of validating the number of visitors and their purpose and the value they ascribe to this use and the knowledge that the NBS is present in the region. One survey campaign will be taken in 2020 at Egå Engsø. Purpose of the visit will be based on survey on site and/or through mail. Visitor characteristics of interest are: age, gender, activities undertaken, length of stay, value ascribed, and alternative recreational activities. Aarhus Municipality and DTU are responsible for data collection.	The reference/baseline situation is obtained by estimating the number and activities of visitors before NBS implementation. The reference data is not available yet.

10.5 Integration with the RECONECT ICT platform

There will be integration with the ICT platform developed in RECONECT and presented is section 3.1. Figure 10.1 shows the integration of water levels at Ega, Jernbanebroen (Inlet) and retention volume Grater Aarhus, Denmark (DB3) which has already been implemented as part of the ICT platform.

Figure 10.1 Example of monitoring data at Ega, Jernbanebroen (Inlet), Grater Aarhus, Denmark (DB3).

Other data that will be captured during RECONECT will be made available, such as measures flood peaks and other Water challenge indicators. Also some of the indicators for the Nature Challenge will be integrated in the ICT platform. Aarhus Municipality and Amphi are mostly responsible for data collection and coordination.

10.6 Evaluation plan

Water

Indicator Flood peak and Delay time to peak

Both the indicator flood peak and delay time to peak will be based on compared by comparing actual values up and downstream as well as by computation of amount of delayed water in the lakes/retention ponds. The consequences in relation to risk of flooding downstream will be analyzed with a river model.

The timescale will relate to the actual flood events with statistical analyses of the data as well.

The two indicators have different purpose. Reduced flood peak will reduce the risk of flooding downstream. Delayed time to peak will increase the preparedness time for eventually emergency effort to take place. They will therefore primarily be analyzed separately. The relationship between the two indicators will be analyzed.

The result will probably be presented to water authorities.

The evaluation is expected to be delivered immediately before and stop after the RECONECT project (depending of the achieved results). Data collection on the hydrometric stations is expected to continue.

Indicator - Pollution in coastal waters

The results have been evaluated in the existing report. There will be a short summary of the results in relation to the RECONECT project.

Indicator - Temperature and dissolved oxygen concentration

Temperature and dissolved oxygen concentration in river Egå will be compared between up and downstream hydrometric stations, witch immediately will show the impact. In the Lystrup area the results from stations downstream the rainwater ponds will be compared with a control station.

The results will be compared with standard values for good ecological status in streams; the consequences of dillution with other recipient water will be evaluated.

The changes in water temperature and dissolved oxygen concentration is expected to show up relatively quickly depending on the current weather conditions

The two indicators will be analyzed separately. It will be taken into account, that the amount and effect of the oxygen content is temperature dependent.

The evaluation is expected to be presented to water authorities.

The evaluation is expected to be finished at the end of the RECONECT project. Depending on the result, the data collection will probably continue after the RECONECT project.

Nature

Indicator – Habitat Area

To assess the impact “I: Changes in habitat area” the shapefiles created for the indicator “Habitat area” before and after NBS implementation will be compared using GIS operations and the changes in area for the different habitat types will be obtained.
If the area for the different habitat types has increased, it will be concluded that the sub-goal “Increase in habitat area” is being achieved. There is no predetermined amount of change (target) that needs to be met.

Changes in habitat areas can take several years to be identified.

Evaluation is planned to be presented to Aarhus Municipality, Aarhus and Lystrup inhabitants.

Evaluation will be made every 3-5 years and will be made once during the RECONECT project. The evaluation will cover a period of 13 years for Egå Engsø (with the baseline in 2006 and 2007 up to 2019) and 5 years for Lystrup (2014-2019).

Indicator - Location of habitat boundaries

The assessed indicator will be compared to the baseline before creation of the NBS (using GIS operations and expert knowledge) and changes in the structure and function of the different habitats will be obtained. Based on the assessed indicator, as well as collected monitoring data (also concerning assessment of other sub-goals, e.g. breeding birds), the evaluation will answer the following questions:

- How fragmented are habitats created by the NBS?
- How have those different habitat patches expanded and/or retreated over time?
- Do created habitat patches gain/retain function of 'the core area' over time?
- Does habitat provision of the NBS change over time?

These questions can take several years to be answered.

There is no target to be met in relation to changes over time in the structure and function of the habitats.
It will be checked if it is possible to compare results to the other similar in size/character NBSs as well as to the natural wetlands. Since the other Demo sites in RECONECT have different characteristics, it will not be possible to compare results between the cases.

Stakeholders: Aarhus Municipality, Aarhus and Lystrup inhabitants.

The evaluation will cover a period of 13 years for Egå Engsø (with the baseline in 2006 up to 2019) and will be made once during the RECONECT project. A plan for the evaluation after the RECONECT project is to be decided.

Indicator - Land cover area

The assessed indicator will be compared to the baseline before creation of the NBS (using GIS operations and expert knowledge) and changes in land cover, and resulting habitats, will be obtained. Based on the assessed indicator, as well as collected monitoring data (also concerning assessment of other sub-goals), the evaluation will answer the following questions:

- Did the NBS creation result in a change in the land cover?
- How has the land cover in the area changed over time?

Changes can be identified as soon as land cover shifts occur. There is no target to be met in relation to the amount of land cover change over time.
It will be checked if it is possible to compare results to other similar in size/character NBSs, primarily in Denmark. Since the other Demo sites in RECONECT have different characteristics, it will not be possible to compare results between the cases.

Stakeholders: Aarhus Municipality, Aarhus and Lystrup inhabitants.

The evaluation will cover a period of 13 years for Egå Engsø (with the baseline in 2006 up to 2019) and will be made once during the RECONECT project. A plan for the evaluation after the RECONECT project is to be decided.

Indicator - Species richness and composition
The assessed indicators will be compared to the baseline before creation of the NBS as well as to reference sites. In the case of Egå Engsø, reference sites will be similar shallow

artificial lakes created in Denmark. In the case of Lystrup Hovmarkspark – other climate adaptation sub-projects in Lystrup will be used.
Since the other Demo sites in RECONECT have different characteristics, it will not be possible to compare results between the cases.

Based on the assessed indicators: Species richness and composition in respect to indigenous vegetation and local/national biodiversity targets, Number and type of protected species (species richness), Diversity of species and Restricted-range species (unplanned impact) as well as existing and collected monitoring data the evaluation will answer the following questions:

- How has biodiversity of the area changed over time?
- How valuable is the created NBS in terms of biodiversity?

Targets for changes in biodiversity are to be defined.
Stakeholders: include Aarhus Municipality, Aarhus and Lystrup inhabitants.

The evaluation will cover period of a 13 years for Egå Engsø (with the baseline in 2007 up to 2019) and 5 years for Lystrup (2014-2019) and will be made once during the RECONECT project. A plan for the evaluation after the RECONECT project is to be decided.

People

Indicator - Number of people that visit or spend time in the NBS area

To assess the impact “Changes in attractiveness of the NBS area” the number of visitors and their purpose for visiting, obtained from the monitoring of the NBS area, will be compared to estimates of the numbers and goals from years prior to the NBS implementation.

If the number of visitors, together with the forms of recreation in the area have increased, it will be concluded that the sub-goal “Increase in recreational opportunities” is being achieved. There is no predetermined amount of change (target) that needs to be met.

The impact “Changes in attractiveness of the NBS area” is estimated to be a good assessment of the recreational use of the NBS area overall, as its qualitative estimations could easily overlap with other proposed indicators such as “Number of recreational activities” and “Number of tourists”. Moreover, it is expected that this indicator will be directly connected to an increase in the overall well-being of the population, including positive physical and psychological influences. Finally, links can be drawn between this impact and the “Green area” impact.

