RECONECT

# Scope of Works for Demonstrators A and B

*Deliverable D2.3*



*Acknowledgement*

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 776866

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# Document Information

| Project Number | **776866** | Acronym | **RECONECT** |
|---|---|---|---|
| Full Title | RECONECT- Regenerating ECOsystems with Nature-based solutions for hydro-meteorological risk rEduCTion | | |
| Project URL | http://www.reconect.eu/ | | |
| Document URL | | | |
| EU Project Officer | Laura Palomo Rios | | |

| Deliverable | Number | D 2.3 | Title | Scope of Works for Demonstrators A and B |
|---|---|---|---|---|
| Work Package | Number | WP2 | Title | Demonstration |

| Date of Delivery | Contractual | 28.2.2019 | Actual | 23.03.2019 |
|---|---|---|---|---|
| Status | version | | final ☑ | |
| Deliverable type* | R | | | |
| Dissemination level ** | | | | |

*R – Report, P – Prototype, D – Demonstrator, O – Other.

**PU – Public, PP – Restricted to other programme participants (including the Commission Services), RE – Restricted to a group specified by the consortium (including the Commission Services), CO – Confidential, only for members of the consortium (including the Commission Services).


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| Abstract *(for dissemination, 100 words)* | This report describes Scope of Works of Demonstrators A and B within RECONECT Project. It presents results of activities carried out within Task 2.3, supported also by other tasks and WPs running in parallel. The main objective is to set the scene for demonstration activities by providing substantial level of detail/description of their projects in terms of NBS type, location characteristics, governance structures, etc. D2.3 aims also to facilitate the process of twinning between Demonstrators A and B for learning and knowledge sharing purposes. Report D2.3 will serve as a basis for development of guidelines for design, implementation, and evaluation of NBS. |
|---|---|
| Keywords | Nature Based Solutions, Eco-Systems, Scope of Works |


| Version Log | | | | |
|---|---|---|---|---|
| Issue Date | Rev. No. | Author | Change | Approved by |
| 23.03.2019 | 1 | V. Penchev, N. Manojlovic, B. Pérez-Lapeña, J. de Jager, A. Kirova, J. Knegt, F. Boogaard | | Z. Vojinovic |
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# Executive Summary

The presented report D2.3 describes Scope of Works for Demonstrators A and B, in accordance to the work-plan of Project RECONECT H'2020-C5-08-2017-GA-776866 aiming to contribute to European reference framework on Nature Based Solutions (NBS) by demonstrating, referencing and upscaling large scale NBS and by stimulating a new culture for 'land use planning' that links the reduction of risks with local and regional development objectives in a sustainable way.

It has been produced as deliverable of WP2 on Demonstration, with the main objective of D2.3 to scope the NBS related demonstration activities by providing substantial level of detail/description of their projects in terms of NBS type, location characteristics, governance structures, etc. D2.3 aims also to facilitate the process of twinning between Demonstrators A and B for learning and knowledge sharing purposes. In addition, this report will further serve as a basis for the development of guidelines for design, implementation, and evaluation of NBS.

Report D2.3 summarises the results of the activities carried out by the RECONECT team primarily within Task 2.3 (*Co-assessment: Specifying baselines, scoping of detailed requirements with a focus on Demonstrators A and B*), supported also by activities carried out within Task 2.1, Task 2.2 and Task 2.5, as well as some activities within WP1, WP3 and WP5, running in parallel.

For specifying baselines and scoping of works of demonstrators an analysis on existing plans and ambitions has been performed. Information on available data and tools has been collected and analysed to determine high potential demonstration NBS, and establish co-assessment and co-creation roles of the RECONECT team in the process of demonstration and up-scaling of selected NBS.

The methodology used for collecting and analysing information is described in **Section II Methodology**. It is based on the RECONECT monitoring and evaluation strategy (to be developed in WP3) to evaluate the demonstrated NBS in relation to their potential to achieve benefits and co-benefits (e.g., flood risk reduction, enhancement of ecological landscapes, amenity and biodiversity, reduction of air pollution and noise, mitigation of heat island effects and health issues, and enhancement of energy efficiency and quality of life). Data collection and analysis of the necessary information for specifying baselines and scoping the works of Demonstrators has been done through questioning, interviewing, information exchange by electronic means, video conferencing, personal meetings, and visits to Demonstrators and NBS sites.

All baseline information from Demonstrators A and B is presented in **Section III and IV, Specifying baseline information & Defining Scope of Works**. This information includes presentation of NBS cases, climatic conditions, geomorphological characteristics, hydrological conditions, hydro-meteorological hazard description, stakeholder and governance, innovation potential, and benefits. Based on this information, and depending on the current stage of the NBS, the individual works are described, and the timeline is established for its construction, demonstration, evaluation and validation. An interactive web-based map showing the characteristics of the Demonstrators' NBS locations has been designed and is available at the RECONECT main web site www.reconect.eu. In addition, detailed description of the NBS sites for all Demonstrators and of the RECONECT project has been made available on Climate Scan, a web-based map application for international knowledge exchange on 'blue-green' projects around the globe.

The individual reports of Demonstrators A and B are subject to co-assessment within **Section V Synthesis of Network of Demonstrators.** The main findings from demo cases individually and as a whole are summarized in this section.

Taking into consideration the type of NBS, the potential for knowledge/lessons-learnt sharing, and based on the information provided by the Demonstrators, which is analysed within this section, the twinning potential between Demonstrators A and B has been assessed, and the structure of the RECONECT Demonstrators' Twining is suggested.

Basic conclusions and recommendations on further steps and activities are suggested in **Section VI Conclusions and Recommendations**. From the extensive knowledge exchange and communication within Task 2.3 leading to the production of this report, an increased awareness of the NBS benefits towards better informed decision making has been established and the first level of an increased international cooperation by RECONECT partners has been achieved.

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# Abbreviations

| | |
|---|---|
| EU FD | EU Floods Directive |
| FRMP | Flood Risk Management Plan |
| HRU | Hydrological response units |
| ICF | Indicator to monitor and evaluate connectivity |
| ICT | Information and Communication Technology |
| IHF | Indicator to monitor and evaluate mesohabitats |
| KPI | Key Performance Indicator |
| MSFD | Marine Strategy Framework Directive |
| NBS | Nature Based Solutions |
| QBR | Indicator to monitor and evaluate vegetation |
| RBMP | River Basin Management Plan |
| SCHAE | Schéma de cohérence hydraulique et d'aménagement d'ensemble |
| WFD | Water Framework Directive |

### Organisations

| | |
|---|---|
| AAKS | AARHUS KOMMUNE |
| ACA | Catalan Water Agency |
| BDCA | Black Sea - Danube Association of Research and Development |
| BFW | Austrian Research Center of Forests Department of Natural Hazards |
| BOKU-MET | Dept. of Meteorology, BOKU- University of Natural Resources and Life Sciences |
| DTES | Department of Territory and Sustainability of Catalonia |
| DTU | Denmark Technical University |
| EAWAG | Swiss Federal Institute of Aquatic Science and Technology |
| FHH | Free and Hanseatic City of Hamburg |
| FOEN | Swiss Federal Office for the Environment |
| HR | Hydrologic Research BV |
| IHE | Institute for Water Education, Delft, the Netherlands |
| InterAct | Inter Act Industrial Automation B.V. |
| IWA | International Water Association UK |
| SEI | Stockholm Environment Institute |
| TAUW | TAUW BV European consultancy and engineering firm |
| TUHH | Hamburg University of Technology |
| UFZ | Helmholtz- Zentrum fuer Umweltforschung GMBH |
| UIBK | University of Innsbruck |
| UNSA | University Nice Sophia Antipolis |

# I. INTRODUCTION

Implementation of Nature-Based Solutions (NBS) for hydro-meteorological risk reduction offers the possibility to break away from traditional practices and enable to **reconnect** our land management practices and developments with nature in order to achieve multiple benefits to services and functions of ecosystems. According to Olsen and Bishop (2009) and van der Nat et al. (2016), such measures are potentially more cost-effective and adaptable than traditional hard engineering measures. However, cost-effective design and implementation of NBS is only part of the answer. Of equal importance is the ability to effectively place them in **diverse local and cultural contexts** and integrate them into broader land and risk management strategies. It is therefore of crucial importance **to understand the complexity of each case** and to design the NBS in such way to minimise social/economic losses and environmental impacts, increase resilience to hydro-meteorological events, and ensure upscaling, business models and financial viability of any interventions. Examples of large scale NBS for hydro-meteorological risk reduction which can provide proof-of-concept for their upscaling and replication is currently lacking and there is a clear need to enhance their evidence base through demonstration within the European reference framework.

Project RECONECT H'2020-C5-08-2017-GA-776866 is an interdisciplinary international project that aims to contribute to European reference framework on NBS by demonstrating, referencing and upscaling large scale NBS and by stimulating a new culture for 'land use planning' that links the reduction of risks with local and regional development objectives in a sustainable way.

In order to contribute effectively to the EU reference framework on NBS and to generate higher impacts across Europe, RECONECT draws upon a number of Demonstrator Sites. They have been carefully selected to cover a range of local criteria including i) climatic and geographic conditions, ii) type of hydro-meteorological events (floods, storm surges, droughts, landslides), and iii) vulnerability to these events. Besides these criteria, the potential for collaboration and upscaling has also played a role in the selection process.

In order to capitalise on the existing knowledge and experiences on NBS within the RECONECT Consortium and initiate the knowledge sharing and upscaling process already in an early project stage, RECONECT bases its demonstration activities on two types of Demonstrators being A and B, which are at different stages in the NBS co-creation process.

In **Demonstrators Type A** the large scale NBS will include the full co-creation (i.e., co-assessment, co-design, co-implementation, co-monitoring and co-evaluation) and validation process during the project lifetime either by requesting co-funding from the EC and/or by deploying their own funds and resources.

The **Demonstrators Type B** cases have a considerable track record in implementing large scale NBS in natural and rural areas and particularly those that are sensitive ones (e.g. mountainous and coastal areas, at watershed/landscape scale) with high local/national/international visibility. In order to capitalise on their experiences on already implemented NBS, RECONECT will demonstrate their NBS by co-monitoring, co-evaluating and validating their multiple benefits.

In that sense, the Demonstrators B can make use and benefit from the already executed NBS within previous projects or initiatives and can provide the knowledge and experience on NBS implementation to the RECONECT Demonstrators A already in the early project phase. It especially relates to the experience on preparatory actions for the implementation, construction of NBS or overall project management activities (e.g. coordination, contracting or communication with the stakeholders). RECONECT draws upon **4 Demonstrators Type A** and **6 Demonstrators Type B**. The geographic spread of the RECONECT demonstrators is shown in *Figure I-1*.


| |
|---|
| **Demonstrators A:** |
| DA1: The Elbe Estuary, DE |
| DA2: Seden Strand, Odense, DK |
| DA3: Tordera River Basin, ES |
| DA4: Portofino Park, IT |
| **Demonstrators B:** |
| DB1: Ijssel River Basin, NL |
| DB2: Inn River Basin, AT |
| DB3: Greater Aarhus, DK |
| DB4: Thur River Basin, CH |
| DB5: Var River Basin, FR |
| DB6: Les Boucholeurs, FR |

*Figure I-1 The geographic spread of the RECONECT Demonstrators*

The RECONECT demonstration activities are coordinated and executed in **WP2 (*Demonstration*).** They cover the full span of the implementation activities starting from the preparatory actions, and stakeholder analysis over planning & design, construction to the preparation of the ground for co-monitoring and co-evaluation actions.

In order to assess and analyse all required actions to be undertaken to demonstrate the NBS in each Demonstrator, the scope of works analysis has been conducted within Task 2.3 (*Co-assessment: Specifying baselines, scoping of detailed requirements with a focus on Demonstrators A and B*), and is presented in this report **D.2.3: Scope of Works for Demonstrators A and B.** It provides substantial level of detail/description of the demonstrator's projects in terms of the NBS type, location characteristics, governance structures, stakeholders or envisaged monitoring and evaluation activities including the time plan of the actions.

Also, this report marks the starting point of the NBS monitoring and evaluation processes, where the multi-benefits of NBS will be systematically monitored and evaluated utilising cutting edge monitoring methods, tools, and ICT technology together with proven and further enhanced good practices for evaluation.

Furthermore, based on the scoped information, the process of twinning between Demonstrators A and B has been initiated. The potential demonstrator pairs for knowledge sharing could be identified, based on the local characteristics, envisaged/implemented NBS and on the demand-supply principle, paving the road for the RECONECT upscaling activities.

This report will benefit from the stakeholder analysis in the RECONECT Demonstrators A and B that is taking place in Task 2.1. (Preparing co-creation: stakeholder analysis, M1-8). The preliminary results of the analysis are included in this report.

The provided information serves as a basis for the report D2.5 where the preparatory actions for the demonstration are given in more detail for all RECONECT Demonstrators. In addition, this report will also be used as input when developing guidelines for design, implementation, and evaluation of NBS, which will be performed in WP5.

# II. METHODOLOGY

In order to scope the Works of the RECONECT Demonstration cases A and B, a survey and a thorough analysis of the local conditions and envisaged demonstration activities has been conducted in all RECONECT Demonstrators.

The overall methodology applied to scope and analyse the Works in Demonstrators A and B is given in Figure II-1.

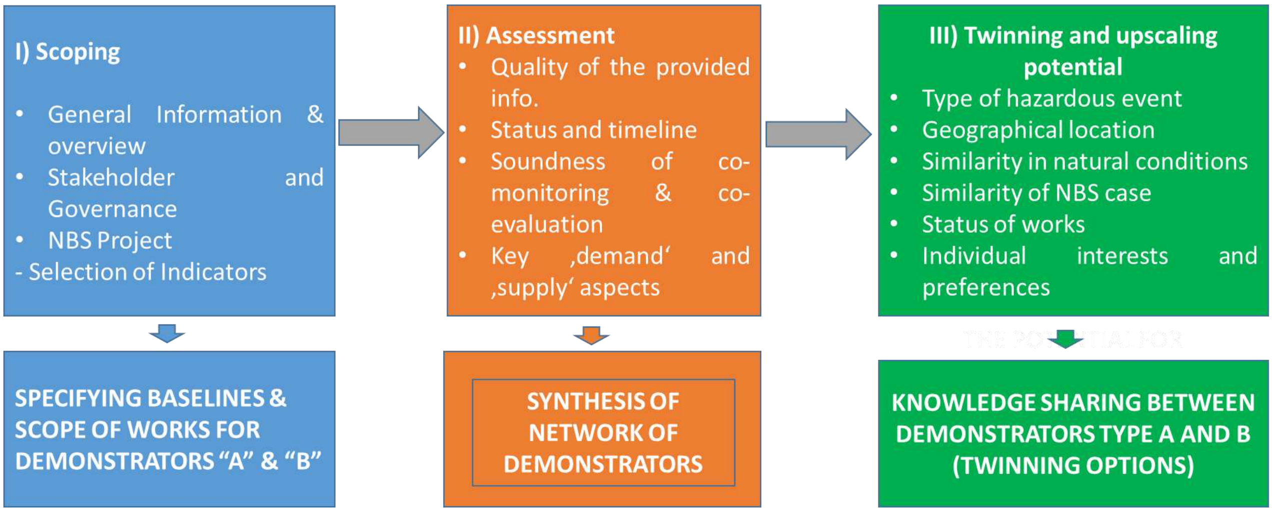


*Figure II-1 The methodology applied to scope the works for Demonstrators A and B (D2.3)*

In order to specify baselines (step 1- Scoping, see Figure II-1), the following information about the Demonstration cases has been collected:

- **General information and Overview**
  - Summary of the NBS case
  - Innovation potential
  - Geomorphological characteristics
  - Climatic conditions
  - Hydrological conditions
  - Hydro-meteorological hazard and problem description
  - Nature
- **Stakeholders and governance**
  - Stakeholders
  - Governance
  - Ownership
  - Project organisation and management
  - "People" – socioeconomical aspects
- **Project Scope: NBS to be demonstrated in RECONECT**
  - Project phases and planning

- Planning & Design
  - Procurement and contracting
  - Finance
  - Construction
  - Monitoring
  - **NBS Key Performance Indicators (KPI)**
  - Monitoring approach
  - Monitoring planning

The key aspect of the scoping process is the appropriate **selection of the key performance indicators (KPI)** to co-monitor and co-evaluate the benefits of NBS in the Demonstration sites.

The KPIs are defined in the RECONECT evaluation framework as depicted in Figure II-2.

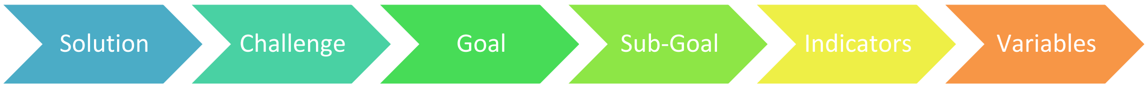


*Figure II-2 Definition of KPIs (Indicators) as a part of the RECONECT evaluation framework (WP3, in development, IHE Delft)*

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 indicators.

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.

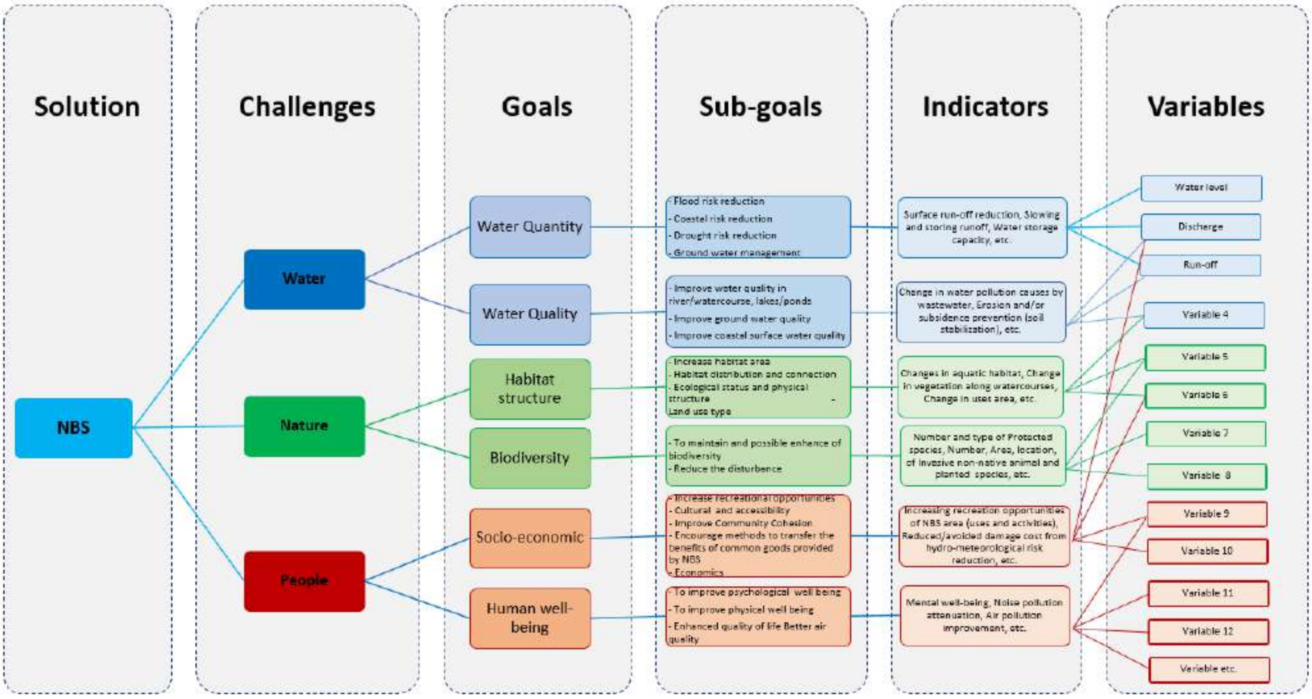


*Figure II-3 Definition of KPIs (Indicators) as a part of the RECONECT evaluation framework – a detailed view (WP3, in development, IHE-Delft)*

In order to have a common basis for the analysis, RECONECT adopted a top-down approach, in which a comprehensive list of KPIs following the pattern as given in Figure II-2 and Figure II-3, has been provided to all Demonstrators A & B for selection (in total 91 indicators covering WATER, NAUTRE and PEOPLE dimensions). In this way, each Demonstration partner could assess the relevance of each indicator for the own case and include it in the monitoring and evaluation plan. The full list of KPIs is given in Annex 1.

The scoping and surveying of the relevant information (step I) also refers to the stakeholder analyses in which the key stakeholders, their roles and level of involvement have been identified for each Demonstrator A and B (as part of Task 2.1). The preliminary outcomes have been included in this report.

Further, the outcomes of the demand-supply analysis on the needs and available expertise of the Demonstrators that has been surveyed in Task 2.2 have been used in a summarised form in this report.

The results of the baseline assessment and the scope of works are presented for each Demonstrator in sections III) and IV) on Specifying Baselines and Scope of Works for Demonstrators A and B, respectively.

**In the following step (step II, see Figure II-2)**, the presented baselines and scope of works have been assessed and evaluated considering the following aspects:

1. Status of the NBS Project:
    a. Quality, clarity and completeness of the provided NBS case description
    b. Planning timeline of the works and their compliance with the overall RECONECT objectives and timelines

c. The soundness of the co-monitoring and co-evaluation procedures including the selected indicators

2. The key ‘demand’ and ‘supply’ aspects of each Demonstrator, i.e.:

   a. Which expertise is needed by the Demonstrator (demand) and

   b. What type of expertise/lessons learnt, in regards to the NBS implementation, monitoring and evaluation the Demonstrator can share with the others (supply).

The results of the analysis are presented in Section V on Synthesis of Network of Demonstrators.

**In the final step (step III, Figure II-2**) the potential for knowledge sharing and twinning between Demonstrators A and B has been assessed, taking into account the following aspects and specific features of each case:

a. Type of hydro-meteorological hazard identified and type of the NBS project (flash flood, fluvial flood, landslide, coastal flood, etc.)
b. Geographical location, distance between partners
c. Similarity in natural conditions (climate, terrain, hydrology, river basin scale)
d. Similarity of NBS type - the technical solutions
e. Status of Works
f. Expressed wish by the Demonstrator for twinning and knowledge exchange

Based on these criteria, Demonstrator A and B couples have been identified and suggested. The twinning among Demonstrators is an initial step of the upscaling process and will be included in the RECONECT upscaling strategy being developed in WP4.

The results of the knowledge sharing and twinning procedure and results are presented in Section V.4 “The potential for knowledge sharing between Demonstrators type A and B (twinning options)”.

# III. SPECIFYING BASELINES & SCOPE OF WORKS FOR DEMONSTRATORS "A"

# 1 DEMONSTRATOR DA-1: DOVE/GOSE ELBE ESTUARY, GERMANY

## 1.1 Overview

### *1.1.1 Summary of the NBS case*

The demonstration activities in the German Demonstrator (DA1) will focus on 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 in the area of 175 km$^2$, to create more retention volume for water during <u>flooding</u>. At the same time necessary stable water levels in the rivers can be provided during <u>droughts.</u> In that sense, the main goal of the DA1 Demonstrator is improved water resources management in the area that is adequately addressing both hydrometeorological events i.e. floods and droughts, by enhancing the existing grey infrastructure with the NBS.

The distribution of the storage volume during flood events will be managed by the RECONECT NBS operation and 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 expected to generate the following benefits:

- Improved management of the hydrometeorological 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

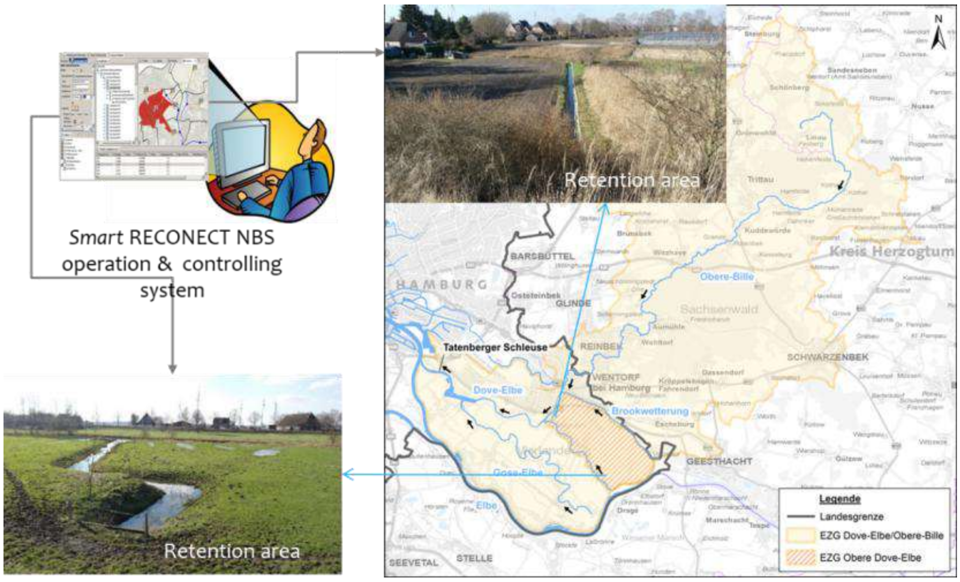


*Figure 1-1 The demonstration area Dove/Gose Elbe (marked in yellow) and the typical retention areas*

### 1.1.2 RECONECT – innovation potential

The innovation potential of the DA1 demonstrator can be seen at different levels, the main ones being:

- Holistic approach to flood and droughts management utilising NBS rather than a piecemeal approach that has been practiced so far
- Innovative technology for the RECONECT NBS operation and controlling system to be applied for a tidal influenced area to manage and (re)distribute the water volume in the Bille and Dove/Gose Elbe river system

### 1.1.3 Geomorphological characteristics

The network of small rivers and streams of the Dove/Gose Elbe system is located in the south-eastern 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 Vier- und Marschlande, which includes Bille/Schleusengraben and Brookwetterung rivers in addition to Dove and Gose Elbe (*Figure 1-1*).

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%). Based on the soil measurements conducted on approx. 2500 measuring spots in the area (BUE, 2004), the soil type is typical for marsh areas. It has an impermeable top layer of on average 6 m thickness, usually composed of clay or peat ($k_f = 1 * 10^{-8}$ to $k_f = 1*10^{-9}$ m/s). Beyond the layer of clay or peat sandy and gravels occur to a depth of 30 m NHN. Only in the north-eastern part of the area (that belongs to the federal state of Schleswig-Holstein), the geest soil type (sandy and silty) is dominating.

### 1.1.4 Climatic conditions

The demonstration area is subjected to the maritime climate due to its proximity to the North Sea. The most relevant parameter for the demonstration activities is precipitation.

*Figure 1-2* depicts precipitation (N) in [mm] expressed in monthly values for the weather station Hamburg- Billwerder that is located in the demonstration area.

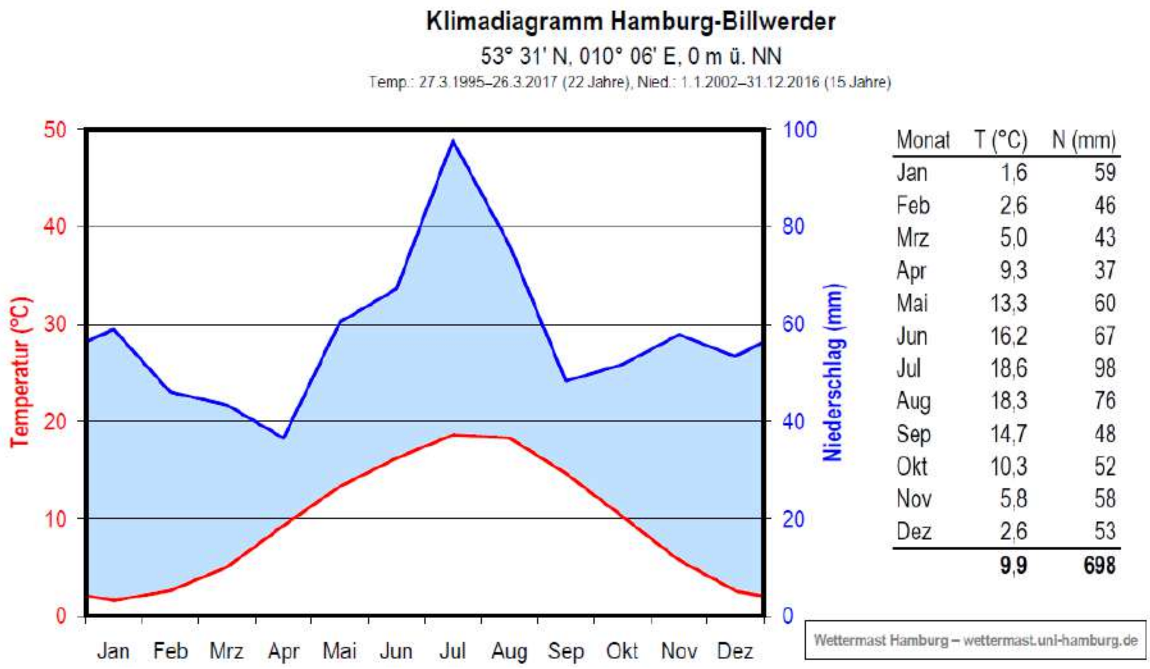


*Figure 1-2 Precipitation values (N) in [mm] for the weather station Hamburg Billwerder location in the demonstration area*

*(Source: University of Hamburg https://wettermast.uni-hamburg.de/frame.php?doc=Klimadiagramm20170328.htm)*

#### 1.1.5 Hydrological conditions

The hydrological conditions in the area are highly complex. They are based on the one hand on the nature of the problem (tidal influenced marsh area) and on the other hand on the historical development of the area. By decoupling or (re)connecting rivers, tranches or ditches in the area, a complex network of various surface waters developed.

The two main rivers of the system **– Dove Elbe and Gose Elbe –** are branches of the Elbe River that have been hydraulically decoupled from Elbe River by dikes and sluices. In order to regulate the water levels within the drainage area, a system of high complexity consisting of the two main rivers including smaller rivers, ditches and pumps as well as water management facilities was developed over time (Figure 1-3).

The lower Dove Elbe begins at the Dove Elbe sluice and runs up to the Tatenberger sluice, where the Dove Elbe flows into the Elbe River. The lower Dove Elbe receives regulated flows at the upstream from the upper Dove Elbe via the Dove Elbe sluice and from the Neuer Schleusengraben via the Krapphofschleuse sluice, on the left side towards the end of the river from the Gose Elbe via the Reitschleuse sluice and the flow at the downstream outflow into the Elbe River is regulated via the Tatenberger sluice. These sluices control the unfavourable combination of inland floods and storm surges from the tidal Elbe River.

The upper Dove Elbe begins behind Elbe River dike as a ditch and ends at the Dove Elbe sluice. The catchment areas of the Dove Elbe and Brookwetterung (see Figure 1-1) are approx. 54 km² and 37 km², respectively. About half the catchment of the Dove Elbe is occupied by the Curslack/Altengamme water extraction area. The Curslack/Altengamme water extraction area contains the water protection area of the Curslack waterworks, which has been supplying drinking water as Hamburg's largest waterworks since 1928.

The Gose Elbe also starts behind the Elbe River dikes as a ditch and flows in north-western direction. The Gose Elbe and Dove Elbe are joining at the Reitschleuse sluice. The catchment area of the Gose Elbe is about 69 km² and is mainly drained through a pumping station into the Dove Elbe (Figure 1-3). The pumping station is necessary as the elevation of the area is quite flat and the water flow from the river into the area has to be prevented. The Gose Elbe is also directly connected to the upper Dove Elbe by the Neuengammer Durchstich.

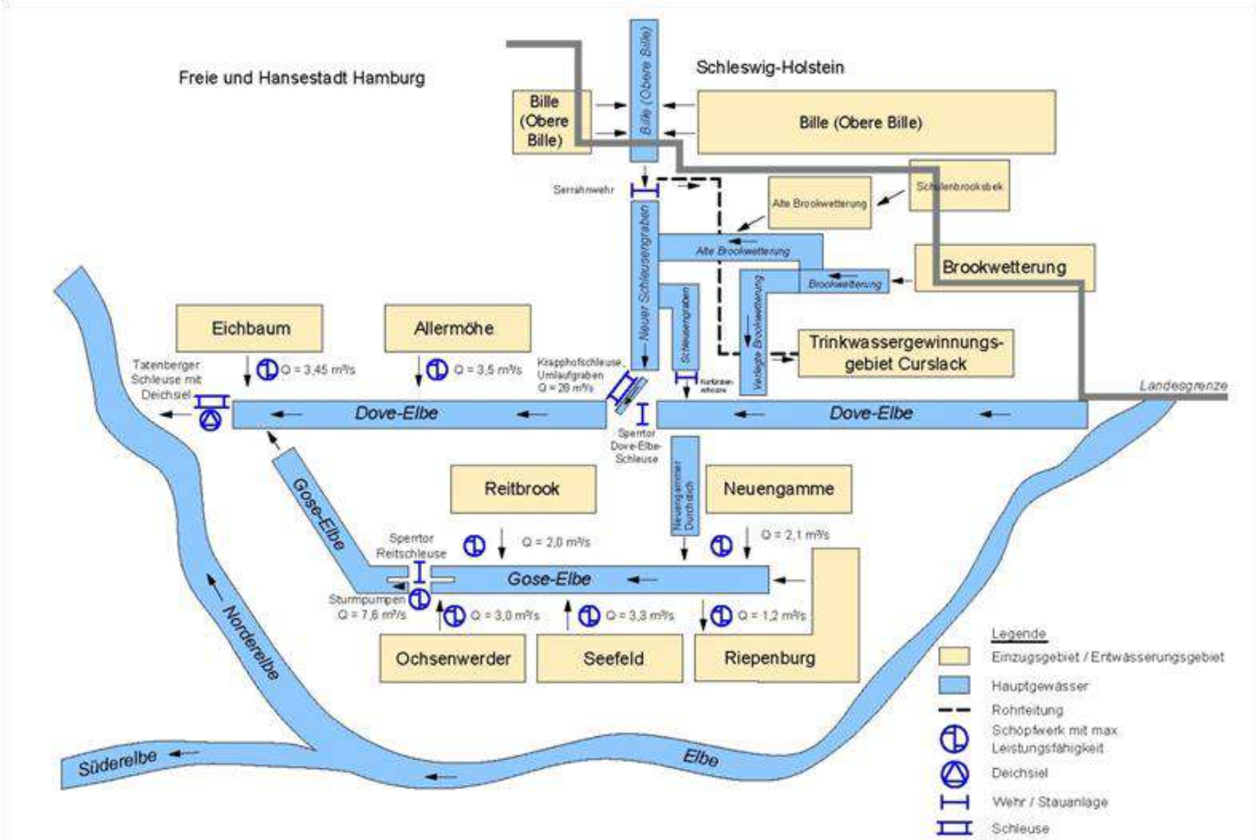


*Figure 1-3 The Dove and Gose Elbe River System with its main elements (subcatchments, main water courses, pipe network, pumping stations, dike outlets, weirs, locks)*

Groundwater is a relevant parameter in the demonstrator project, due to its exploitation for drinking water supply.