Time scale: changes in recreational opportunities can be expected to be identified quickly. Rather than a large emergence of new recreational activities, the expectation is to see a shift of regular activities (e.g. jogging, biking, etc.) to the new NBS area.

Stakeholders include: Aarhus Municipality, Aarhus inhabitants, DTU.

Evaluation frequency and length: Evaluation will be made twice annually. The survey will be done once within the lifetime of RECONECT.

11 Thur River Basin, Switzerland - DB4

11.1 Description of the study area

The river Thur is located in NE Switzerland, draining the front ranges of the Swiss NE Limestone Alps (S of the Lake Constance basin). It is a tributary of the River Rhine which flows into the North Sea.

The river Thur catchment is primarily rural, with agricultural activity mainly in the lowlands, and a few towns and villages. Water quality in the Thur catchment is adversely influenced by intensive agriculture and sewage water inflows mainly in the lower part of the catchment. The Thur river was used as case study in two EU-Projects: REFORM (http://www.reformrivers.eu/home) and ADVOCATE (http://www.theadvocateproject.eu/). Over a period of 10 years, Eawag as well as water management partners have worked on the Thur catchment; this work was performed within the framework of two transdisciplinary projects: RECORD and RECORD Catchment.

11.2 Description of the NBS

One of the various NBS implemented in the Thur river catchment was the river restoration project located at Niederneunforn (Thurgau, Switzerland). The main goal of this NBS was to make the area and the river a more natural area (Nature challenge area), connecting the originally riparian forest to the river again so that it can be inundated from time to time. Despite this main focus, other aspects related to the Water and People challenge areas were also taken into account and evaluated. The project is complete (finished by 2003), nevertheless some continuous monitoring and assessment of the impacts of the river restoration are still on-going.

11.3 Goals and sub-goals addressed by the NBS

Table 11.1 presents the challenge area and defined goals and sub goals for the Swiss Demonstrator DB4.

Table 11.1 Challenge area and defined goals and sub goals for the Swiss Demonstrator DB4.

Challenge area	Goal	Sub-goal
WATER	Water quantity	A) Flood risk reduction
		B) Groundwater management
	Water quality	C) Improve water quality in rivers
		D) Improve groundwater quality
NATURE	Habitat structure	E) Increase habitat area (quantity)
	Biodiversity	F) To maintain and enhance biodiversity
PEOPLE	Socio-economics	G) Increase recreational opportunities
		H) Stimulate/increase economic benefits

11.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

Despite not being the main goal of the NBS project, the NBS has the potential to alter the river hydraulics, and consequently affect flood risk. The NBS was designed in such way that the extra forest inundated area creates more space for water, which is expected to contribute to flatten flood peaks and ultimately reduce future flood hazard and risk.

As the main purpose of the river restoration would involve the spread of water into larger areas to create a large riparian area, this could impact groundwater because of increased infiltration and also because if surface water reaching a drinking water well location, it can temporarily not be used. It is thus important to understand how the NBS could influence groundwater levels after extreme events.

Micropollutants, such as pharmaceuticals and personal care products (PPCP), industrial chemicals and pesticides, are discharged into rivers from wastewater treatment plants (WWTP). These are point pollution sources that can deteriorate river water quality. By restoring the river reach, water is spread over larger areas, enhancing surface water – groundwater interactions and stimulating biogeochemical processes associated. This yields improved hyporehic exchange in the restored parts of the river and promotes natural attenuation of contaminants in the river and groundwater.

Restoring the river reach as NBS spreads the water into larger areas and thus is potentially impacting groundwater quality due to easier infiltration of river water into groundwater. This is especially important for losing rivers. On the other hand, enhanced hyporehic exchange in restored parts of the river can promote natural attenuation of contaminants in the river and groundwater. Therefore, the main purpose is to monitor groundwater quality if groundwater is used for drinking water production.

Increasing habitat area is a regulating ecosystem service for maintaining populations and habitats and refers to the direct and indirect benefits people obtain from those habitats. Expansion and/or retreat of crucial habitats linked to the ecosystem services provided by those habitats (e.g. mediation of flows, metabolism of matter, habitat provision, recreation, etc.) gives also the possibility to assess potential for quantitative benefits of NBS linked to the People challenge area.

Assessment of changed biodiversity as a result of NBS implementation gives understanding of the quality of natural assets as basis for the ecosystem functioning and multiple human uses.

Recreational opportunities correspond to the possible activities that people can do during their leisure time. River restoration as NBS can increase the variety of options people find at the site in comparison to an engineered river site. Restoring the river reach as NBS can stimulate the economy and increase economic benefits. This might be to the best of the communities in the vicinity of the NBS.

For the Thur River demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (11.2, 11.3 and 11.4) includes the monitoring procedure to collect the required data.

Table 11.2 Defined Indicators for the Water Challenge component of the RECOENCT NBS implementation and monitoring in DB4

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Flood hazard reduction	Flood hazard	Semi-distributed hydrodynamic model is used to simulate and predict discharge and water levels along the entire river course of the Thur river. This includes the location of NBS and downstream. These results are then used to calculate river water level and discharge. Digital elevation model, rainfall time series, evapotranspiration data, water level and discharge time series are used as input for the model. The data is available since January 1978. It consists of 52 rainfall gauging stations and 6 water levels and discharge gauging stations. The rainfall data is collected hourly while discharge and water level measurements every 15 min. Evapotranspiration is calculated by using MODES data (satellite images). Agencies for the Environments of the Swiss Cantons and Swiss Federal Office for the Environment (FOEN) are responsible for data collection.	Continuous river water level and discharge at downstream of NBS location are simulated based on measurements of discharge and water level at selected locations throughout the river course. There is an ultrasound sensor to measure the river water level located 500 m upstream of the NBS. For the base line or reference situation, flood hazard was simulated using the hydrodynamic model simulated and data are available
Groundwater management 	U: Groundwater reaching surface	Groundwater level	Piezometers to measure groundwater levels every 15 min as well as measurements of discharge and river water levels at selected locations throughout the river course. Ultrasound sensor located at the bridge 500 m upstream of the NBS to measure the river water level. Data are available January 1978 (in 1 piezometer), between July 2008 until August 2012 (18 piezometers), between September 2012 until August 2017 (3 piezometers). However, there are only 3 piezometers close to NBS available, covering an area of 5 km^2.	The groundwater level is used to measure and predict groundwater level in predominantly agricultural areas There were groundwater level measurements from before the implementation of the NBS (1 piezometer). These measurements were used as baseline and were considered to define the reference value to which the groundwater level measurements after the NBS were compared to.