The groundwater body (El12) is in a poor state, with respect to chemical and quantitative status. The reason for the poor state are locally high concentrations of chloride caused by saltwater intrusions. Regional analyses specific for the project area can be made by the evaluation of water analysis from groundwater observation wells. Groundwater levels in the area are depicted in *Figure 1-4*.

### 1.1.6 Hydro-meteorological hazard and problem description

The NBS to be implemented in RECONECT will address the two main hydro-meteorological hazards:

- 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). The process of designation passed the public hearings and participation during the period of 2015-2017. In that sense, the demonstration within RECONECT is in line and will contribute to the implementation of the EC Floods Directive (2006/60/EC).

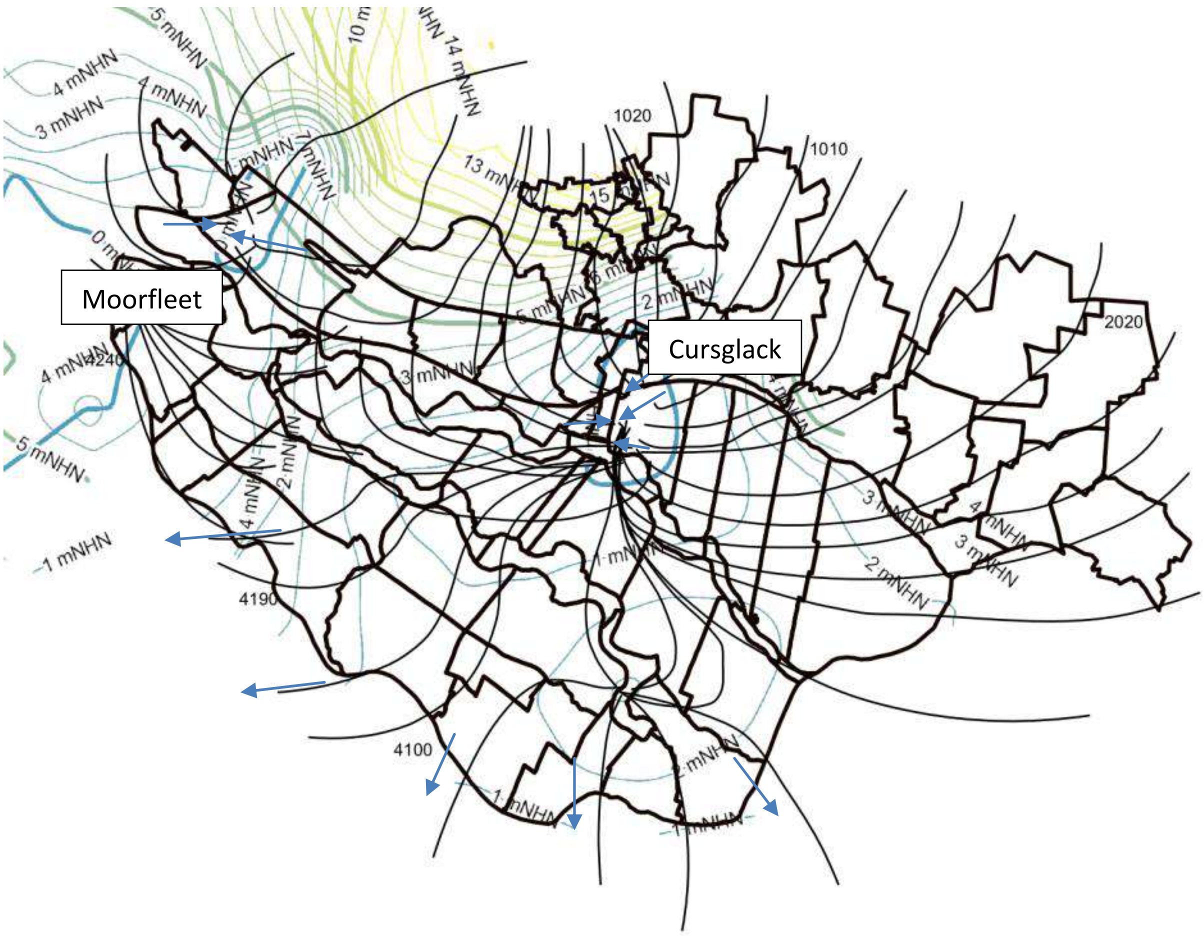


*Figure 1-4 Groundwater levels (coloured lines) and flow direction. The area of Curslack is the main potable water source in Hamburg; Moorfleet is the low-lying urban area*

*(Source STUCK project)*

### *1.1.7 Nature*

Different types of protected areas for the preservation of natural resources are located within the demonstration area.

The area is of prominent importance as a groundwater extraction site for the drinking water supply of the City of Hamburg (Gebiete für die Entnahme von Wasser für den menschlichen Gebrauch). This area comprises a total of 28 km². A partial area (24 km²) of the extraction site was declared as water protection area in 1997. The status of these areas are regulated by the Federal and Water Law of the City of Hamburg. Furthermore the following protected sites were declared in the demonstration area:

- nursing grounds and growth areas of juvenile fishes,
- recreational purposes and swimming (EC-Directive 76/160/EC),
- as hazardous area according the Nitrate Directive (EC-Directive 91/676/EC),
- as nutrient sensitive according the waste water directive (Directive 91/271/EC),

16.01 km² of the working area comprises the extension of protected areas according the European Bird (Directive 79/409/EC) and Directive of Flora, Fauna, Habitats Directive 92/43/EC. 15.99 km² comprise nature protection areas related to surface water according to the Hamburg Natural Environment Protection laws.

## 1.2 Stakeholders and governance

### *1.2.1 Stakeholders*

In the demonstration area, there is a number of public and private stakeholders that are having and influence or are affected by the NBS actions.

The key public stakeholders have been identified as follows:

- The Ministry of Environment and Energy responsible for the management of water courses and groundwater
- The Agency for Roads, Bridges and Waterways (LSBG)
- The Hamburg City District of Bergedorf
- Hamburg Water Utility responsible for the water supply of the city of Hamburg
- Politics (including the Senate Chancellery)

Further, the following stakeholders have been identified and should be considered for the co-creation of NBS:

- Heritage Conservation Agencies
- Water boards
- Dwellers and general public
- Local organisations and associations such (e.g. the fishing clubs)
- Nature conservation actions and associations
- Business and Industry:
    - Shipping
    - Tourism
    - Agriculture
    - Real Estate Agencies
- Universities/ Science

Also, the politics and the developments at the political and strategic level are perceived as a potential risk and can have an impact on the NBS implementation in the area.

The actual roles and relevance of the above mentioned stakeholder groups are developing in a dynamic manner and the distribution of roles and relevance currently cannot find the consent among the RECONECT team. An outcome of the discussion on the stakeholders is depicted in *Figure 1-5*.

### *1.2.2 Governance*

The main authority involved is the Ministry of Energy and Environment (BUE) who is the responsible for the design and implementation of the NBS. The Bergedorf district will operate and maintain the system with the support from the BUE.

### *1.2.3 Ownership*

The ministry of Environment and Energy is owner of the NBS. The maintenance and operation will be conducted by the Bergedorf district.

### *1.2.4 Project organisation and management*

The NBS demonstration will be undertaken by the Ministry of Energy and Environment (BUE) supported by the Agency of Roads, Bridges and Waterways (LSBG) and the Bergedorf district. Hamburg University of Technology (TUHH) will provide the scientific support to the implementation. The Senate Chancellery coordinates the different project activities.

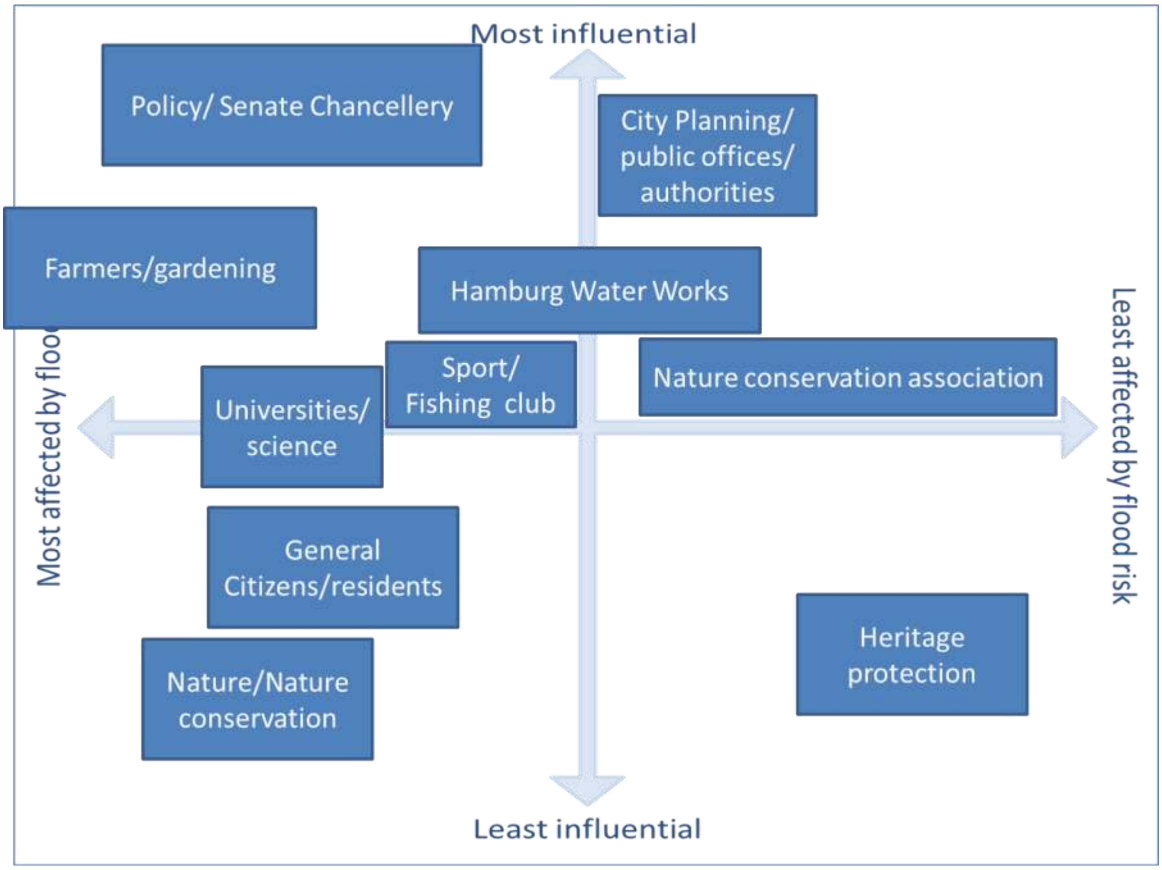


*Figure 1-5 Organo-sociogram of the key stakeholders in the demonstration area (one version produced by the members of the RECONECT HH team)*

#### 1.2.5 *"People" – socioeconomic aspects*

The Vier- und Marschlande is a rural and natural area of the State of Hamburg with 27.431 Inhabitants (Census Data Hamburg North, 2015). It is dominated by the natural and agricultural areas, where typically vegetables and plants & flowers are grown. Due to the natural areas, some of them being under NATURA 2000, it is also often used as a recreational area (sports, fishing, boat tours) and for tourism.

Within the Communication and Participation Program Forum Tideelbe (https://www.forum-tideelbe.de/), the co-creation process has already been initiated involving the key stakeholders in the area while addressing the future development of the Dove/Gose Elbe area (Meine & Schruttke, 2018).

## 1.3 Project Scope: NBS to be demonstrated in RECONECT

### 1.3.1 *Scope summary*

Within RECONECT the innovative NBS operation and real time controlling system will be implemented to optimise the usage of the retention areas in the Dove and Gose Elbe river system. The main functional elements of this solution are the (natural) storages in the water courses and in the flood plains of the demonstration area. The distribution of the storage volume will be controlled by the NBS operation and real time controlling system, which is to be developed and implemented at the local authority (the district of Bergedorf). The demonstration will be executed in the following phases (see Table in section 1.3.2).

### 1.3.2 *Project phases and planning*

*Table 1-1 Elbe Estuary NBS project phases and planning*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning: (Server setup) | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | If required | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | If required | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

### 1.3.3 *Planning & Design*

The planning and design phase will benefit from the previous project and activities in the area. In the STUCK project (https://www.stuck-hh.de/index.php?id=40), a concept for the smart operation of the retention areas has been developed, which will serve as a basis for the NBS design and implementation in RECONECT.

### 1.3.4 *Procurement and contracting*

The equipment for the NBS control& operation system will be purchased following the Hamburg Law and acts on the procurement and contracting.

#### 1.3.4.1 *Finance*

The implementation of the NBS will be funded by the EC, i.e. the RECONECT Project. Once implemented, it will be embedded in the overall infrastructure for flood protection in the area including the grey assets with the aim to generate hybrid solutions (with the current value of approx. 10 Mio EUR).

### 1.3.5 *Construction*

The construction/ implementation phase will include the following steps:

- Setting up and operation of the server for the control& operation system
- Setting up of the rainfall- runoff model for
- Technical implementation of the automatic data transfer from the forecasting system regarding surges, precipitation, discharges to the server
- Technical implementation of the optimised management of the retention areas due to control and distribution of the storage volume
- Adaptation of the retention areas (if required)

### 1.3.6 *Monitoring*

The following indicators have been/ will be monitored within RECONECT:

#### 1.3.6.1 *Indicators*

DA-1 Hamburg has selected 23 Indicators to monitor, of which 10 in category Water, 4 in category Nature, and 9 in category People, as presented here below in Table 1-2.

*Table 1-2 Elbe Estuary NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | Surface runoff reduction | Precipitation<br>- Soil type<br>- Land use<br>- Topography /DEM<br>- Radiation<br>- Temperature<br>- Evaporation<br>- Wind speed<br>- Roughness coefficient<br>- Infiltration capacity<br>Will be measured or taken from the existing reports and databases | | STUCK Project |
| | Slowing and Storing runoff | See above | Computed utilising HN models (KALYPSO) | STUCK Project |
| | Flood hazard | Discharge and Water levels<br>Topography | Existing maps will be taken where exist + Computed utilising HN models (KALYPSO) | Flood hazard Mapping in Hamburg urban catchments (Implementation of the EC FD) |
| | Vulnerability | - Land use map<br>- Infrastructures data<br>- Population data<br>- Building/Housing | Taken from the existing databases including the online available Hamburg Transparenzportal | |
| | Delay time to peak | - Discharge time series, (m3/s)<br>- Water level time series (m.sl)<br>- Topography (DEM)<br>- Channel cross sections<br>- Roughness coefficient | | |
| | Flood peak reduction | - Discharge time series, (m3/s)<br>- Water level time series (m.sl)<br>- Topography (DEM)<br>- Channel cross sections<br>- Roughness coefficient | | |
| | Changes in water pollution caused by wastewater | Pollutants as relevant (in preparation) | Existing measuring stations and reports if applicable | |
| | Reduced pollutants coming from land to water | Pollutants as relevant (in preparation) | Existing measuring stations and reports if applicable | |
| | Attenuation of heavy metals and nutrients contamination in surface water | Pollutants as relevant (in preparation) | Existing measuring procedures and devices and reports if applicable | |
| | Sediment deposition | TSS | Existing measuring procedures | |

| | | | | |
|---|---|---|---|---|
| NATURE | Distribution of public green spaces | | Official reports and existing procedures | |
| | Biodiversity | | Official reports and existing procedures | WWD |
| | Diversity of landuse in agricultural area | | Existing and surveyed (Geo)data | |
| | Change in landcover | | Existing and surveyed (Geo)data | |
| PEOPLE | Increase recreational opportunities of NBS areas | All People indicators will be discussed with the RECONECT experts on social monitoring to set up the methodology | | |
| | Number of tourists | | | |
| | Number of cultural events in NBS area | | | |
| | Number and value of people spend time in the NBS areas | | | |
| | Number of green jobs in the area | | | |
| | Reduced/ avoided damage cost from hydro-meteorological risk reduction | | | |
| | Economic benefit from the reduction of stormwater that typicaly needs to be treated in a public sewerage system | | | |
| | Change in land and/or property values | | | |
| | Number of people communicating in the area | | | |

#### 1.3.6.2 *Monitoring approach*

The monitoring plan of the demonstrated NBS will start with the baseline monitoring and will make use of the previous monitoring activities mainly in relation to the water quantity (such as precipitation or discharge). Moreover, the existing equipment and services will be used for the baseline and after the implementation monitoring. The experience with the monitoring of the 'nature' parameters from the STUCK Project will be used as the basis for setting up the monitoring program and its dynamics. The expertise from the social sciences available in the RECONECT team is needed to set up the monitoring plan for the 'PEOPLE' indicators.

The final time plan for monitoring will be adjusted when the expertise and the time plans of the thematic experts (for the assessment and monitoring of the PEOPLE and NATURE indicators) will be available.

### 1.3.6.3 *Monitoring planning*

*Table 1-3 Elbe Estuary monitoring plan*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| Water | Quantity | | | | | | | | | | | | | | | | | | | | |
| | Quality | | | | | | | | | | | | | | | | | | | | |
| Nature | All | | | | | | | | | | | | | | | | | | | | |
| People | P1 | | | | | | | | | | | | | | | | | | | | |

#### 1.3.6.4 *Data management system*

The data required for the implementation is available at the responsible institutions (BUE and LSBG).

Moreover, the census data as well as the basic geo data (maps, land use) is available online. (http://transparenz.hamburg.de/ and https://geoportal-hamburg.de/Geoportal/geo-online/)

As one of the key demonstration aspects here is to develop a control and operation system as an ICT platform, the activities to integrate the data and information into the RECONECT Services platform are planned for the forthcoming periods.

### 1.3.7 *Evaluation*

The NBS to be implemented are expected to generate the following benefits and co-benefits.

1) Reducing risk to hydro-meteorological events:
    - floods
    - droughts
2) Improvement of the ecological conditions in the water courses and catchments
    - Continuous functioning of the fish ladders and passages
    - Improved biodiversity
    - Contribution to development Goals of the Water Framework Directive (2000/60/EC)
3) Positive impact on economy and social environment (agriculture, drinking water supply for Hamburg – groundwater wells, tourism, recreational)

### 1.3.8 *References & Sources*

Behörde für Umwelt und Energie, Amt für Umweltschutz, Freie und Hansestadt Hamburg (2004): Umsetzung der EG-Wasserrahmenrichtlinie (WRRL) – Landesinterner Bericht zum Bearbeitungsgebiet Bille: Bestandsaufnahme und Erstbewertung. Stand 20.09.2004. Hamburg. https://www.hamburg.de/contentblob/4237764/b7b16f17148b5838805b8ae7860dc372/data/d-landesinternerbericht-bille.pdf

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# 2 Demonstrator DA-2: Odense Coastal Area, Denmark

## 2.1 Overview

### *2.1.1 Summary of the NBS case*

Due to the change in climate the suburban area at Seden Strand is threatened by flooding due to the rising sea level. At Strand 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 both by EU´s Bird Directive[1] and Habitat Directive[2]. The status of the Natura 2000-site has to be improved because of a decline of habitats due to cultivation and overgrowth among others.

Instead of trying to solve the above challenges separately this project wants to combine the interests and with a holistic approach look at solutions which make (more) space for people, nature and water.

At Seden Strand this includes:

- Removal of existing low coastal summer dikes and moving them inland to a higher location
- Promote rehabilitation of new habitats (salt meadows - 1330) outside the new dikes
- Recreation of meanders of existing streams
- Focus on target species like the avocet (Recurvirostra avosetta) and the natterjack toad (Epidalea calamita)

See more in Figure. 2-1.

### *2.1.2 RECONECT – innovation potential*

- Developing tools on how to combine solutions dealing with climate changes and loss in biodiversity.

[1] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds
[2] Directive 1992/43/EEC of the European Parliament and of the Council of 21 May 1992 on the conservation of natural habitats


*Figure 2-1 Project area and planned actions*

Developing tools to compare the effect/added value of a nature- based solution compared to a "traditional grey solution".

With these tools there will be a great potential for "copying"/up scaling the NBS approach to other similar locations at protected coast lines.

Matching NBS innovations with the needs of wider groups of stakeholders will be described in the Stakeholder analysis undergoing within Task 2.1.

The same report will give details also on drivers and/or barriers for up scaling of these innovations

### *2.1.3 Geomorphological characteristics*

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 %


*Figure 2-2 The project area and the surrounding area.*

The area surrounding Seden Strandby is primarily used for farming including production of vegetables and grazing with horses. See Figure 2-2

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.

### 2.1.4 Climatic conditions

The climate conditions of the project area near Odense are dominated by Atlantic coast conditions as shown below.

Snowfall happens from November to march, but due to the climate change, periods with snowfall are decreasing. However, some winters with more continental weather conditions can include longer periods with snowfall and ice on Odense Fjord and even the more open seas.

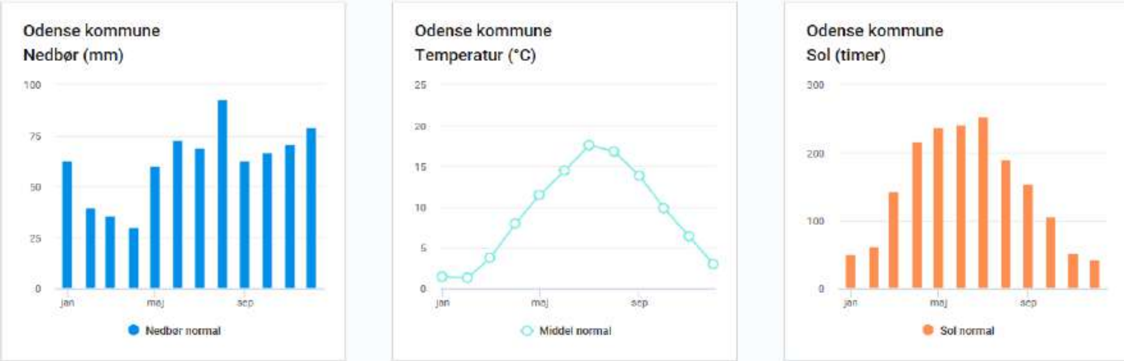


*Figure 2-3 Precipitation (mm), Temperature (°C) and Sunshine (hours) in the project area near Odense*

### 2.1.5 Hydrological conditions

The catchment area of two minor streams crossing the project area is only 4,1 km$^2$. The two small streams are in the 1950 replaced from their natural course to a channel with a sluice at the eastern border of the project area, in order to cultivate the march area.

- River length 3,5 km and 1,0 km
- River length within the NBS area 1,5 km
- Total catchment area 4,1 km$^2$
- River discharge year average 39 l/sec.

Coastal systems:

- Mean sea level + 0,05 m, normal high tide 0,4 m,
- Significant wave height 0,5 m at NBS site,
- Storm surge + 1,95 m (100 years return period)
- Water salinity 2,5 %.
- Water quality in Odense Fjord is hampered of outlet of fertilizers form the catchment including one third of the area of Funen
- Bathing in the shallow water of Odense Fjord is not practiced due to better conditions at the nearby beaches at the open sea.

### 2.1.6 Hydro-meteorological hazard and problem description

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.

The high-water level at the actual conditions is + 1,95 m with a 100-ears return period and +1,55 m with a 20-years return period.  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.

### 2.1.7 Nature

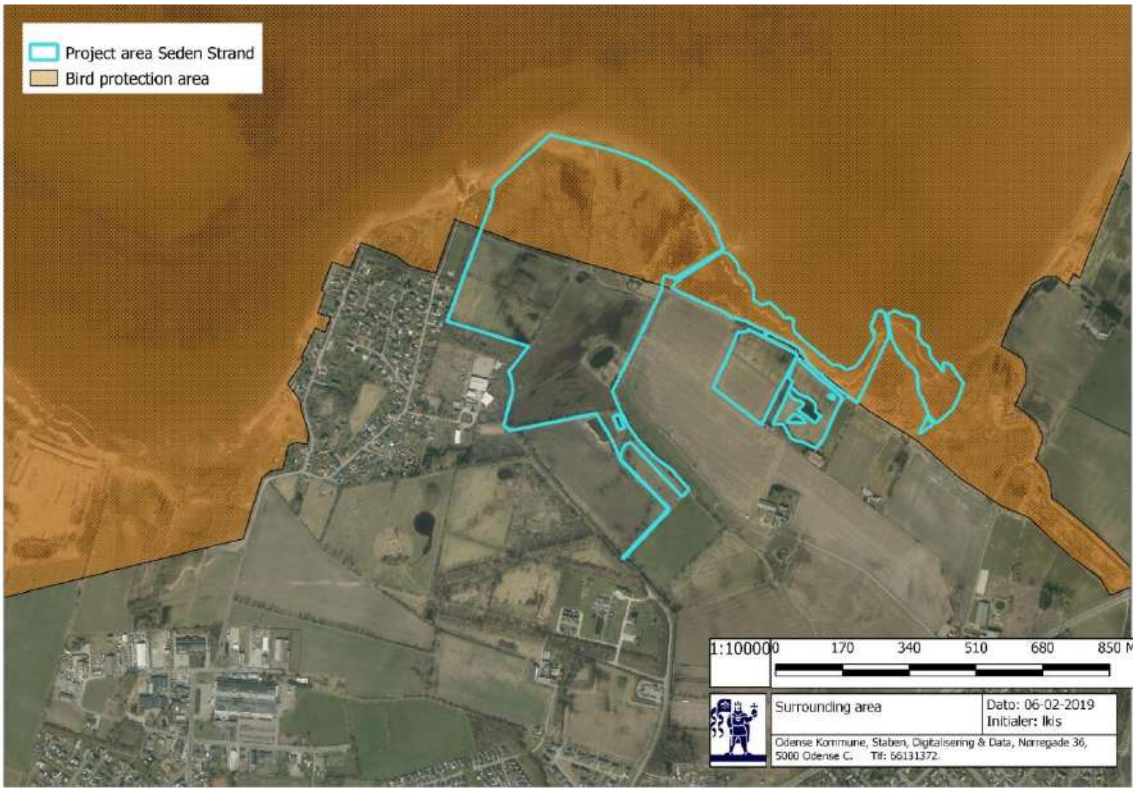


*Figure 2-4 Natura 2000 at Seden Strand. It covers 50 % of the project area.*

Odense Fjord is an important resting and breeding area for waders, ducks, geese and swans. Odense Fjord and the surrounding fiord habitats are therefore designated as a Natura 2000 site DK008X075, protected both by EU´s Bird Directive[3] and Habitat Directive[4]. See fig. 2-4 and 2-5.

Approx. 50 % of the project area at Seden Strand is placed within the Natura 2000 area at Odense Fjord.

| | | |
|---|---|---|
| **Birds:** | **Barnacle goose (*Branta leucopsis*)** | **Western marsh harrier (*Circus aeruginosus*)** |
| | Whooper swan (Cygnus cygnus) | Mute swan (*Cygnus olor*) |
| | Eurasian coot (*Fulica atra*) | White-tailed eagle (*Haliaeetus albicilla*) |
| | Goosander (*Mergus merganser*) | Red-breasted merganser (*Mergus serrator*) |
| | European golden plover (*Pluvialis apricaria*) | Pied avocet (*Recurvirostra avosetta*) |
| | Common tern (*Sterna hirundo*) | Arctic tern (*Sterna paradisaea*) |
| | Sandwich tern (*Thalasseus sandvicensis*) | |

*Figure 2-5 Birds for which the Natura 2000 site at Odense Fjord has been designated. Underlined species are relevant for the project area.*

[3] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds

The coastal areas are dominated by Atlantic salt meadows (see Fig. 2-5). The area of salt meadows has historically been larger but has declined due to cultivation. According to the survey of the habitat carried out in 2011 (http://naturereport.miljoeportal.dk/577060 ) the quality of the habitat has been assessed as moderate. The indicators of the habitat quality show moderate signs of change due to the human activity and higher disturbance than under good condition.

The Natura 2000 site DK008X075 has been established among others for protection of the Atlantic salt meadows (1330) and barrier beach with perennial plants (1220) habitat types.

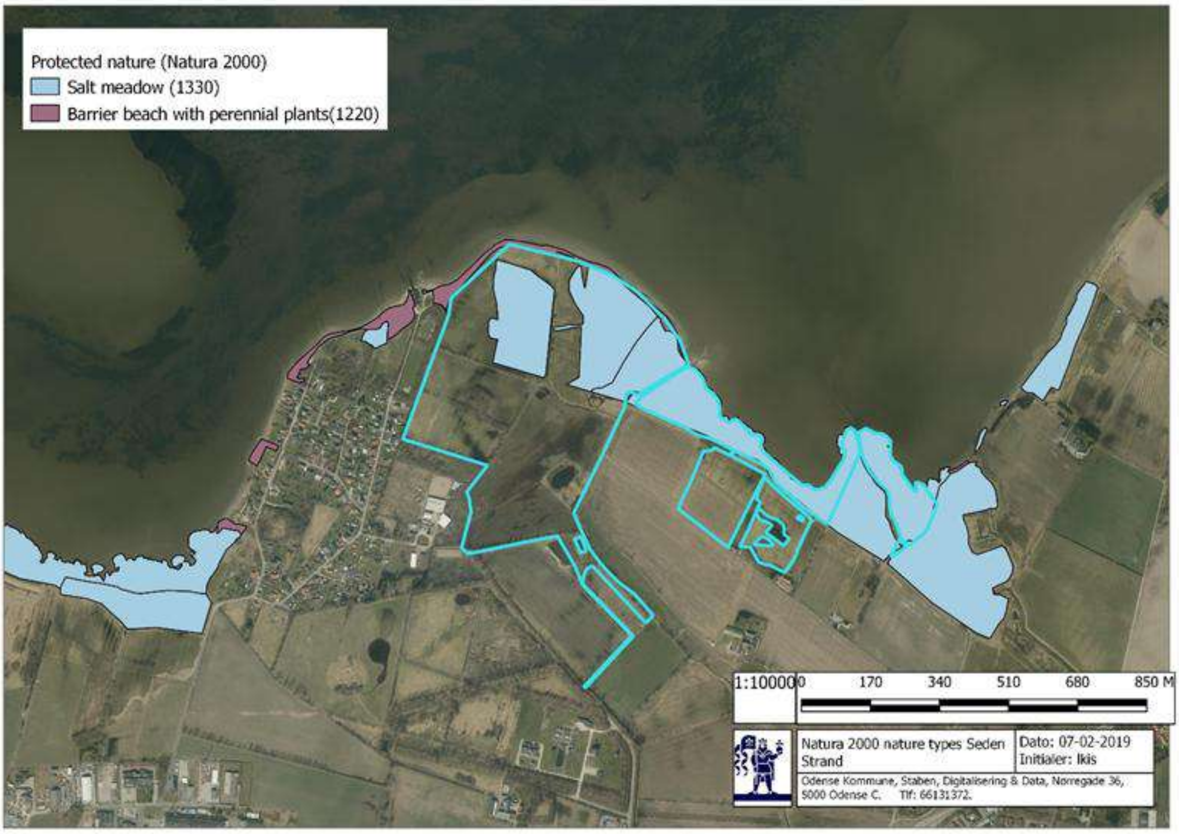


*Figure 2-6 Nature types within the project area. Codes are referring to the official Natura 2000 code; given for all Natura 2000 nature types.*

## 2.2 Stakeholders and governance

### *2.2.1 Stakeholders*

We have several interests in the area who we have an obligation to deal with: protection of urban areas, protection of infra structure, stopping biodiversity loss in and outside Natura 2000, protection of valuable coastal landscapes. Various stakeholders (incl. local authorities, sectoral agencies, NGO, the general public, etc.) are involved in this process.

Detailed information on stakeholders' involvement is being collected and analysed within Task 2.1 "Preparing co-creation: stakeholder analysis", (Demonstrators Survey) and can be found in the relevant documents elaborated within this Task.

### *2.2.2 Governance*

The main authority within the project is Odense Municipality. The municipality is responsible both for dealing with climate changes locally and the conservation of nature excluding marine habitats.

### 2.2.3 *Ownership*

The land where the NBS will be constructed is privately own. The construction of the NBS will be led by Odense Municipality as well as maintenance during 3 years after the construction is finished.

Consequently, the maintenance will be handed over to the landowners. This is stated in the land register.

### 2.2.4 *Project organisation and management*

The demonstration project at Seden Strand will be completed by a cluster including:

- Odense Municipality
- Permissions, developing of demonstration project, construction and maintenance (also including financing)
- Amphi International
- Developing of demonstration project, monitoring
- Rambøll
- Developing of demonstration project, monitoring

### 2.2.5 *"People" – socioeconomical aspects*

The project area is located within distance of approx. 8 km from the Odense, the largest city on the island Fyn with 178.210 inhabitants (2018). Seden Strand, a suburban settlement of 338 inhabitants (2018) is bordering the area of the project from the West. 142 private houses/properties are at the direct risk of flooding. The prices for private housing range from approx. 1.200 -1.880 EURO per m2 (www.boligsiden.dk).