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
			Agency for the Environment of the Canton Thurgau and Eawag are responsible for data collection.	
Improve water quality in rivers 	U: Drinking water production (due to micropollutants)	Water pollution caused by wastewater	Monitoring is done regular (twice per year) and for a period of time event-based sampling of raw water for drinking water production to quantify the concentration of micropollutants, e.g. carbamazepine, benzotriazole and the herbicide MCPA. Chemical concentrations is available since the wells went into production. The sampling data from water supply well located close to the Thur river. The raw water is analysed in the lab by using Analytical methods. Drinking water supply utilities is responsible for data collection.	Chemical concentrations is used to measuring micropollutant concentrations in raw water to be used for drinking water production Data are available from before implementation of NBS. This can be used to define a baseline situation on the contamination of the drinking water wells at the vicinity of the NBS. The reference values are set by the Swiss federal laws.
Improve groundwater quality 	U: Pollution of groundwater used for drinking water production.	Pollution in groundwater	Monitoring is done twice per year and for a period of time event-based sampling of groundwater to analyse concentrations of pre-defined water contaminants, e.g. carbamazepine, benzotriazole and the herbicide MCPA. The groundwater is analysed in the lab. Groundwater quality available for some extreme events. 3 piezometers close to NBS were available covering an area of 5 km^2. Other data that can be used as surrogate to groundwater quality, such as electrical conductivity, pressure head (water level) and groundwater temperature, are available every 15 min. Data is available since 1978 in January (in 1 piezometer), between 2008 in July until August 2012 (18 piezometers), between September 2012 until August 2017 (3 piezometers). Agency for the Environment of the Canton Thurgau and Eawag are responsible for data collection.	Piezometers groundwater samples for contaminant analyses, electrical conductivity, pressure head (water level) and groundwater temperature is to measure and predict medium- and long-term impacts of river restoration on groundwater quality An extensive long-term data series of the quality of groundwater (water contaminants samples and surrogate information such as electrical conductivity, water level and water temperature) is available.

Table 11.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DB4

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: Increase area and connectivity of habitats.	Habitat area	Areal imagery survey of habitat area is used to measure extension of habitats. Spatial analysis of area and field surveys is collected by using drone flights. Various surveys were conducted already after the implementation of the NBS. The data is available since July 2002 for 5 km^2. The sampling and survey is defined 2 times: before and 4 times after NBS was implemented. Agency for the Environment of the Canton of Thurgau is responsible for data collection.	The extent of the habitats before the implementation of the NBS were calculated based on aerial surveys.
To maintain and enhance biodiversity 	I: Changes in biodiversity of habitats.	Species richness and composition	Counts of different species are seen in the vicinity of the NBS. The counting can be done by dedicated field survey campaigns and take advantage of hobbyists like bird watchers. Quantitative data on species richness (vegetation, earthworms, amoeba) and appearance of little ringed plover (bird) are available since 2008/August; 2009/July; 2010/August (species richness); yearly data for little ringed plover (the latter was not obtained by Eawag but can very likely be made available) for 0.8 km^2. The data is collected by field surveys with classification of terrestrial habitats 3 times after restoration was done. Research group of the ETH-domain within the framework of the RECORD project is responsible for data collection.	Number of species is used to define if and how biodiversity is changing. For the flora species, no data from before the restoration directly at the NBS site was available. Therefore, a reference/baseline situation a few hundred meters upstream of the NBS location was used. The reference/baseline situation was investigated using the same methods as for the biodiversity assessment after the implementation of the NBS. As the baseline data for the little ringed plover (bird) one can consider the non-existence of the bird in the area of the NBS before its implementation. This bird had disappeared more than 100 years ago when the Thur river was engineered

Table 11.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DB4

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase recreational opportunities 	I: Increased quality of life for humans.	Number of people that visit or spend time in the NBS area	Field survey and questionnaire for habitants of nearby communities are used to evaluate the change in number of people to visit the NBS. The data is available since January 2012. The sampling is based on field survey and questionnaire.to evaluate the activity of an area of 5 km2 for one time. ETH Zurich and Eawag are responsible for data collection.	The questionnaire is used as reference the time before the implementation of the NBS is used.
	I: Increased quality of life for humans.	Purpose of the number of visits to the NBS area	Field survey and questionnaire for habitants of nearby communities are used to evaluate the number of activities during a visit at the NBS site The data is available since January 2012. The sampling is based on field survey and questionnaire.to evaluate the activity of an area of 5 km2 for one time. ETH Zurich and Eawag are responsible for data collection.	The questionnaire is used as reference the time before the implementation of the NBS is used.
Stimulate/increase economic benefits 	U: Increase or loss of land and/or property values	Land and/or property values	Land and/or property values are used to measure development of land and/or property values and to find out if people are willing to pay for the NBS. The data is available since January 2017. The sampling is based on questionnaires and discussion with land and/or property owners nearby communities to the NBS for one time. ETH Zurich and Eawag are responsible for data collection.	No active evaluation of land and/or property values was performed at the site of the NBS before it was created.

11.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. In particular the calculated indicators for the different challenges (Water, Nature and People). The data to assess the indicators will not be directly available in the ICT platform. However, some data such as the predicted water levels and discharge at selected locations along the river course can be found in the internet, e.g. https://www.hydrodaten.admin.ch/en/2044.html

11.6 Evaluation plan

Water

Indicator – Flood Hazard

The semi-distributed hydrodynamic model was implemented before the NBS was in place, providing a good basis for defining a reference value above which flooding may occur at downstream locations from the NBS. This reference value was set by the Agencies for the Environments of the Swiss Cantons involved and the Swiss Federal Office for the Environment (FOEN), as part of the overall flood risk management plan for the entire Thur catchment. The Agencies for the Environments are responsible for the evaluation of the data produced by the model.

Indicator – Groundwater level

Groundwater level measurements were taken every 15 min and were transmitted to a data base for constant evaluation. A groundwater level threshold above which it was assumed that the drinking water well would be affected was established by the Agency for the Environment of the Canton Thurgau. To define this reference value, the conditions before the implementation of the NBS were taken into account. The target was, therefore, that the groundwater level stayed below the reference value.

Indicator - Water pollution caused by wastewater

The presence of micropollutants in drinking water is assessed every day. Based on the presence of micropollutants and other pharmaceutical products in the water, before and after the implementations of the NBS, one can assess the impact of the NBS. The target is that the concentration of micropollutants stays below the reference values set by the Swiss federal laws. The analysis is conducted by the water utilities.

Indicator - Pollution in groundwater

An extensive long-term data series of the quality of groundwater (water contaminant samples and surrogate information such as electrical conductivity, water level and water temperature) is available. This could be used to establish a reference value for the groundwater quality level before the implementation of the NBS. These overall reference values are defined at the Thurgau cantonal and Swiss federal levels.

By comparing the contaminants concentrations and the values of the surrogate measurements with the reference values from before the implementation of the NBS and

with the overall reference values defined by the governmental agencies, one can evaluate the impact of the river restoration project in the groundwater quality.

Nature

Indicator – Habitat Area

The main goal for the river restoration was to reconnect the forest (of national importance) to the river, increasing the riverine habitats for diverse flora and fauna species. In order to define a reference value and to evaluate the impact of the NBS, the habitats areas were measured before the NBS was implemented. This allows for the comparison of the habitat areal extents over time and ultimately to evaluate the impact of the NBS on the diverse habitats. The direct comparison of the habitat areas after and before the NBS implementation is how the evaluation can be conducted.

People

Indicator – Number of people that visit or spend time in the NBS area and Purpose of the number of visits to the NBS area

To evaluate the increase of recreational opportunities, the number of people that visit or spend time in the NBS area and the purpose of the number of visits to the NBS area can be assessed by the results of a questionnaire to the population in the surrounding communities.

For the Thur case, no active evaluation on activities of people was conducted at the site before the NBS was implemented. However, the questionnaire contained comparisons of activities and number of people concerning the time before and after the restoration. Thus, the opinions expressed “before restoration” can be used as a reference/baseline.

Indicator Land and/or property values

There is no reference values for the situation before the implementation of the NBS. As such, the results of further questionnaires can be used to evaluate the relative long-term impact of the NBS on the land/ property values. Another possible way of evaluating this sub-goal is to compare the results of further questionnaires with the value of land/property of similar areas without the implementation of NBS.

12 Var river basin, France - DB5

12.1 Description of the study area

The Var Éco-Vallée in the Lower Var river basin is a flagship project of the French Government and represents an innovative approach to manage and combine different environmental challenges, including the hydro-meteorological events in suburban and urban areas.

Low valley of the Var river is a good example of a long history of human interference in its morphological and sedimentation processes. Different measures in the valley and upstream of it have been implemented over the years. At the beginning the focus was on the structural measures followed by hydraulic structures along the Var river. Site is located in the west part of the city of Nice and as a part of a new innovative construction set a good example of how new technologies and consideration of nature potential can create a unique NBS system.

Preconstruction land use was mainly agricultural land with individual and collective housing. Starting from 1960's the area starts its development by construction of airport who at this time is second by its frequency in France.

The shape of the area is river valley, with flat flood plains. These characteristics are influential on the risks listed for demonstration site especially for:

- Floods: they arise from extreme weather conditions that affect the flow of rivers and may cause intense storm runoff,
- Landslides: storm runoff during heavy rainfall on steep slopes can cause landslides,
  falling rocks, etc.
- Flood 1994.

More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5.

12.2 Description of the NBS

The new project Eco-Vallee, focuses on new urban development of this area forcing both, grey green and blue infrastructures. The highlight is on:
Green dikes, combining the increase in retention capacity with the enhancement of habitats.
Installation of eco-district in the upstream part of the valley in the village called St Martin-du-Var
The main purpose of NBS is to provide wellbeing for the people and nature. This is achieved by combining new living space, education centre, and transportation hub with existing natural protection areas that have high biodiversity potential.

Figure 12.1 NBS site, Var low valley, Nice, France

12.3 Goals and sub-goals addressed by the NBS

Table 12.1 presents the challenge area and defined goals and sub goals for the French Demonstrator.

Table 12.1 Challenge area and defined goals and sub goals for the French Demonstrator DB5

Challenge area	Goal	Sub-goal
WATER	Water quantity	A) Flood risk reduction
NATURE	Habitat structure	B) Increase habitat area (quantity)
		C) Habitat provision and distribution (quality)
PEOPLE	Socio-economics	D)Increase recreational opportunities
		F)Stimulate/increase economic benefits

12.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

As NBS site is located in the flood plain the flood protection structures, embankments and weirs, already existed. Their function was multifunctional: to protect habitants from flood and to provide water during the summer month for agricultural purposes. At present, with change in land use the protection structures are: embankments and retention ponds within NBS area. The main purpose of retention ponds and embankments is to prevent future flooding by handling excess surface water during extreme events and reduce possible economic loss.

Spatial increase in habitat area is not planned but the defined habitats within the NBS are monitored under NATURA2000 framework. This sub-goal will be monitored in order to see

how urban regeneration of the area is influencing the existing habitat areas. Here, the imperative is to preserve existing habitat and avoid decrease of habitat area. For this purpose we are using and following NATURA2000 framework. The urban regeneration of the NBS area is focused on economic development, development of new transportation hub that has regional importance but at the same time the existing habitat resource should not be threatened. Within this sub-goal the focus is to preserve the area of the existing habitats. According to Biodiversity Guide, issued in July 2011, the imperative is to include nature preservation in any new project or development. The long term goals are to extend the boundaries of protected areas in Metropole Nice Cote d'Azure.

Spatial increase in habitat area is not planned but the defined habitats within the NBS are monitored under NATURA2000 framework. The Biodiversity Guide, created in July 2011, also signifies the importance of habitat preservation and condition the development of NBS. The NBS is within the national development project that is changing the land use and land cover of the NBS. The project brings the economic development and construction the new regional transportation hub in the area and the challenge is to avoid disruption of the existing protected areas. Here, the monitoring is crucial because it will provide the effect that urban development has on habitat structure, especially the number of species of flora and fauna.

The lower Var valley is the most important coastal wetland on the Côte d'Azur. Despite a context very marked by human development, this site brings together several types of natural environments (mud flats, pebble banks, open waters) rare elsewhere in the department. This gives the site an attractive character for avifauna, especially for water birds. Nearly 200 species of birds frequent the site, of which about 50 species are of community interest. The NBS brings challenge in preserving existing biodiversity of flora and fauna following the change in number and type of protected species.

The new construction within NBS resulted in increasing number of recreational opportunities for population that lives in NBS or come for recreation. The urban development in NBS area is bringing economic benefits to the area along with development of dense transportation network and construction of regional transportation hub. This new urban structure will bring much more people to the NBS, either for work or for recreation. The new development is bringing increase of public green spaces within NBS and by that recreation opportunities are bigger.

The changes in NBS are from 2010 when the change in economic value becomes more visible and comparable. New construction site and change in land use directly contribute to increase of building prices in NBS.

For the Var River Basin demonstrator the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (12.2, 12.3 and 12.4) includes the monitoring procedure to collect the required data.

Table 12.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DB5

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Flood hazard reduction	Flood hazard	2D hydrodynamic is used to prediction of water depths and flow velocities after NBS implementation. Meteorological parameters, rainfall time series, runoff time series, roughness, digital elevation model, discharge time series, and river geometry data are available since September 2017. Weather data reports can be obtained from (MeteoFrance and https://www.vigicrues.gouv.fr/). Water levels and discharge data are collected monthly. The university of Nice is responsible for data collection.	The data will be used as input data for 2D hydrodynamic model to predict water depths and flow velocities for current data in order to observe the effect of NBS in the area. For the base line or reference situation, the situation before implementation in the NBS and before flood event 1994 will be used.

Table 12.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DB5

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: Change in habitat size	Habitat area	Satellite and area images of habitat area after the implementation NBS will be used to assess preserve the existing habitat area. The data is not yet available. However, the data has been collected since September 2019 for the whole area. The university of Nice is responsible for data collection.	To be defined
Habitat provision and distribution (quality) 	I: Changes in aquatic habitat, changes in flora and fauna in habitat	Changes in aqatic habitat, flora and fauna	Aerial pictures and satellite images for different periods of aquatic habitat, flora and fauna will be used to assess the habitat quality in terms of number of species of flora and fauna. The data is not yet available. However, the data has been collected since September 2019 for the whole area. The university of Nice is responsible for data collection.	To be define

Table 12.4 Defined Indicators for the People Challenge component of the RECONECT NBS implementation and monitoring in DB5

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase recreational opportunities 	I: Changes in recreational points of the NBS area	Number of people spending time in NBS	Statistical data of number of people spending time in NBS area will be used to confirm increase in recreational opportunities of the NBS area. The data can be obtained from INSEE - Statistical Institute. The data has been collected since September 2019. The university of Nice is responsible for data collection.	The reference/baseline situation is based on the data from 2010.
Stimulate/increase economic benefits 	I: Changes in attractiveness of the NBS area	Building prices in NBS area	Statistical data of building prices is used to identify changes in parcel and building prices in existing flooding zones and/or the municipality. The data is available since 2000. The university of Nice is responsible for data collection.	To be confirmed

12.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. In particular the calculated indicators for the different challenges (Water, Nature and People).

12.6 Evaluation plan

Water

Indicator – Flood Hazard

The evaluation of the defined sub-goal, flood risk reduction will be done with comparison of reference flood map and new flood maps. Rationale is based on the fact that with existing NBS the flood risk reduction will decrease. This is due to renewed embankments and new retention ponds within NBS. At this stage timeframe for comparison is 5 years, but if there is a significant precipitation of flood wave the maps will be produced and compared.

Importance of this evaluation to the stakeholders is significant, preferably to decision makers at Metropole Nice Cote d'Azure, because it will be possible to have direct measure of how flood risk is reduced within NBS along with the urban change.