Ca. 50 % of the project area is used for agriculture. 66 hectares of agricultural land in the project area is at the risk of flooding. The land prices range from 6700 EURO/ha for meadows up to 25000 EURO/ha for plough land and are similar to the land prices along the coastline on the island.

## 2.3 Project Scope: NBS to be demonstrated in RECONECT

### 2.3.1 *Scope summary*

The demonstration project at Seden Strand will use a holistic approach and work with solutions which combine the interests in the area and makes (more) space for people, nature and water.

At Seden Strand this includes:

- Removal of existing low coastal summer dikes and moving them inland to a higher location
- Promote rehabilitation of new habitats (salt meadows - 1330) outside the new dikes
- Recreation of meanders of existing streams
- Focus on target species like the avocet (Recurvirostra avosetta) and the natterjack toad (Epidalea calamita)

### 2.3.2 *Project phases and planning*

*Table 2-1 Odense Coastal area NBS Project phases and planning*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Nov18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land compensation (already done) | | | | | | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

<u>Project phases</u>

1. *Preparation and planning – September -2018 – March-2019*
2. *Creation, co-creation, (co-)design – January 2019 – July 2019*
3. *Land compensation - Agreed already with landowners*
4. *Environmental impact assessments & Permitting – April 2019 - October 2019*
5. *Tendering, procurement and contracting – July 2019 – November 2019*
6. *Execution of works – November 2019 – December 2020 (depending on weather, can be earlier if permitting will be ready earlier)*
7. *Baseline situation & Monitoring – March 2019 – December 2022*
8. *Evaluation & Closure – January 2023 – August 2023*

### 2.3.3 Planning & Design

The detailed design of the dikes and the area in front of the dikes will be done through this project by the cluster consisting of Amphi International, Rambøll and Odense Municipality. Further information on planning and design is being collected and analysed within Task 2.2 "Establishing baselines, Demand and Supply Analysis" (Demonstrators Survey) and can be found in the relevant documents elaborated within this Task.

### 2.3.4 Procurement and contracting

The construction which will be made as part of RECONECT will be led by Odense Municipality. The contractor for the assignment will be chosen after a public procurement according to the public procurement act.

### 2.3.5 Construction

The construction part of the project will be financed with support from the Danish state, RECONECT and Odense Municipality. The main obstacle for the project has been completing the landowner agreements. These has been finalized before the start of RECONECT.

### 2.3.6 Monitoring

#### 2.3.6.1 Indicators

DA-2 Odense has selected 23 Indicators to monitor, of which 6 in category Water, 8 in category Nature, and 9 in category People, as presented here below in Table 2-2.

*Table 2-2 Odense Coastal area NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | Vulnerability | - Land use map<br>- Infrastructures data<br>- Population data<br>- Building/Housing | | Variables and evaluation method will be decided during setting up monitoring program |
| | Storm surge | Data source:<br>http://kysterne.kyst.dk/hoejvandsstatistikker.html<br>- Bathymetry and DEM data<br>- Tidal variation<br>- Barometric pressure<br>- Wave height<br>- Spatial scale of storm<br>- Amplitude of surges<br>- Duration of surge<br>- Length of coastline affected by the surge | A hydrodynamic model | Variables and evaluation method will be decided during setting up monitoring program |
| | Coastal Hazard index | - Historical flood events and consequences<br>- Frequency of floods<br>- Flood inundation<br>- Distance and topography influences the territory being affected<br>- Flood depth (m)<br>- Tidal variation (m) | | Variables and evaluation method will be decided during setting up monitoring program |
| | Exposed value index (EVI) | - Population density (inhabit/km2)<br>- Built density (building/km2)<br>- Heritage<br>- Potential damage<br>- Land use | | Variables and evaluation method will be decided during setting up monitoring program |
| | Coastal vulnerability index (CVI) | - Geomorphology<br>- Coastal slope (%)<br>- Shoreline rate (m/yr) | | Variables and evaluation method will be decided during setting up |

| | | | | |
|---|---|---|---|---|
| | | - mean tide range (m)<br>- Mean significant wave height (m)<br>- Relative sea level rise rate (mm/yr)<br>- Historical flooding events and consequences<br>- Land use | | monitoring program |
| | Change in Groundwater level/water table | Groundwater level measured in dip wells | | |
| NATURE | Changes in riparian habitat | **Riparian habitat area (km²)** / Will be monitored by aerial images and visual observations. | | |
| | Changes in aquatic/wetland habitat | **Aquatic/wetland habitat area (km²)** / Will be monitored by aerial images and visual observations. | | |
| | Change in location of habitat boundaries | **Habitat boundaries for each habitat type** / Will be surveyed on the site by mapping habitats or/and fixed-point photography. Historic data source: NOVANA monitoring program https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF | | |
| | Change in vegetation along watercourses | **Vegetation along re-created watercourses** / Will be surveyed on the site by transect/square mapping. Historic data source: NOVANA monitoring program https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF | | |
| | Conservation status of habitats | **Structure and function including presence of typical species** / Will be surveyed on the site by transect/quadrat survey. Historic data source: NOVANA monitoring program https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF | Nygaard, B., Nielsen, K.E., Damgaard, C., Bladt, J. & Ejrnæs, R. 2014. Fagligt grundlagfor vurdering af bevaringsstatus for terrestriske naturtyper. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 142 s. - Videnskabelig rapport fra DCE – Nationalt Center for Miljø og Energi nr.118 http://dce2.au.dk/pub/SR118.pdf | |
| | Species richness and composition in respect to indigenous vegetation and local/national biodiversity targets | **- Number of species/** Will be surveyed on the site by transect/quadrat survey. Historic data source: NOVANA monitoring program https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF | | |
| | Number and type of protected species | **-Type and number of protected species/** Will be surveyed on the site by transect/quadrat survey. Historic data source: NOVANA monitoring program https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF as well as other available databases | | |

| | | | | |
|---|---|---|---|---|
| | Diversity of species | **- Number of species and/or number of individuals for each species/**Will be surveyed on the site by transect/quadrat survey. Possibility of using e-DNA method and Invertebrate species index. Historic data source: NOVANA monitoring program https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF as well as other available databases | | Evaluation method will be decided during setting up monitoring program |
| **PEOPLE** | Increasing recreational opportunities of NBS area | **Number of recreation activity in the area**/ | | Variables and evaluation method will be decided during setting up monitoring program |
| | Number and value of people visit or spend free time in NBS area | - **Number of people visit the area**/ will be obtained by setting up dataloggers at the observation towers/paths which are going to be built in the project | | Variables and evaluation method will be decided during setting up monitoring program |
| | Number of tourists | - **Number of people visit the area**/ will be obtained by setting up dataloggers at the observation towers/paths which are going to be built in the project | | Variables and evaluation method will be decided during setting up monitoring program |
| | Accessible NBS area per capita | - NBS free space area<br>- Number of people that could access | | Variables and evaluation method will be decided during setting up monitoring program |
| | Average journey time for people by foot to NBS area or average distance from home/public transport to NBS area | - Time from home/public transportation to NBS area (by foot, bike)<br>- Distance from home/public transportation to NBS area | | Variables and evaluation method will be decided during setting up monitoring program |
| | Enhancing attractiveness of places for living and working, and to visit | - **Number of people visit the NBS area**/ will be obtained by setting up dataloggers at the observation towers/paths which are going to be built in the project | | Variables and evaluation method will be decided during setting up monitoring program |
| | Reduced/avoided damage cost from hydro-meteorological risk reduction | - Flood depth<br>- Flood velocity<br>- Land use map<br>- Infrastructure data<br>- Damage data<br>- Inundation map | | Variables and evaluation method will be decided during setting up monitoring programme |
| | Change in land and/or property values | - Price of land and/or properties (euro)<br>- Willingness to pay | | Variables and evaluation method will be decided during setting up monitoring programme |
| | Mental well-being | - Feeling happiness, the satisfaction of desires, etc.<br>- Personal characteristics<br>- Mental Well-being scales asking participants how they have felt over the previous four weeks in relation to a number of items (e.g., feeling relaxed, feeling useful), with responses rated on a 5-point scale from "none of the time" to "all of the time" | | Variables and evaluation method will be decided during setting up monitoring programme |

The monitoring program is going to be developed during next months. It is going to be carried out mainly by involved partners. Rambøll is going to be responsible for monitoring and evaluating water and people indicators. Amphi International is going to be responsible for monitoring and evaluating of nature indicators, including innovative method e-DNA. Odense Commune will be installing some of monitoring equipment (e.g. data loggers for visitors) as well as will be involved in development of e-DNA method.

Historic data concerning nature indicators will be obtained among others from previous surveys under Danish NOVANA national monitoring and assessment programme for aquatic and terrestrial environments (Svendsen at al., 2005; http://novana.au.dk/om-novanaaudk/).

#### *2.3.6.2 Monitoring approach*

Monitoring approach is going to be developed. Time-plan has not been decided yet.

#### *2.3.6.3 Monitoring planning*

Monitoring plan is going to be developed. Time-plan has not been decided yet.

### *2.3.7 References & Sources*


Svendsen, L.M. & Norup, B. (eds.) 2005: NOVANA. Nationwide Monitoring and Assessment

Programme for the Aquatic and Terrestrial Environments. Programme Description – Part 1. National Environmental Research Institute, Denmark. 53 pp. – NERI Technical Report No. 532.

https://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR532.PDF

Svendsen, L.M., Bijl, L. van der, Boutrup, S. & Norup, B. (eds.) 2005: NOVANA. National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments. Programme Description – Part 2. National Environmental Research Institute, Denmark. 138 pp. – NERI Technical Report No. 537.

https://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR537.PDF

http://novana.au.dk/om-novanaaudk/ - NOVANA portal

http://www.miljoeportal.dk/borger/Sider/Borger.aspx - The Danish Environmental Portal (about in English: http://www.miljoeportal.dk/English/Sider/default.aspx)

# 3 Demonstrator A: Tordera River Basin, Spain

## 3.1 Overview

### *3.1.1 Summary of the NBS case*

The Tordera River Basin is located in Catalonia, in the north-eastern part of the Iberian Peninsula, and it covers an area of 900 km². The Tordera river is born at Montseny Natural Park (1,076 m.a.s.l.) and it flows into the Mediterranean Sea forming the Tordera Delta. Several cities are located along its course (Blanes: 38,790 inh., Malgrat de Mar: 18,439 inh., Sant Celoni: 17,754 inh., Tordera: 16,937 inh., Hostalric: 4,139 inh.). Tordera River Basin 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. In the context of the Tordera River Basin Levee Management Plan – a measure included in the Flood Risk Management Plan of the River Basin District of Catalonia and currently under development – different types of NBS will be analysed with the aim to reduce flood risk by means of restoring the natural functioning of floodplains and wetlands, while at the same time enhancing the environmental value associated to these areas. The type of NBS that will be studied include, but are not limited to, water storage areas, wetland restoration, setback of levees, enhancing transversal connectivity. The two main expected benefits of the implementation of NBS in the Tordera River Basin are the reduction of flood risk in highly vulnerable areas and the improvement of the environmental status of some other areas. However, we also anticipate that some difficulties might arise in acquiring the land required to implement some of the planned measures and/or in signing stewardship agreements with the land owners.

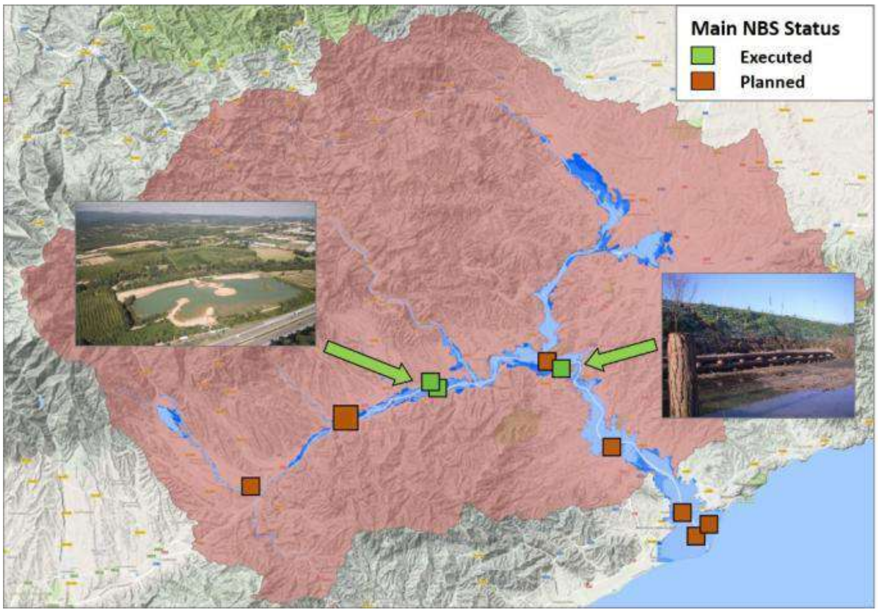


*Figure 3-1 NBS planned and implemented in the Tordera River Basin*

### *3.1.2 RECONECT – innovation potential*

Currently, and with regard to flood protection and flood risk management, there are not many examples of NBS implemented in the River Basin District of Catalonia. Thus, the innovation potential of this type of measures is high, as they might bring about a change of paradigm in the design and implementation of flood protection measures.

In our view, the key innovations and/or main points regarding the implementation of NBS in the Tordera River Basin are:

a) **NBS allow for flood risk protection without worsening the ecological status of water courses**. The current European legal framework obliges member states to reduce, mitigate and/or manage flood risk (Directive 2007/60/EC) as well as to maintain or at least to not deteriorate the ecological status of their water courses (Directive 2000/60/EC). In this sense, grey infrastructure (e.g. river channelization), unlike NBS, often fails in meeting both objectives, as in most cases it entails important hydro morphological alterations.

**b) NBS are more adaptive in a context of climate and environmental change.** By working with nature, NBS may provide flexible and sustainable alternatives to address different environmental challenges. In this sense, we expect that the implementation of NBS in the Tordera River Nasin will help to enhance the resilience and adaptive capacity within the watershed.

These innovations perfectly align with the needs of wider groups of stakeholders as the expected benefits associated to the implementation of NBS in the Tordera River Basin are:

- Reducing flood risk in vulnerable areas (e.g. urban areas, industrial areas, infrastructures, tourist areas)
- Increasing time to flood peak, thus increasing response time
- Enhancing environmental values of the area, including biodiversity
- Enhancing groundwater recharge
- Promoting the restoration of habitats by reconnecting riverbeds and floodplains
- Providing new recreational areas to the population

An important question regarding NBS and a potential barrier for up scaling, is who owns them and thus who is responsible for their maintenance over time. Ideally, the municipality in which the NBS is located should undertake its maintenance. However, small municipalities might not have the will and/or capability to carry out this task. On the other hand, it might be difficult for the Basin Authority to take responsibility for maintaining all NBS located within the River Basin District, as they work not at local but at regional scale.

#### *3.1.3 Geomorphological characteristics*

Different reaches with different geomorphological characteristics can be identified in the Tordera river. The upper reach, that stretches from the Tordera source to the municipality of Sant Celoni, presents the geomorphological characteristics of mountain streams (coarser river bed material and steeper slopes). The middle and lower reaches of the Tordera river present lower slopes (< 1%) and finer bed material, becoming a sand-bed river from the confluence of one of its main tributaries, Riera de Arbúcies, to the outlet at the Tordera Delta. NBS are planned to be implemented in the middle and lower part of the basin, as it is the most flood-prone area and where most of the vulnerable areas and activities lay.

The predominant land cover categories in the Tordera River Basin are forest (64%) and shrubs (15%). Urbanized areas account for 8% of the total area of the basin, whereas 11% of the area is covered by agricultural fields and 1% by infrastructures (roads and railways).

An inventory of the existing flood protection measures in the Tordera River Basin is being carried out in the context of the Levee Management Plan. There are many discontinuous dikes and levees along the course of the Tordera River as well as along one of its main tributaries, Riera de Santa Coloma – Sèquia de Sils. Most of them are intended to protect agricultural land. Besides, two artificial wetlands that function as water retention areas can be found in the Tordera River Basin: Estany de Sils and Les Llobateres.

On the other hand, there are important linear infrastructure systems (i.e. roads and railways) that cross through the basin and that may determine the characteristics of the flooding, functioning in some cases as dikes. These infrastructures, and their interaction with river flow and flooding, will be also studied in the context of the Levee Management Plan.

The dominant hydrological soil group is D (58%), following the classification of the US Soil Conservation Service. Soils in this group have high runoff potential when thoroughly wet.