Nature

Indicator – Habitat Area

Evaluation is done by comparison of change in habitat size, between reference year and current year. In this case monitoring will contribute to overview effects of NBS on habitat area. Here the focus is to maintain the same habitat size and avoid spatial reduction. In evaluation the NATURA2000 reports will be used and also using the satellite images. The long term goals are to extend the boundaries of protected areas in Metropole Nice Cote d'Azure.

Change in habitat boundaries can come after many years. Taking that into account at the beginning of monitoring period the shape file will be created with mapped areas of habitat within NBS. Any observed change, in case there is a change, will be reflected in shape file.

Indicator – Changes in aquatic habitat, flora and fauna

Evaluation is done by comparison of change in habitat size, between reference year and current year. In this case monitoring will contribute to overview effects of NBS on habitat area. Here the focus is to maintain the same habitat size and avoid spatial reduction. In evaluation the NATURA2000 reports will be used and also using the satellite images. The long term goals are to extend the boundaries of protected areas in Metropole Nice Cote d'Azure.

Change in habitat flora and fauna species can come after many years. Taking that into account at the beginning of monitoring period the shape file will be created with mapped areas of habitat within NBS. Any observed change, in case there is a change, will be reflected in shape file.

People

Indicator - Number of people spending time in NBS

To assess the impact recreational points within NBS an analysis will be conducted by comparison of number of recreational area within NBS before and after urbanization of the area. The satellite images will be compared with mapped recreational points in NBS before and after development of the area.

Indicator - Building prices in NBS area

How NBS is contributing to economic attractiveness? There are a lot of factors that are contributing of economic attractiveness. The sub-goal will be achieved after validation of attractiveness of NBS area. The comparison will be visible on building prices are changed in flood risk areas in NBS over the last decade for example. However, achievement of this sub-goal is beneficial to local stakeholders having on mind the touristic character of the area.

13 Les Boucholeurs, France - DB6

13.1 Description of the study area

The demonstrator is located in the west, Atlantic coast of France. A small urban commune has significant structure “Les Boucholeurs” is a district of Châtelaillon-Plage located on the limit of Yves, two cities of the Charente-Maritime county. This district count approximately 600 houses and have an important activity in oyster and mussel farming. Les Boucholeurs extends in border of a vast bay and presents houses on the sea front directly exposed to waves as well as setback constructions on the location of former leveed marshes.

Floods are one of the hydro meteorological hazards relevant for this NBS area, in particular, the recent event Xynthia that occurred on February 2010. The effect of Xynthia on flooding and erosion was significant, especially in the department Vandee and Charente-Maritime.

Storm Xynthia caused a lot of damages. In Les Boucholeurs, the urbanized zone has undergone both, north, overtopping on the sea front (the strong exposure to waves caused two deaths) and, south, water entrances on a very large linear due to levees and dunes overflowing. The canal that crosses the urbanized area (the Punay port canal) contributed to store the water in the high stakes zone. The foreshore ramps were not equipped with locking devices and allowed the passage of large flows. The lighter marshes were severely damaged after being submerged. However, the permeability of road and railway infrastructures allowed a part of the water to spread outside the most vulnerable areas.

More details about the study area and the NBS demonstrator can be found in Deliverable 2.3 and 2.5.

13.2 Description of the NBS

The existing waterfront has been converted into paved promenade. The dense urbanization started on the former site of embankment system combined with marchland (existing system of retention areas). This area was in a way a natural buffer boundary with the Atlantic coast. Its primary function was to compensate swells from the north and storms coming from the west.

Existing flood protection structures in this NBS area is a flood protection wall re-constructed after Xynthia event. The protection wall is located along the sand beach of this NBS area and with existing dune system creates a flood protection system.

Following the storm Xynthia in 2010, the municipality of Châtelaillon-Plage has set up, with the municipality of Yves, Aix and Fouras, a system to fight against different types of flood called PAPI (Program of Actions Of Flood Prevention).

Lessons learned after Xynthia event and work done within PEARL project showed great potential of nature in this area to compensate flood and readiness of local community to know as much as possible about the existing solutions.

Figure 13.1 NBS site, Les Boucholeurs, France

13.3 Goals and sub-goals addressed by the NBS

Table 13.1 presents the challenge area and defined goals and sub goals for the French Demonstrator.

Table 13.1 Challenge area and defined goals and sub goals for the French Demonstrator DB6.

Challenge area	Goal	Sub-goal
WATER	Water quantity	A) Coastal risk reduction
		B) Increase habitat area (quantity)
NATURE	Habitat structure	C) Habitat provision and distribution (quality)
		D) Increase recreational opportunities
PEOPLE	Socio-economics	E) Stimulate/increase economic benefits
		F) Coastal risk reduction

13.4 Indicators to address the Water, Nature and People challenges

The following considerations were taken into account while deciding the monitoring indicators:

The NBS site is located in the coastal area along with the protection structures, wall and wetland area. The function is multifunctional: protection of habitants from high waves and coastal surge. At present, there is no change in land use and for this location the focus is on reconstructed protection wall after Xynthia event (2010) and big potential of wetland to absorb the wave.

Spatial increase in habitat area is not planned but the defined habitats within the NBS are monitored under NATURA2000 framework. This sub-goal will be monitored in order to see how urban regeneration of the area is influencing the existing habitat areas. Here, the imperative is to preserve existing habitat and avoid decrease of habitat area. For this purpose we are using and following NATURA2000 framework. The urban regeneration of the NBS area is focused on economic development, development of new transportation hub that has regional importance but at the same time the existing habitat resource should not be threatened. Within this sub-goal the focus is to preserve the area of the existing habitats. According to Biodiversity Guide, issued in July 2011, the imperative is to include nature preservation in any new project or development. The long term goals are to extend the boundaries of protected areas in Metropole Nice Cote d'Azure

Spatial increase in habitat area is not planned but the defined habitats within the NBS are monitored under NATURA2000 framework. Here, the monitoring is crucial because it will provide the effect of NBS on habitat structure, specially the number of species of flora and fauna. The site Les Boucholeurs is unique area located in the Atlantic coast of west France. The existing one of the most representative examples of the large inland hinterlands of the Atlantic center offering habitats - particularly grassland - over large areas, remarkable for their originality (presence of salt in variable quantities) and their diversity. One of the large central Atlantic back-marshes: tidal mud flats and more or less brackish hygrophilous meadows separated by a large network of freshwater ditches are the main features. The NBS brings challenge in preserving existing biodiversity of flora and fauna following the change in number and type of protected species.

The renewed protection wall along the coastline in the NBS resulted in increasing number of recreational opportunities for population that lives in NBS or come for recreation. There is significant number of vacation houses located in NBS area. The reconstruction after Xynthia event resulted in increased number of recreational points within NBS.

The changes in NBS are from 2010 when the change in economic value becomes more visible and comparable. New construction site and change in land use directly contribute to increase of building prices in NBS. Here, the Xynthia event is a milestone since after the event, the reconstruction of protection wall is done. The activities of local stakeholders are still focused on raising awareness of existing coastal risk. Population in NBS is now more aware of the existing risk and measures taken even on individual level are contributing to risk reduction and increase of building prices.

For the Les Boucholeurs demonstrator site the following tables summarized the outcome of the application of the tool and the template prepared for this purpose. Each table (13.2, 13.3 and 13.4) includes the monitoring procedure to collect the required data and the reference event or base line description.