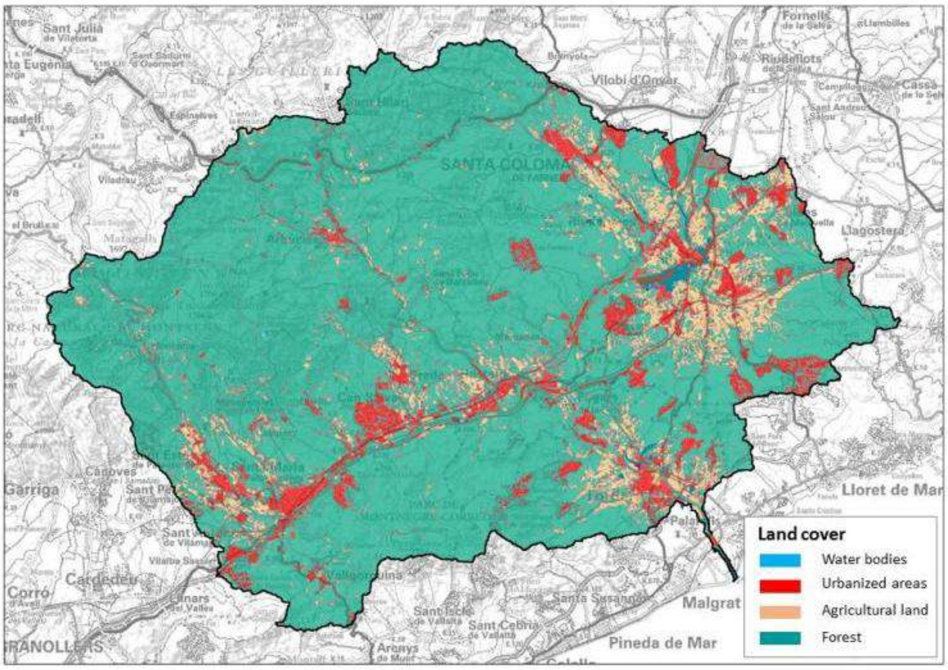


*Figure 3-2 Dominant land cover in the Tordera River Basin*

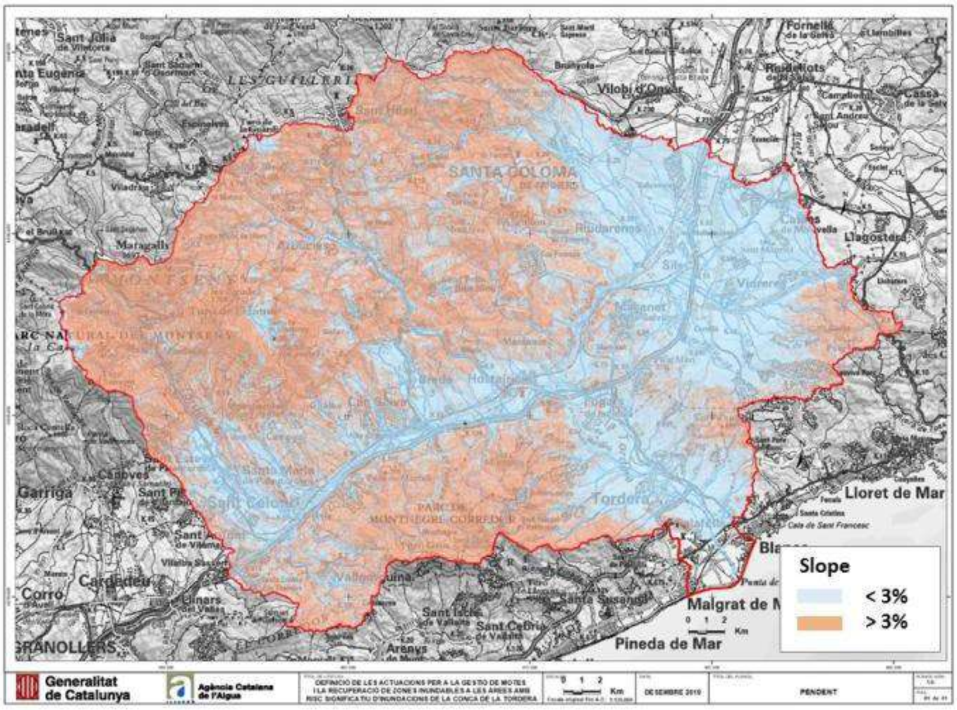


*Figure 3-3 Terrain slope in the Tordera River Basin*

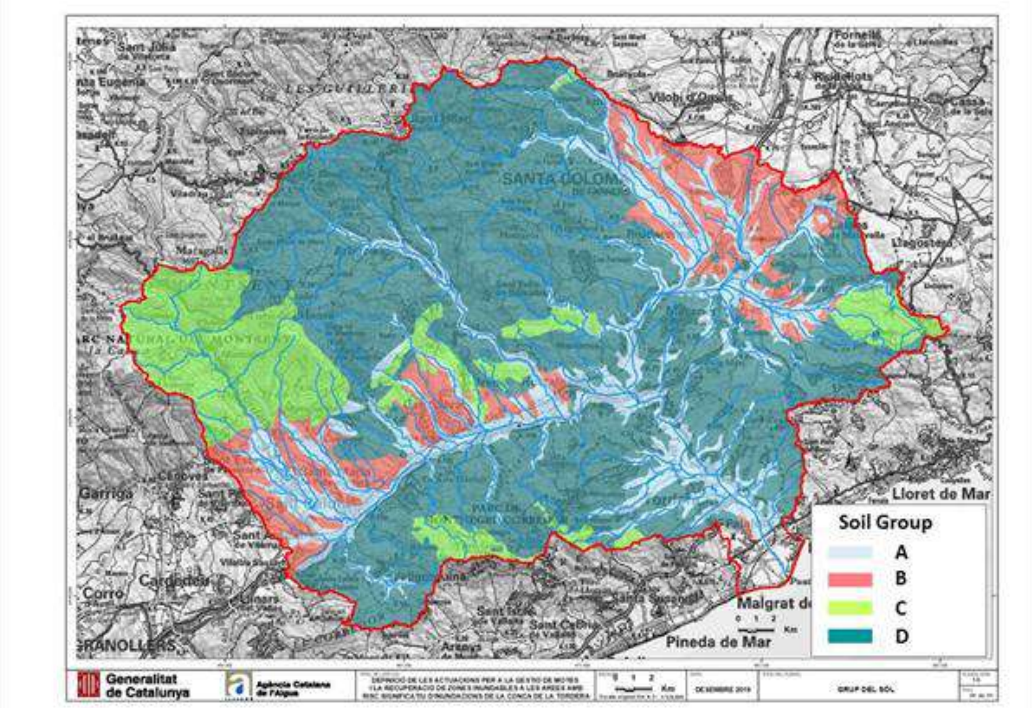


*Figure 3-4 Soil group in the Tordera River Basin*

### *3.1.4 Climatic conditions*

The Tordera River Basin has a Mediterranean climate characterized by wet and mild winters and dry and hot summers. The precipitation regime is highly seasonal and irregular, with two dry seasons (January-February, June-August) and two rainy seasons (March–May, September–December), being the months of October and July the rainiest and the driest, respectively. Climatic differences between headwaters (mountainous area) and the outlet of the basin (coastal area) can be observed.

*Table 3-1 Climatic Characteristics of the Tordera River Basin*

| Climatic Characteristics of the Tordera River Basin | | | | |
|---|---|---|---|---|
| Temperature | | | Precipitation | |
| Average annual temperature | Average of the hottest month | Average of the coldest month | Rainy season | Average annual precipitation |
| 14.6 ºC | 23.4 ºC | 6.9 ºC | Spring and Autumn | 800 mm |
| | | | | |

Flash floods are the main climate driven hazard in the Tordera River Basin, occasionally causing serious material damages to vulnerable areas. Flash floods are caused by events of intense precipitation, occurring mainly in autumn. Important parameters that define this type of hazard are total amount of rainfall, rainfall intensity, infiltration and retention capacity of the basin, topography, and land use, among others.

### *3.1.5 Hydrological conditions*

The Tordera river flows for approximately 62.2 km from its source at Montseny Natural Park (1,076 m.a.s.l.) to the Mediterranean Sea. Its basin covers an area of 900 km².

River discharge is highly seasonal, to the point that the final reach of the Tordera river runs dry during summer months. There are four automatic river gauging stations located along the

Tordera reach. Besides, hydrological and hydraulic models of the Tordera are being developed in the context of the Tordera River Basin Levee Management Plan with the aim to better characterize the response of the basin to heavy rainfall events and the flooding conditions associated to these events.

There are five groundwater bodies within the Tordera River Basin, all of them protected to certain extent:

- Montseny – Guilleries (ES100MSBT13): Good chemical status
- Maresme (ES100MSBT18): Bad chemical status
- La Selva (ES100MSBT14): Bad chemical status
- Al·luvials de l'alta i mitjana Tordera (ES100MSBT34): Good chemical status
- Al·luvials de la baixa Tordera i Delta (ES100MSBT35): Good chemical status. This water body had serious salinization problems in the past due to overexploitation. Nowadays, these problems have been solved with the construction and start of operation in 2002 of the Tordera Desalinization Plant, that supplies drinking water to 300.000 inhabitants in the area.

Regarding superficial water bodies, 20 of them have been identified in the Tordera River Basin: 7 have a good ecological status and 13 are in bad ecological status.

There are also 7 wetland areas from which only 1 is in good ecological status.

#### *3.1.6 Hydro-meteorological hazard and problem description*

As mentioned before, 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, that we do not plan to tackle in the context of this project, as:

- Coastal erosion and storm surge flooding. In the Tordera Delta the coastline is receding and threatening infrastructures and other activities present in the area. Flooding due to storm surges also occur from time to time.
- Urban flooding due to in-site heavy rainfall is also a problem in some of the urban areas located within the basin.

#### *3.1.7 Nature*

There are different protected areas within the boundaries of the Tordera River Basin (e.g. Massís del Montseny natural park, fluvial protected areas, bird protection areas etc.). A detailed identification and characterization of these areas, as well as the mapping of riverine habitats, is being carried out in the context of the Tordera River Basin Levee Management Plan and it is expected to be concluded in the coming weeks.

Some of the works that we plan to carry out and that may potentially change "Nature" are: landscape works, the construction of artificial ponds, and the planting of vegetation.

### 3.2 Stakeholders and governance

#### *3.2.1 Stakeholders*

Key stakeholders to be involved in the development of NBS in the Tordera River Basin are:

- **Catalan Water Agency (ACA):** It is River Basin Authority responsible for managing the water cycle in Catalonia. Among its responsibilities is to develop and implement the

River Basin Management Plan (RBMP) and the Flood Risk Management Plan (FRMP) for the River Basin District of Catalonia, in compliance with the EU Water Framework Directive and the EU Floods Directive, respectively. ACA is currently developing the Tordera River Basin Levee Management Plan, measure included in the FRMP that was approved in March 2018. The main objective of the Plan is to characterize flooding conditions in the basin as well as to analyze and plan the NBS (among other types of measures) to be implemented in the Tordera River Basin to help reduce flood risk.

- **Municipalities:** Municipalities are responsible for land use planning and civil protection at local level. In this sense, those municipalities in which NBS will be located and implemented will necessarily become key stakeholders to be taken into account in the design, implementation and maintenance of the measures.
- **Association of camp-sites located in the Tordera Delta**: The Tordera Delta is an important tourist spot where several camp-sites are located. The Delta area is very prone to flooding, so according to Spanish legislation camp-sites should adopt protection measures to reduce flood risk. In this sense, and in the context of the Tordera River Basin Levee Management Plan, NBS to reduce flood risk in the lower reach of the Tordera river will be analysed with the necessary participation of the Association of camp-sites.
- **Department of Territory and Sustainability of Catalonia (DTES)**: It is the Department of the Catalan Government responsible for land use and environmental planning at regional level. It is also developing the Programme of Green Infrastructure of Catalonia, that aims to establish the guidelines and roadmap to develop and implement green infrastructure in Catalonia.
- **Other key stakeholders (environmental NGO's, research groups, etc.)**: There are different groups of people that have worked or are currently working on the Tordera River Basin. Collaboration and participation of these groups as stakeholders will be promoted when relevant to the project.

#### *3.2.2 Governance*

All the authorities that might be involved at some stage of the project have been identified as key stakeholders. In this sense, the governance structure will be similar to the stakeholder map. At regional level, the authorities that will/might be involved are:

- **Catalan Water Agency (ACA)**: It will be involved in all stages of the project as it is the River Basin Authority responsible for planning and implementing flood risk reduction measures at basin level. It is also the authority that grants construction permits within a distance of 100 meters from the river bank.
- **Department of Territory and Sustainability of Catalonia (DTES)**: DTES has responsibilities in land use planning and environmental planning at regional level, and it is developing a programme of green infrastructure at Catalan level. Coordination between ACA and DTES will be needed in the design and implementation stage of the project to make sure that NBS follow the requirements to be considered green infrastructure. In addition, DTES may help with land acquisition as well as to arrange stewardship agreements when needed. Previous to the construction stage, and in case it is needed, DTES will evaluate the environmental impact assessment of the NBS and grant the necessary permits.

At local level:

- **Municipalities:** They will grant construction permits for those NBS located more than 100 meters away from the river bank. They may also help with land acquisition and to arrange stewardship agreements when needed.

### 3.2.3 Ownership

Currently, ACA is developing the Tordera River Basin Levee Management Plan that will define the type and location of the different NBS to be implemented within the basin. The definition of the measures is expected to be completed by January 2020. So questions about ownership of the land and of the NBS are not yet defined. However, and regarding the ownership of the land, firstly we will identify those publicly-owned plots that are close to the river and that are suitable to construct NBS. Secondly, we will identify abandoned gravel mining pits that have not been restored yet and that might be suitable for constructing water retention ponds. In other cases, we will study the possibility of signing stewardship agreements with land owners.

In relation to the ownership of the NBS, it will depend on its purpose. If the NBS helps to reduce flood risk in a very local area, the owner and responsible for maintenance and operation should be the municipality. This could be a potential barrier for up scaling, as small municipalities might not have the will and/or capability to carry out the maintenance and operation of the NBS. In the case the NBS helps to reduce flood risk to a larger area of the basin, then ACA will be the owner and responsible for maintenance and operation of the NBS.

### 3.2.4 Project organisation and management

The construction of NBS in the Tordera River Basin is a measure included in the Flood Risk Management Plan of the River Basin District of Catalonia, approved in March 2018. Budget has been already allocated for its planning, design and implementation. In this sense, ACA will develop project management tasks (both financial and technical) throughout the different stages of the project, outsourcing the different works (development of the Levee Management Plan, elaboration of the executive projects, execution of the NBS). The Tordera River Basin Levee Management Plan, currently under development, is expected to be completed by January 2020. Once the Plan is finished, ACA will hire a consultancy company to elaborate the executive projects needed for the NBS construction.

As mentioned before, there is already budget allocated for the construction of NBS. However, and in case the NBS benefits only one municipality, it is required for the municipality to pay for the 20% of the total cost of the construction. This is also a reason why involving municipalities in the early stages of the project is crucial. Furthermore, other funding options will be explored (e.g. European funds).

### 3.2.5 "People" – socioeconomic aspects

Most relevant municipalities affected by flooding from the Tordera River are:

*Table 3-2 Demographics of most relevant municipalities in the Tordera River Basin.*

| Municipality | Population (inh.) | Population density (inh./km$^2$) |
|---|---|---|
| Blanes | 38,790 | 2,196.5 |
| Malgrat de Mar | 18,439 | 2,090.6 |
| Sant Celoni | 17,754 | 272,2 |
| Tordera | 16,937 | 201.4 |
| Hostalric | 4,139 | 1,220.9 |
| | | |

We do not have demographic, neither socio-economic, information at watershed level, but in comparison with other basins within the River Basin District of Catalonia, the Tordera cannot be considered a very densely populated basin.

Agricultural land accounts for the 11% of the total area of the basin, being 7% rainfed agriculture and 4% irrigated agriculture. Most of it is located in the Delta area and in the catchment of Tordera's main tributary, Riera de Santa Coloma – Sèquia de Sils. Agricultural land is not expected to be affected by the NBS, although in some cases stewardship agreements with land owners might be desirable.

The more relevant socio-economic benefits that we expect to achieve with the construction of NBS in the Tordera River Basin will be associated to the reduction of flood risk (e.g. reduction of material losses due to flooding, land value increase, etc.) and the restoration of natural areas (e.g. increase of recreational areas, environmental education associate to restored areas, etc.)

## 3.3 Project Scope: NBS to be demonstrated in RECONECT

### *3.3.1 Scope summary*

The main goal of the NBS to be implemented in the Tordera River Basin is to reduce flood risk in different vulnerable areas within the watershed while enhancing the environmental value of riverine habitats. We are still in the planning phase of the project, so these are the only activities that have been defined so far. Thus, the planning stage will include the following activities:

a) Identification of protection structures present in the basin (i.e. dikes, levees, water retention areas) and available land (i.e. abandoned gravel mining pits, public-owned land)

b) Hydrological and hydraulic modelling of the basin to assess flood hazard and flood risk

c) Analysis of alternatives, including a multi-criteria analysis and cost-benefit analysis

The NBS planning phase is expected to be concluded by January 2020. At that point ACA expects to have a clearer idea of the project activities and project timeline.

### 3.3.2 *Project phases and planning*

*Table 3-3 Tordera River Basin NBS Project phases and planning*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works[5] | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

[5] The plan is to implement different NBS within the project timespan that may have different timelines. This is the reason why the "execution of the works" and "monitoring" stages have been extended to the end of the project.