Table 13.2 Defined Indicators for the Water Challenge component of the RECONECT NBS implementation and monitoring in DB6

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Flood risk reduction 	I: Coastal hazard reduction	Coastal flood hazard	2D hydrodynamic is used to prediction of water depths and flow velocities after NBS implementation. Meteorological parameters, rainfall time series, runoff time series, roughness, digital elevation model, discharge time series, and river geometry data are available since 2019. Weather data reports can be obtained from (MeteoFrance and https://www.vigicrues.gouv.fr/). The University of Nice is responsible for data collection.	The data will be used as Input data for 2D hydrodynamic model to predict water depths and flow velocities for current data in order to observe the effect of NBS in the area. For the base line or reference situation, the flood map before reconstruction process in NBS area before 2010 already exist.

Table 13.3 Defined Indicators for the Nature Challenge component of the RECONECT NBS implementation and monitoring in DB6

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase habitat area (quantity) 	I: Maintain the same habitat size	Habitat area	Satellite and area images of habitat area after the implementation NBS will be used to assess preserve the existing habitat area. The data is not yet available. However, the data has been collected since September 2019 for the whole area. The University of Nice is responsible for data collection.	To be defined
Habitat provision and distribution (quality) 	I: Changes in aquatic habitat, changes in flora and fauna in habitat	Changes in aqatic habitat, flora and fauna	Aerial pictures and satellite images for different periods of aqatic habitat, flora and fauna will be used to assess the habitat quality in terms of number of species of flora and fauna. The data is not yet available. However, the data has been collected since September 2019 for the whole area. The University of Nice is responsible for data collection.	To be define

Table 13.4 Defined Indicators for the People Challenge component of the RECOECNT NBS implementation and monitoring in DB6

Sub-goal	Impacts	Indicators	Monitoring procedure	Reference Event/ Base line
Increase recreational opportunities 	I: Changes in recreational points of the NBS area	Number of people spending time in NBS	Statistical data of number of people spending time in NBS area will be used to confirm increase in recreational opportunities of the NBS area. The data can be obtained from INSEE - Statistical Institute. The data has been collected since September 2019. The University of Nice is responsible for data collection.	The reference/baseline situation is based on the data from 2010.

13.5 Integration with the RECONECT ICT platform

There will be some level of integration with the ICT platform developed in RECONECT and presented is section 3.1. In particular the calculated indicators for the different challenges (Water, Nature and People).

13.6 Evaluation plan

Water

Indicator – Flood hazard

The evaluation of the defined sub-goal, coastal risk reduction will be done with comparison of reference flood map and new flood maps. Achievement of this sub-goal is of high importance. Reduced coastal risk is providing security to population in NBS area and protects assets. The reference model result is available and will be used for comparison with of flood maps created with reconstructed protection wall exploring the effect of the same event. The reduction of coastal flood hazard is visible since within NBS embankments is renewed and the new flood gates are created in order to provide better protection.

The results will be showed to local stakeholders in NBS preferably to municipality Châtelaillon-Plage. Since Xynthia event in 2010 the focal point regarding safety is on monitoring coastal hazard.

Nature

Indicator – Habitat Area

Evaluation is done by comparison of change in habitat size, between reference year and current year. In this case monitoring will contribute to overview effects of NBS on habitat area. Here the focus is to maintain the same habitat size and avoid spatial reduction. In evaluation the NATURA2000 reports will be used and also using the satellite images. Change in habitat boundaries can come after many years. Taking that into account at the beginning of monitoring period the shape file will be created with mapped areas of habitat within NBS. Any observed change, in case there is a change, will be reflected in shape file.

Indicator - Changes in aquatic habitat, flora and fauna

Sub-goal is achieved by comparison of existing number of flora and fauna species in reference year and in current year. Her, it is important to mention that change related to habitat provision and distribution will not be visible during the project life.
Change in habitat flora and fauna species can come after many years. Taking that into account at the beginning of monitoring period the shape file will be created with mapped areas of habitat within NBS. Any observed change, in case there is a change, will be reflected in shape file.

People

Indicator - Number of people spending time in NBS

To assess the impact recreational points within NBS an analysis will be conducted by comparison of number of recreational area within NBS before and after reconstruction of protection wall of the area after Xynthia event 2010. The satellite images will be compared with mapped recreational points in NBS before and after development of the area. For monitoring action a statistical data will be used from official France Statistical website. Also, the data from tourist organisation will be taken into account.

Indicator - Building prices in NBS area

How NBS is contributing to economic attractiveness? There are a lot of factors that are contributing of economic attractiveness. The sub-goal will be achieved after validation of attractiveness of NBS area. The comparison will be visible on building prices are changed in flood risk areas in NBS over the last decade for example. However, achievement of this sub-goal is beneficial to local stakeholders having on mind the touristic character of the area

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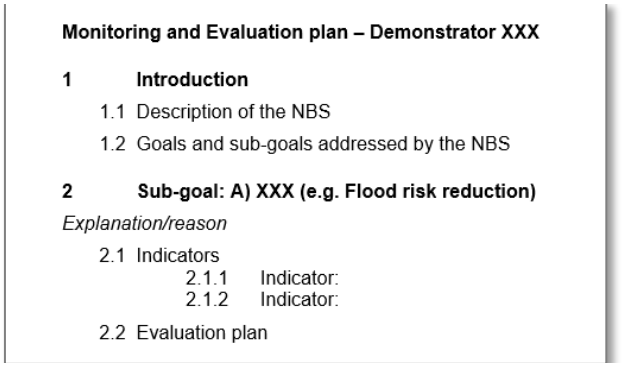
Annex A. Template

Annex A presents the template that was circulated, filled in, and discussed with Demonstrators A and B to produce the first version of D2.6.

The template is structured as follows:



Monitoring and Evaluation plan – Demonstrator XXX

1 Introduction

1.1 Description of the NBS

1.2 Goals and sub-goals addressed by the NBS

2 Sub-goal: A) XXX (e.g. Flood risk reduction)

Explanation/reason

2.1 Indicators

2.1.1 Indicator:

2.1.2 Indicator:

2.2 Evaluation plan

After the introduction section, each section that follows focusses on a sub-goal (e.g., section 2 is devoted to Sub-goal A) and that the evaluation plan is for evaluating the performance of the NBS in achieving the sub-goal (e.g., Sub-goal A).

The template contains, for some of the sections, in red text the context where the section fits in, as well as some definitions. Blue text provides instructions on how to fill in the requested information.

Finally, the circulated template was intended to guide demonstrators on describing monitoring and evaluation procedures within the context of how sub-goals, indicators, data monitoring, impact assessment, and NBS performance in achieving a given sub-goal fit all together in RECONECT. The template was structured in such a way that demonstrators needed to describe their monitoring activities as well as how the information fits within the NBS evaluation framework.

Monitoring and Evaluation plan – Demonstrator XXX

1 Introduction

1.1 Description of the NBS

- *Briefly describe the demonstrator case, highlighting the main goals/sub-goals addressed by the NBS in a narrative form.*

1.2 Goals and sub-goals addressed by the NBS

"Goals" and "Sub-goals" are those objectives that the NBS aims to achieve

- *Use the table below to list the goals and sub-goals addressed by the NBS. Match the goals and sub-goals to the ones depicted in the "RECONECT Indicator Selection Tool" (attached to this document).*

  Use a named list for all sub-goals in the second column (A, B, C) as it will be easier to identify them in the following parts of the document when describing the monitoring and evaluation plans under the different sub-goals.

Challenge area	Goal (Select Goals from the "RECONECT Indicator Selection Tool")	Sub-goal (Select Sub-goals from the "RECONECT Indicator Selection Tool")
WATER		
NATURE		
PEOPLE		

2 Sub-goal: *Write here the name of the sub-goal*

- *Under heading "Explanation/reason" provide a brief explanation of the reason why the NBS addresses the sub-goal.*

Explanation/reason

2.1 Indicators

In the following sections you will outline the plan to monitor each indicator with the purpose to monitor the identified impact and demonstrate whether the sub-goal is achieved.

The following sub-sections carry the name of each indicator.

- *Fill the table below with the following information:*
  - *In the first column: the sub-goal*
  - *In the second column: Impacts*
    - *Name the impacts for this sub-goal that are going to be monitored by the indicators.*
    - *Distinguish between intended and unintended impacts.*
      - *Mark intended impacts as "I: name of impact" related to the sub-goal. Intended impacts are those effects/changes that are not only desirable but sought within NBS implementation in relation to the sub-goal.*
      - *If applicable, mark unintended impacts as "U: name of impact" related to the sub-goal. Unintended impacts are those (usually) negative, unforeseen effects/changes that occur after NBS implementation in relation to the sub-goal.*
  - *In the third column: Indicators*
    - *List the indicators that you use to monitor the (intended or unintended) impact in this sub-goal.*
      - *You can use the indicators in the "RECONECT Indicator Selection Tool" in relation to this sub-goal.*
      - *If the "RECONECT Indicator Selection Tool" does not contained your desired indicator, then define an indicator yourself. Write a short paragraph explaining why this indicator is needed.*

Sub-goal	Impacts	Indicators

2.1.1 **Indicator:** Write here the name of the indicator

Impact (intended or unintended) monitored by the indicator
Write down the impact that is monitored by the indicator as written in the table in section 2.1 above for this sub-goal
Monitoring question(s) addressed by the indicator
Write down the question that is answered by the indicator
Monitoring procedure
Fill in the following information <u>for each model and/or for each data</u> you require to assess the indicator for the situation after NBS implementation.

Model required (if applicable)
If applicable, write the type of model needed for this indicator
Purpose
Explain in one sentence the purpose of using this model for this indicator
Availability of the model
Write here "Already available", or "Not available yet" to specify whether the model is or in not available and therefore considered a gap.
Data required: *Write here the name of the monitoring data to assess the indicator after NBS implementation and add the information requested for the following items.For each data required use a separate table.* *If a model has been listed above, you can include all the input data required to build the model and predict the value of the indicator in one single table.*
Purpose
Explain here in one sentence the purpose of collecting these data to assess the indicator
Availability of the data <u>after</u> NBS implementation
Write here "Already available", or "Not available yet" to specify whether the data after NBS implementation is already available or is not available yet (and is to be obtained in the RECONECT project). If the data is not available yet, we consider it a <u>data gap</u> and you can interpret what follows as the plan to obtain the data.
Type of data
Write here "qualitative" or "quantitative"[2] for the type of data
Method
Explain here in one sentence or very briefly the method used to collect these data
Spatial sampling/Spatial coverage
Explain here in one sentence or very briefly the locations where data is collected. For remote sensing data, this refers to the area covered by the data

[2] *Quantitative* data can be counted, measured, and expressed using numbers. Quantitative data can be generated through, for example, tests, experiments, surveys, and metrics.
Qualitative data is descriptive and conceptual. Qualitative data can be categorized based on characteristics. Qualitative data can be generated through, for example, texts and documents, interview transcripts, and observation and notes.

Temporal sampling/frequency
Explain here in one sentence how often the data is collected
Starting year/month of data collection
Specify the year and month in which the data described here under "Data Required" starts (or has started) to be collected
Responsible for data collection
If possible, specify the name of the organization(s) responsible for the data collection.
Data in "RECONECT ICT Platform" and if "YES" the Responsible organization to share the data
Write "YES" or "NO" if you would like to display this data in the RECONECT ICT Platform. If "YES" and if possible, specify which organization deals with sending the data. It might be that you need to only write here the name of your organization.

2.1.2 **Indicator:** Write here the name of the indicator

If another indicator is to be described, used the same instructions as in section 2.1.1.

Reference/baseline situation
The value of the indicator for the reference/baseline situation is used for comparison with the value of the indicator after NBS implementation, to demonstrate that the sub-goal is being achieved. ▪ *Please select the value of the indicator for the reference/baseline reference/baseline used from these choices:* ○ ***before implementation in the NBS area[3]*** ○ ***before and after implementation in a control area[4]*** ○ ***a specified reference value[5]*** ▪ *Please write in one sentence (or if you have more information, write a paragraph) explaining how and from where the reference/baseline situation data is obtained.* ▪ *Write "Available" or "Not yet available" to specify whether the data required to define the reference/baseline situation is available or not available yet (and is to be obtained in the RECONECT project). If data to define the reference/baseline situation is not available, it is considered a data gap.*
Indicator to be displayed in the "RECONECT ICT Platform" (YES/NO)

3 *The value of the indicator used as reference is the one before implementation of the NBS.*

4 *The value of the indicator used as reference is the one before and after implementation of the NBS in a control area (area with similar environmental conditions to accommodate for other changes in indicator value unrelated to the presence of the NBS).*

5 *The value of the indicator used as reference has been determined, for example, by regulation.*

Write down "YES" or "NO". Writing "YES" or "NO" here will help us to identify functionality that may be needed in the RECONECT ICT platform to display the (assessed) indicator.
Note that here we mean the indicator and not individual data needed to assess the indicator (you have specified whether you plan or not to display individual data in the "RECONECT ICT Platform" above under section "Data required")

2.2 Evaluation plan

In previous sections you have outlined how you plan to monitor the data needed to assess the indicators.

In this section you are going to (briefly) explain how you plan to compare the monitored values and reference/baseline values to assess the impact/change and put the result in perspective to answer whether the NBS achieves the sub-goal. If you have addressed several indicators you will also reflect on them as a whole to answer whether the NBS achieves the sub-goal.

- *Write a short paragraph addressing the following:*
    - *For each indicator:*
        - *briefly explain how you plan to make the comparison between the value of the monitored indicator after NBS implementation and the one in the reference/baseline situation to determine if there has been any change and therefore assess impact*
        - *After you compare the monitored indicator value(s) to the reference/baseline value(s) and you observe a change, how could it be interpreted that the sub-goal is being achieved? Is there a target value of change that needs to be met?*
    - *The time scale to which each of the indicators apply. Over which time scale should the indicators show that the sub-goal has been achieved or not?*
    - *If you have described several indicators, how do you plan to look at them as a whole to answer whether the NBS achieves the sub-goal? Reflect on the possible difference in time scales of the several indicators.*
    - *To whom the evaluation will be presented (i.e., to which stakeholders)?*
    - *How often and for how long (also beyond RECONECT) will the evaluation be carried out?*

Annex B. A framework for selection of indicators and variables for monitoring and evaluation purposes

Selection of indicators and variables for monitoring and evaluation purposes of RECONECT demonstrators

Since there is no universally agreed set of indicators and variables that can be used for each and every NBS case it is necessary to develop a tool that supports selection of specific indicators and variables to reflect variety of local contexts and situations. The list of indicators and variables contained in the tool is compiled from different sources (e.g., NBS related projects and scientific papers) that relate to the following the six themes/topics: water quantity, water quality, habitat structure, biodiversity, socio-economics and human well-being. The tool aims to support selection of specific indicators and variables for different NBS demonstration sites which could be then used for monitoring (baseline and ongoing) and evaluation activities.
The framework applied for the development of indicators and variables is illustrated in Figures 1 and 2.