### 3.3.3 *Planning & Design*

The project is still in the first stages of the planning process, which consist in modelling the actual response of the basin to heavy rainfall events with the goal to better assess and characterize flood risk. This work is expected to be concluded by July 2019. The next step in the planning process will be to analyse different alternatives of NBS in different locations of the basin to see how they contribute to reduce the overall flooding conditions. Based on a multi-criteria and a cost-benefit analysis, the better solutions will be selected.

Once decided the type and location of the NBS, the design process will start. In this process, which is expected to start in January 2020, we plan to involve some key stakeholders, especially municipalities in which NBS will be located.

A brief summary of the data and models used in the planning process can be found bellow.

HEC-HMS hydrologic model (free software): To define the hydrographs associated to different scenarios (2.33, 10, 50, 100 and 500 years return period) for the Tordera River and its tributaries, except Sèquia de Sils. Data from rain gauges and stream gauges have been used for calibration. The hypothesis used in the calculations are:

- SCS loss method
- SCS Unit Hydrograph Model
- Muskingum-Cunge Model for channel flow

IBER hydrodynamic model (free software): To define the hydrographs associated to different scenarios (2.33, 10, 50, 100 and 500 years return period) for Sèquia de Sils, a tributary of the Tordera River. The model solves the 2D Saint Venant equations using an unstructured finite volume solver.

Data used to set up the hydrologic models include: Digital Elevation Model (5x5 m), land use/cover, geological maps, precipitation maps for different return periods, and different thematic cartography (e.g. river system, delimitation of watersheds, etc.)

HEC-RAS 1D-2D hydraulic model (free software): It will be used to analyse the hydraulic characteristics of the flood (i.e. water depth and velocity) for different scenarios (2.33, 10, 50, 100 and 500 years return period).

For the set-up of the hydraulic model different data will be used, including: Digital Elevation Model (2x2 m), land use/cover, and different thematic cartography (e.g. topography 1:1,000 and 1:5,000; topography of bridges and hydraulic structures, etc.)

### 3.3.4 *Procurement and contracting*

ACA is the organization responsible for procurement services and works. Procurement rules are well established in the Spanish legislation, so depending on the type of works and/or the price to be paid for the works different types of contracts may be applied.

#### 3.3.4.1 *Finance*

ACA has its own budget to implement the different measures included in the Flood Risk Management Plan of the River Basin District of Catalonia. In this sense, the budget allocated in the Plan to be spent in the Tordera River Basin amounts to 1,450,000 €. This budget is planned to be spent by the end of 2021. However, in the second cycle of implementation of the Floods Directive (2022-2027), more budget could be allocated to the construction of NBS in case it is needed.

### 3.3.5 *Construction*

This stage of the project has not been reached yet.

### 3.3.6 Monitoring

#### 3.3.6.1 Indicators

DA-3 Tordera river has selected 20 Indicators to monitor, of which 8 in category Water, 9 in category Nature, and 3 in category People, as presented here below in Table 3-4. The list of indicators to be monitored is still tentative, as DA-3 are still in the planning phase of the project.

*Table 3-4 Tordera River Basin NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | Slowing and storing runoff | We will extract all this information from available thematic cartography:<br>- Precipitation<br>- Soil type<br>- Land use<br>- Topography /DEM<br>- Roughness coefficient | A hydrological model (HEC-HMS / IBER), will be used to compute surface run-off and this will be compared to the baseline value to assess a potential reduction. | |
| | Flood hazard | - Water discharge ($m^3/s$)<br>- Water level (m)<br>- Water velocity (m/s) | A hydraulic model (HEC-RAS 1D-2D) will be used to assess flood hazard for different scenarios and this will be compare to the baseline value to assess a potential reduction | |
| | Vulnerability | - Land use map<br>- Infrastructures data<br>- Population data<br>- Building/Housing | GIS processing | |
| | Delay time to peak | - Discharge hydrograph<br>- Discharge time series ($m^3/s$)<br>- Flood duration<br>- Flood peak<br>- Lag time (Travel times of reaches) | A hydraulic model (HEC-RAS 1D-2D) will be used to assess flood hazard for different scenarios and this will be compare to the baseline value to assess a potential reduction | |
| | Flood peak reduction | - Discharge hydrograph<br>- Discharge time series ($m^3/s$)<br>- Flood peak | A hydraulic model (HEC-RAS 1D-2D) will be used to assess flood hazard for different scenarios and this will be compare to the baseline value to assess a potential reduction | |
| | Change in Groundwater level/water table | Indicator included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Attenuation of pollution in groundwater | Indicator included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Seawater intrusion | Indicator included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |

| | | | | |
|---|---|---|---|---|
| NATURE | Changes in riparian habitat | - Riparian habitat area ($km^2$) | - GPS<br>- Aerial images | |
| | Changes in aquatic habitat | ACA has its own indicator (IHF) to monitor and evaluate mesohabitats. This indicator is included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Connectivity/fragmentation of habitat structural | ACA has its own indicator (ICF) to monitor and evaluate connectivity. This indicator is included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Change in vegetation along watercourses | ACA has its own indicator (QBR) to monitor and evaluate vegetation along water courses. This indicator is included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Conservation status of habitats | - Available cartography of habitats | - GIS processing | |
| | Change in land cover | - Land cover data | - Satellite imagery | Important to assess buffer zones for riverine areas |
| | Number and type of protected species | ACA has its own indicators to monitor and evaluate number and type of protected aquatic species. This indicator is included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Diversity of species | ACA has its own indicators to monitor and evaluate the diversity of aquatic species. This indicator is included in the Monitoring Programme of the Water Framework Directive. The monitoring approach will be the one established by this Programme. | | |
| | Number, area, location, of invasive non-native animal and planted species that are threatening to ecosystem, habitats or species | - EXOACUA and EXOCAT databases | | This databases are updated periodically |
| PEOPLE | Increasing recreational opportunities of NBS area | - Number of recreation activity in the area | Not defined yet | |
| | Provision of NBS sites for education and research | - Number of student benefiting from education and research about NBS | Not defined yet | |
| | Reduced/avoided damage cost from hydro-meteorological risk reduction | - Flood depth<br>- Flood velocity<br>- Land use map<br>- Infrastructure data<br>- Damage data<br>- Inundation map | - Hydraulic modelling<br>- GIS processing | |

#### 3.3.6.2 *Monitoring approach*

ACA does not have any monitoring programme in place except for those indicators that have to be reported to the European Commission in compliance with the Water Framework Directive. In this sense, the only indicators that ACA will be able to monitor are those related to the ecological status of water bodies[6] and those that can be hydrologically and/or hydraulically modelled.

At this stage of the project, it is still uncertain if we will be able to outsource the monitoring works. Thus, the demonstrator appreciates any help from project partners in this regard. Besides, there are a few environmental NGO's working in the Tordera (and already identified as stakeholders), that we expect would be interested in collaborating in the monitoring process of the NBS.

[6] However, the monitoring of the WFD indicators has its own timeline and working scale, and they might not be coincident with the project timeline.

#### 3.3.6.3 *Monitoring planning*

The monitoring planning is still tentative, and dependent on the timeline of ACA's WFD Monitoring Programme. In this sense, the timeline associated to indicators included in the WFD Monitoring Programme has not been detailed in the table below (indicators coloured in purple).

*Table 3-5 Tordera river Basin tentative monitoring plan*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| | W3 | | | | | | | | | | | | | | | | | | | | |
| | W4 | | | | | | | | | | | | | | | | | | | | |
| Water | W5 | | | | | | | | | | | | | | | | | | | | |
| | W6 | | | | | | | | | | | | | | | | | | | | |
| | W7 | | | | | | | | | | | | | | | | | | | | |
| | W8 | | | | | | | | | | | | | | | | | | | | |
| | N1 | | | | | | | | | | | | | | | | | | | | |
| | N2 | | | | | | | | | | | | | | | | | | | | |
| | N3 | | | | | | | | | | | | | | | | | | | | |
| | N4 | | | | | | | | | | | | | | | | | | | | |
| Nature | N5 | | | | | | | | | | | | | | | | | | | | |
| | N6 | | | | | | | | | | | | | | | | | | | | |
| | N7 | | | | | | | | | | | | | | | | | | | | |
| | N8 | | | | | | | | | | | | | | | | | | | | |
| | N9 | | | | | | | | | | | | | | | | | | | | |
| | P1 | | | | | | | | | | | | | | | | | | | | |
| People | P2 | | | | | | | | | | | | | | | | | | | | |
| | P3 | | | | | | | | | | | | | | | | | | | | |

#### 3.3.6.4 Data management system

ACA has different repositories where to store data:

- A server where hydrologic and hydraulic models are stored
- A server where cartographic information, including hazard and risk maps, is stored. This server is linked to a web viewer (http://sig.gencat.cat/visors/VISOR_ACA.html)
- Oracle database, where specific characteristics and information associated to elements present in the territory (e.g. bridges, infrastructures, urban areas, sewage treatment plants, etc.) that interact with water courses and/or are located in flood prone areas are stored.
- Hydrometeorological web viewer, where information from rain gauges and stream gauges can be consulted (http://aca-web.gencat.cat/aetr/vishid).

We would love to integrate the data related to our NBS in the RECONECT Services platform, once we know which are its technical requirements and capabilities.

### 3.3.7 Evaluation

The expected benefits of NBS are the reduction of flood risk which may be expressed in terms of the value of damages prevented by constructing the NBS.

Other possible co-benefits are: increase in land value due to the construction of NBS, development of additional recreational possibilities, enhancement of touristic and cultural values, enhancement of the environmental status of the riverine habitats, provision of additional water storages and reuse possibilities, groundwater recharge.

### 3.3.8 References & Sources

ACA (Agència Catalana de l'Aigua). 2017a. Pla de gestió del districte de conca fluvial de Catalunya 2016 – 2021. Barcelona, Spain: ACA

(http://aca.gencat.cat/web/.content/30_Plans_i_programes/10_Pla_de_gestio/02-2on-cicle-de-planificacio-2016-2021/bloc1/101_pdg2_plagestio_dcfc.pdf)

ACA (Agència Catalana de l'Aigua). 2017b. Programa de mesures del pla de gestió del districte de conca fluvial de Catalunya 2016 – 2021. Barcelona, Spain: ACA

(http://aca.gencat.cat/web/.content/30_Plans_i_programes/10_Pla_de_gestio/02-2on-cicle-de-planificacio-2016-2021/bloc2/201_pdm2_programa_mesures.pdf)

ACA (Agència Catalana de l'Aigua). 2004. Planificació de l'Espai Fluvial (PEF) de la conca de la Tordera. Barcelona, Spain: ACA.

(http://aca-web.gencat.cat/aca/documents/ca/publicacions/espais_fluvials/publicacions/estudis_pef/f_tordera/pef_tordera.htm)

ACA (Agència Catalana de l'Aigua), DGPC (Direcció General de Protecció Civil), DGSCM (Direcció General de Sostenibilitat de la Costa i el Mar). 2018. Pla de gestió del risc d'inundació del districte de conca fluvial de Catalunya. Barcelona, Spain: ACA.

(http://aca.gencat.cat/web/.content/30_Plans_i_programes/20_Gestio_del_risc_inundacions/1er-cicle-de-planificacio/bloc1/101_1_Proposta_PGRI_ca.pdf)

ACA Cartographic services:

- Geoservices: http://aca.gencat.cat/ca/laigua/consulta-de-dades/geoserveis/
- Thematic maps: http://aca.gencat.cat/ca/laigua/consulta-de-dades/descarrega-cartografica/
- Sensor data: http://aca.gencat.cat/ca/laigua/consulta-de-dades/dades-obertes/
- Interactive applications: http://aca.gencat.cat/ca/laigua/consulta-de-dades/aplicacions-interactives/

# 4 Demonstrator DA-4 Portofino Regional Natural Park, Italy

## 4.1 Overview

### 4.1.1 *Summary of the NBS case*

The Promontory of Portofino shows views and landscapes among the most famous in the world. Made by conglomerate rock masses overlying marly limestone flysch, it has geomorphologic and microclimatic features that, in a limited territory, have created very different environments. 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.

The analysis of geomorphological, geological, historical and socio-economic factors has clearly shown that the abandonment of the terraces led to an increase in geo-hydrological risk in an area already struggling to maintain a delicate balance between natural and historical aspects of its landscape.

The Portofino Natural Park is promoting interventions aimed at reducing geo-hazards and vulnerability against climate changes, above all the extreme rainfall events. There interventions are mostly carried out through natural and nature-based solutions, aimed at exploiting and regenerating ecosystem services and natural functions of the area.

NBS Works done in the Portofino Natural Park within RECONECT relates in particular:

1. dry-stones walls construction and abandoned terraces restoration, with the aim to preserve the terraced landscape, and push the agricultural activities;
2. hydraulic-forestry operations on water courses;
3. riverbed and tributary operations;
4. natural engineering interventions along hiking paths;
5. interventions of forest amelioration and re-forestation.

Some small catchments involved in RECONECT project: in the San Fruttuoso village Catchments (Rio dei Fontanini and Vallone di San Fruttuoso streams) and in the Paraggi village Catchments (Fosso dell’Acqua Viva and Fosso dell’Acqua Morta streams).

### 4.1.2 *RECONECT – innovation potential*

Nature and biodiversity conservation are crucial missions of Portofino Natural Park, then the challenge of this Italian case is to demonstrate NBS for georisk mitigation in a context of conservation and innovation.  In a regional context where extreme hydro-meteorological events are getting more frequent and damaging every year, the RECONECT project is an opportunity to demonstrate the effectiveness of alternative/complementary solutions for georisk reduction, to grey infrastructures, that helps to exploit the natural predisposition of ecosystems facing and securing from natural disasters.  Besides, NBS are the most appropriate approach to geo-hydrological risk reduction in a context where natural framework is of high value, either for itself or for recreational and touristic motivations. The intense urbanization that characterizes some areas of Liguria region, is in close contact with areas of great natural value, and NBS may help in reconstructing an equilibrium that has often been interrupted. The high adaptability of NBS may be crucial in an area dominated by high energy processes that impact on a complex and heterogeneous morphology. Finally, NBS have been chosen because they allow to test their effectiveness and their adaptability to changing boundary conditions within the project lifetime, whilst other kind of interventions (e.g. the grey ones) need a longer time to assess their good or bad performance.

Other innovation aspects are:

- Innovative monitoring technology and methods;
- Positioning of the Park among national and international institutions that are adopting and promoting 'holistic approaches' with integrated NBS and IT solutions to manage climate change impacts.

The Portofino area was hit in 2016 and 2018 by extreme hydro-meteorological events. In 2016 the area was swept away by a "downburst" and consequently the local administration decided to recovery the damages with a naturalistic oriented management. Interventions after the downburst were addressed to retrieve the above-soil to minimize the geo-hydrological risk and basing on natural solutions according to the Park policies and the ones of the ZCS IT1632603 "Parco di Portofino". The idea of using natural techniques to prevent risks was also enforced among local administrators and stakeholders after the sea storm and coastal flood of 27-29th October 2018.

Main drivers for innovation up scaling are the past experiences of the Portofino Park in natural risks mitigation, carried out in the framework of different projects (the last is the Maritime INTERREG TrigEau), that attracted the attention of administrators on these issues and let understand that RECONECT could be of interest at local and regional scale. The largely shared peculiar geomorphologic features of the area (Liguria, Campania, Sicilia–Pantelleria, Balearic island, Greece, Canaries and mountain regions like Alpine area, Chile, China) assure RECONECT methodology and techniques a spread applicability.

Costs and the funding constraints may represent a limitation, as the difficulties to find designer and operators skilled on NBS technologies. Besides, mentality is often a barrier too, underlining the contrast between an impossible unlimited development and a sustainable one.

### *4.1.3 Geomorphological characteristics*

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 m asl): steep slopes, small catchments and high cliffs are the main morphological features.

Three catchments compose the pilot area that extends on a conglomerate bedrock (tab 4-1, fig. 4-1).

*Table 4-1 Main features of the pilot catchments.*

| **Catchment** | **Area ($km^2$)** | **Mean slope (%)** |
|---|---|---|
| Vallone dei Fontanini | 0.44 | 75 |
| Fosso di San Fruttuoso | 0.59 | 65 |
| Fosso dell'Acqua Morta | 1.48 | 50 |

Slope gradient frequently exceeds 75%.