Figure 1: RECONECT framework for development of indicators and variables;

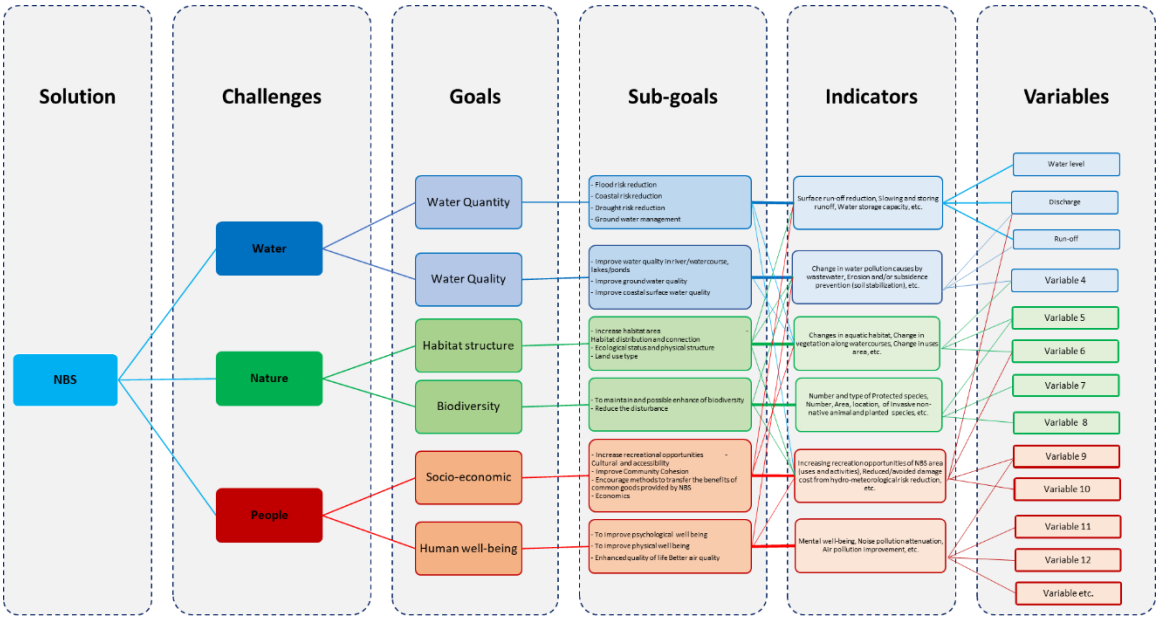
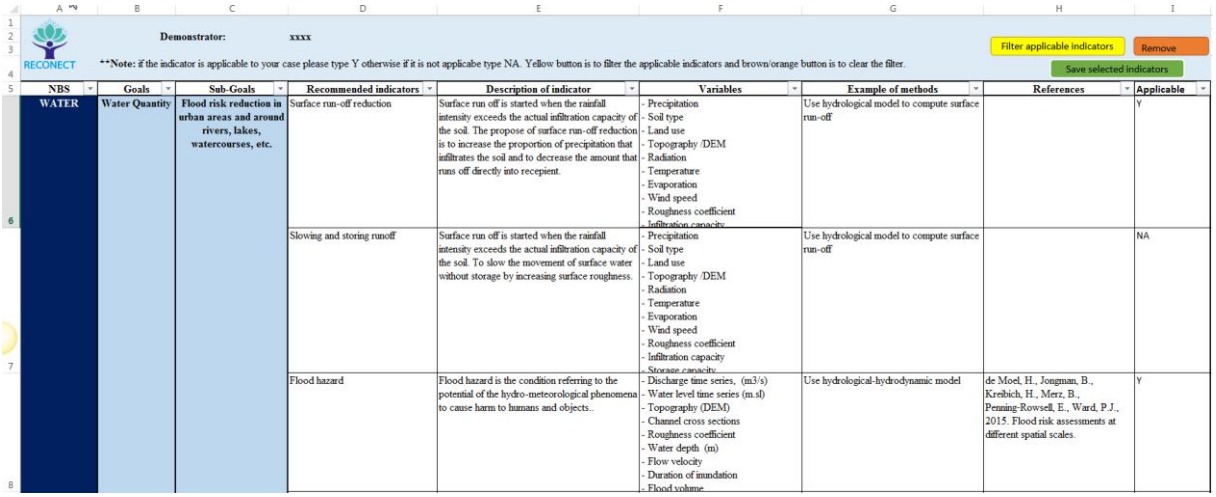


Figure 2: RECONECT framework for development of indicators and variables;

The framework starts from an NBS 'Solution' and proceeds through 'Challenges', 'Goals', 'Sub-Goals' in order to come up with the list of 'Indicators' and 'Variables':

1. **Solution** refers to a particular site where a solution has already been implemented (Demonstrator B) or it will be implemented (Demonstrator A).
2. **Challenge** refers to RECONECT challenge areas: Water, Nature and People.
3. **Goal** represents a theme/topic within the challenge area (these could be water quantity, water quality, habitat structure, biodiversity, socio-economics and human well-being).
4. **Sub-Goals** are subthemes within 'Goals' which will be assessed through indictors.
5. **Indicators,** which are derived from variables, are the first, most basic, *metrics or aspects* which can be used to measure, describe or assess the change and state of sub-goals over a period of time.
6. **Variables,** which are the most basic component of indicators, are data which can be used to monitor/measure and assess change in the state of indicators.

The tool is a rather simple Excel spreadsheet (Figure 3) which requires the user to fill in column I (Applicable: where ***Y*** refers to applicable indicator and ***NA*** to not applicable indicator) and to sort out the selection of applicable indicators and variables by pressing the filter (yellow button) in cell H4. Once this is done the user then needs to save the file with a new name with Excel Macro-Enabled Workbook type or if you would like to save only selected "Recommended indicators", "Description of indicator", "Variables", "Example of methods", and "References", you can press the green button.



RECONECT

Demonstrator: xxxx

****Note:** if the indicator is applicable to your case please type Y otherwise if it is not applicabe type NA. Yellow button is to filter the applicable indicators and brown/orange button is to clear the filter.

Filter applicable indicators | Remove | Save selected indicators

NBS	Goals	Sub-Goals	Recommended indicators	Description of indicator	Variables	Example of methods	References	Applicable
WATER	Water Quantity	Flood risk reduction in urban areas and around rivers, lakes, watercourses, etc.	Surface run-off reduction	Surface run off is started when the rainfall intensity exceeds the actual infiltration capacity of the soil. The propose of surface run-off reduction is to increase the proportion of precipitation that infiltrates the soil and to decrease the amount that runs off directly into recepient.	- Precipitation - Soil type - Land use - Topography /DEM - Radiation - Temperature - Evaporation - Wind speed - Roughness coefficient - Infiltration capacity	Use hydrological model to compute surface run-off		Y
			Slowing and storing runoff	Surface run off is started when the rainfall intensity exceeds the actual infiltration capacity of the soil. To slow the movement of surface water without storage by increasing surface roughness.	- Precipitation - Soil type - Land use - Topography /DEM - Radiation - Temperature - Evaporation - Wind speed - Roughness coefficient - Infiltration capacity - Storage capacity	Use hydrological model to compute surface run-off		NA
			Flood hazard	Flood hazard is the condition referring to the potential of the hydro-meteorological phenomena to cause harm to humans and objects..	- Discharge time series, (m3/s) - Water level time series (m.sl) - Topography (DEM) - Channel cross sections - Roughness coefficient - Water depth (m) - Flow velocity - Duration of inundation - Flood volume	Use hydrological-hydrodynamic model	de Moel, H., Jongman, B., Kreibich, H., Merz, B., Penning-Rowsell, E., Ward, P.J., 2015. Flood risk assessments at different spatial scales.	Y

Figure 3: Illustration of a tool for selection of indicator and variables;