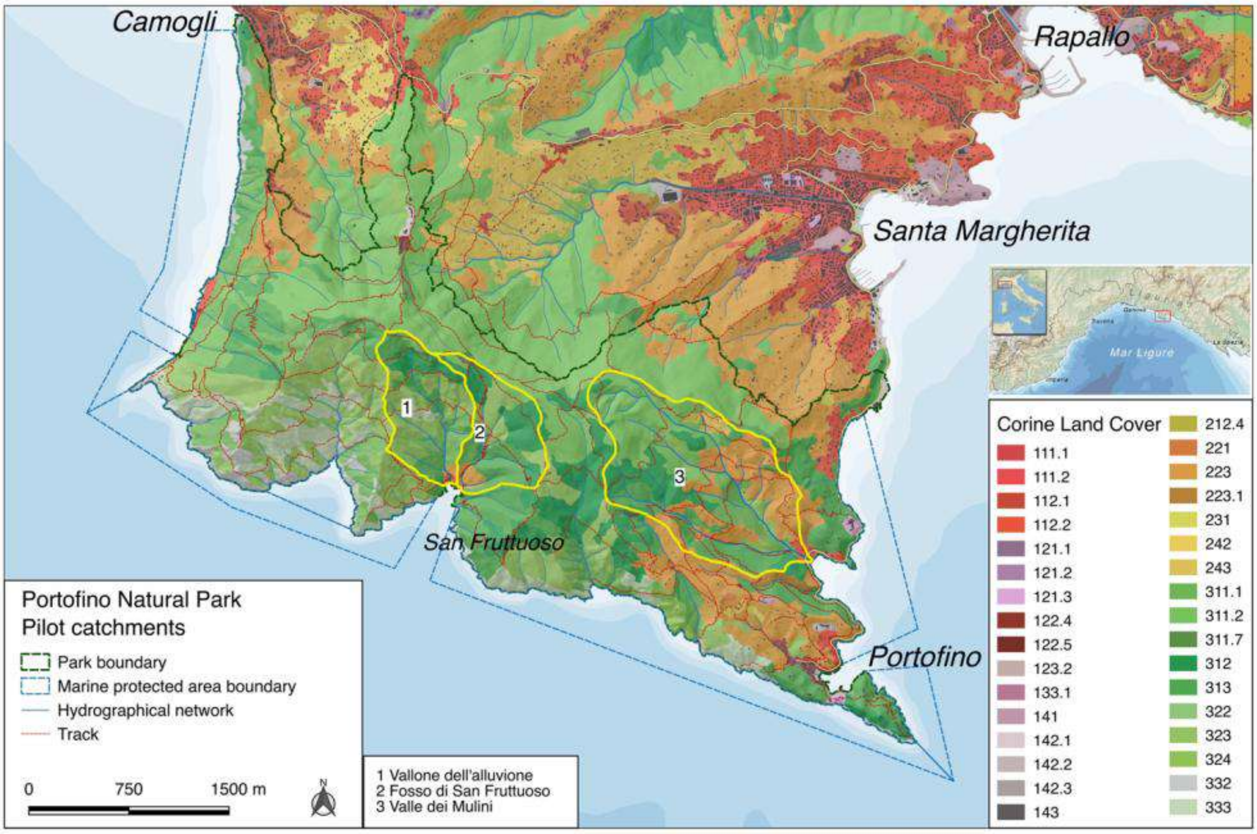


*Figure 4-1 Pilot areas location and land use (Corine Land Cover code).*

Land cover is prevalently natural with a concentration of anthropic structures, historical heritages, roads, tourism facilities and houses at the stream's mouths (Tab. 4-2). Dry-stone man-made terraces for agricultural purposes constitute an important human modification present in all the pilot areas and constitute a possible source of debris or hyperconcentrated flows threatening human structures in case of heavy rain-flash flood.

*Table 4-2 Corine Land Cover in the three catchments.*

| CLC-code | Area ($m^2$) | Area (%) |
|---|---|---|
| 112 | 14000 | 0.56 |
| 223, 243 | 485200 | 19.25 |
| 311, 312, 313 | 1593000 | 63.22 |
| 323 | 321300 | 12.75 |
| 324 | 86000 | 3.41 |
| 333 | 20500 | 0.81 |

Some limited interventions have been realized locally to prevent cliff collapse and to recovery terraces; culverts at the streams' mouth are exposed to saturation by solid and floating transport.


Figure 4-2 *Pilot area – San Fruttuoso Abbey (X century) and the underlying culvert.*

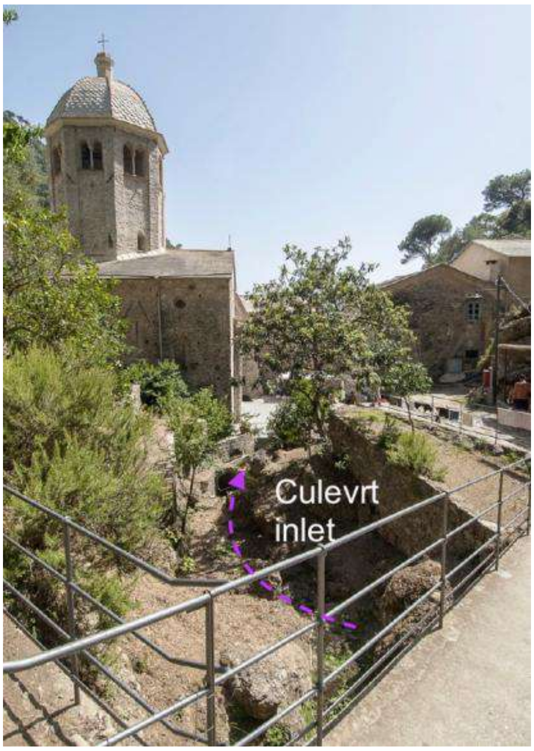


*Figure 4-3 Pilot area – Vallone dei Fontanini: culvert inlet.*

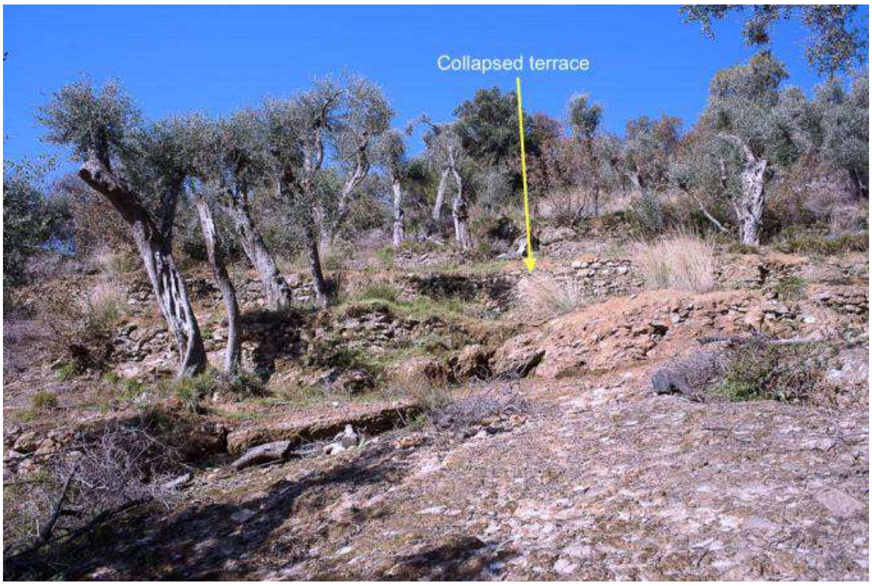


*Figure 4-4 Pilot area – Vallone dei Fontanini: collapsed man made terraces.*

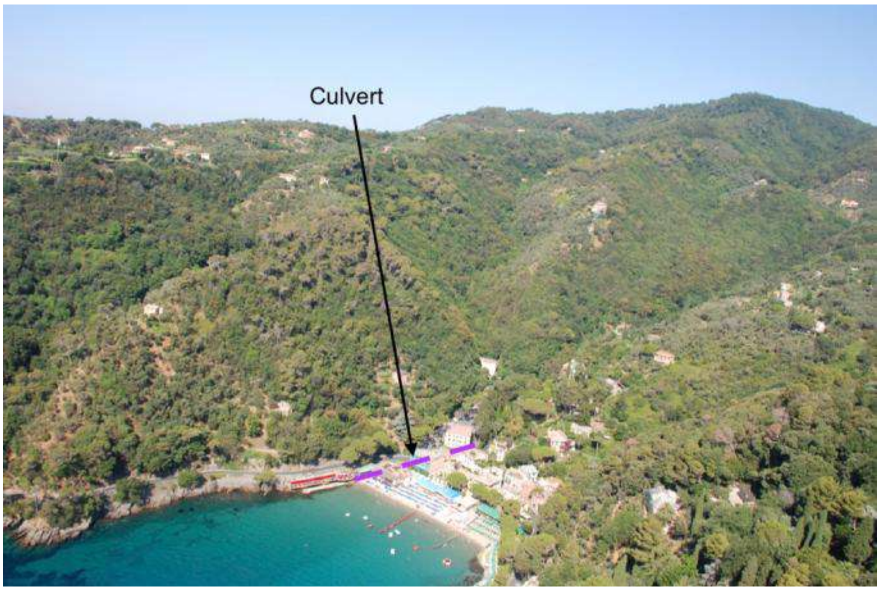


*Figure 4-5 Pilot area – Paraggi, Fosso dell'Acqua Morta catchment: tourism facilities and road lay on the culverted and floodable area at the mouth of the stream.*


*Figure 4-6: Pilot area – Paraggi culvert inlet.*

### *4.1.4 Climatic conditions*

The climate is Mediterranean, Csa according to Köppen, with hot summers, mild winters and rainy autumns. The microclimate is strongly conditioned by the morphology: elevation, slope and aspect cause local different conditions. The area may be subdivided into two zones: a) typically Mediterranean one on the southern slope, with dry, warm summers and mild winters; b) a mid-hill zone on the northern slope, with lower mean winter temperatures and higher rainfall, especially in the sectors exposed to the N.

Maximum rainfall usually occurs in fall, while minimum in summer; annual mean rainfall is comprised between about 1000 and 1600 mm. Mean annual temperature ranges between 12 and 13 °C, reaching 23-24 °C in summer and 7-8°C in winter.

Rainfall often occurs with strong intensity that appears to be increasing in both frequency and intensity. The present-day beach in San Fruttuoso was shaped in 1915 by intense precipitation (> 400 mm/12h) that triggered debris flows along the steep slopes. Recently intense events happened, causing spread damages: 23-24/9/1993, 4-5/11/1994, 6/10/1995, 22-23/10/1999, 6/11/2000, 24-26/11/2002, 31/10-2/11/2003, 1/6/2007, 4-5/11/2011, 18/1/ 2014, 26/7/2014, 16/10/2016. The area has been hit even by intense sea storm: 15-16/12/1993, 31/10-2/11/2003, 30/10/2008, 1/1/2010, 29/10/2018. Precipitation intensity is the crucial parameter, together with wind.

### *4.1.5 Hydrological conditions*

The three small catchments of the pilot area (see section 4.1.3 for area), due to the morphometric asset of the area, are characterized by the presence of a stream network with high gradient and strong irregular discharge: hydrographical network in 'Vallone dei Fontanini' stream and 'Fosso di San Fruttuoso' stream catchments present water flowing only during and after rainy days. In Fosso dell'Acqua Morta main stream, on the opposite, a small amount of running water is always present, probably due to the relatively more extended catchment and a more extended hydrogeological one. Table 4-3 presents the main features of the hydrographical network.

*Table 4-3 Hydrographical network feature of the three catchments.*

| Catchment | Hydrographical network length (km) | Main stream length (km) | Main stream mean gradient (%) |
|---|---|---|---|
| 1 | 2.82 | 1.14 | 44 |
| 2 | 1.96 | 0.82 | 48 |
| 3 | 7.51 | 1.83 | 19 |

In the three catchments several scarcely water flow springs are spread and water is partially collected on aqueduct for drinking water. Due to the lack of pollution, chemical or biological, in the whole Portofino promontory, water quality is good.

NBS solution will be applied along slopes and will not interest the seaside, whose quality is optimal.

### 4.1.6 Hydro-meteorological hazard and problem description

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 triggering. Debris and hyperconcentrated flow have been often moving from terraced slopes: the main recent event of this type happened in 2011 in the 5 Terre area, together with the one in Gazzo di Leivi in 2014, about 12 km East from the pilot areas. Both the events caused two casualties and heavy damages. A similar event in 1915 shaped the beach in San Fruttuoso and localized ones hit the pilot areas.

Moreover, wind storm recently destroyed several trees along the steep slopes and the ones that actually are close to the hydrographical network may potentially increase the floating transport that may occlude the culverts that are present at the mouth of the streams and where vulnerability of human structures is high: cultural heritage, as the San Fruttuoso ancient Abbey, tourism facilities and essential infrastructure in Paraggi, at the mouth of Fosso dell'AcquaMorta.

NBS will be crucial in reducing the potential instability of terraced areas, in regenerating wood areas and recovering the highly frequented tracks.

### 4.1.7 Nature

The pilot areas are included in Natura 2000 and Portofino Natural park, then natural features and peculiar habitats are prevailing. The inhabited zones are concentrated in the more exposed to geo-hydrological risk areas: the relationships between nature elements and anthropic ones is sometimes considered conflictual.

Planned works will comprise recovery of terraced areas to reduce the possible debris flow source and afforestation, trying to improve the natural recovery and reduce the hazard associated both to the absence of trees and by the presence of dead ones: floating and solid transport, in fact, occlude culverts in the inhabited areas. NBS will play the role of accelerating the nature recovery after occurred damage and to stabilize the anthropogenic diffused structures of terraces.

*Table 4-4 Synthetic geographical data*

| Synthetic geographical data | |
|---|---|
| Park surface | 1.056 ha |
| Bare rocks | 2,7 % |
| Pinewood | 10,5 % |
| Ilex wood | 13,1 % |
| Oak wood | 2,1 % |
| Chestnut wood | 8,4 % |
| Ampelodesma steppe | 6,3 % |

| | |
|---|---|
| Scrubland | 14,6 % |
| Mixed deciduous forest | 20,8 % |
| Black locust trees | 0,4 % |
| Olive groove | 15,8 % |
| Reafforestation | <0,1 % |
| Private gardens and parks | 4,5 % |
| Built up areas | 0,8 % |
| Maximum and minimum altitude | 0 - 610 m |
| Municipalities | 3 |
| Inhabitants | 679 |
| **Naturalistic data** | |
| Boar n° (census 2013) | > 100 |
| Grown wild goat (census 2013) | > 85 |
| Birdsspecies (census 2010) | 96 |
| Amphibian species (census 2011) | 6 |
| Plant species (census 2011) | 935 |
| Natura 2000 habitat n° (census 2009) | 23 |

## 4.2 Stakeholders and governance

### *4.2.1 Stakeholders*

Portofino Park's stakeholders are represented by a series of categories such as Administrators, President, Park Councillors and Regional Councillors for the Liguria Regional Authorities, mayors and councillors of the municipalities of the area and surrounding areas, related local and regional political forces, prevailing local economic subjects most of them from the tourism sector (both hospitality – hoteliers, owners of houses to be rented and BBs - and catering, sellers of objects and services such as environmental guides, tourism and MTB, bathing, boatmen, mooring, renting bicycles, cars, canoes etc., and transport in general) and of the property (real estate, building, gardeners).

In addition to the residents (in the Park about 600 people live), great relevance is given to the houses' owners, given the very high values of the real estate. At the opposite side are land owners, not always coinciding with the previous ones, and the few subjects that cultivate land and raise animals, not having in that their major income.

Citizens are significantly organized in local associations (local, cultural, voluntary, sports or mixed) numerous in if compared to the total number of inhabitants, supporting the trade Associations. Finally, the University, teachers and students, and the numerous employees and technicians working in local administrations have importance.

### *4.2.2 Governance*

Portofino Park is managed by a Council, stating all the general issues, adopting the planning and programming instruments, approving all the administrative, accounting and financial measures. The Council is composed by 5 representatives appointed by the Park Community (its advisory body). Three of them are identified by the local authorities whose territory is interested by the Natural Park, and one (at least) represents general interests. The Board is chaired by the President, representing the Park Authority towards third parties, convening the Board, promoting and taking initiatives aimed at guiding the management activity of the entity according to the objectives of the Board.

### 4.2.3 *Ownership*

One third of the Park territory is represented by public property, whilst the remaining part is private. Public properties, with the exception of the coastline, ports and waterways, are largely wooded areas, managed by the Park Authority in agreement with the Municipalities that own these areas. Hence, areas where NBS interventions will be implemented will be maintained by the Park Authority or by the related Municipality. Private properties are managed according to the rules stated in the Park's plan, which provide, upon a private - public agreement, that areas where NBS are implemented will be maintained in a future by the Park.

### 4.2.4 *Project organisation and management*

Portofino Park Demonstrator A is carried out by Italian partners grouped in a cluster. They are:

1. Portofino Park Authority (partner 27) acting as institutional entity and beneficiary of NBS interventions
2. CNR-IRPI (partner 28) acting as scientific partners expert in geo-hydrological aspects (with subcontractor University of Genoa)
3. GISIG Association (partner 15) in charge for the coordination of the contributions by the Italian cluster and the contacts with project coordination and WP leaders.

In addition, during the project external professionals and companies are appointed by the Portofino Park to carry out design and implementation of NBS interventions.

As beneficiary of the NBS interventions, the Portofino Park is responsible for managing and controlling works on a technical and financial point of view through its technical and administrative offices. Portofino Park manages the public bids for assigning work design and implementations as well as follows the environmental assessment procedures (if needed) requested by Liguria Regional Authority. It is supported on a scientific point of view by CNR-IRPI and for project management aspects by GISIG. Portofino Park, moreover, is the entity who takes direct contacts with main project actors (Municipalities of the area as well as private land owners) whilst general contacts with local and national RECONECT stakeholder are undertaken indistinctly by all the three partners of Italian cluster.

Portofino Demo A has prepared a tight timeline for works implementation, considering all (or the majority of) aspects and actions needed to reach its final aim (NBS implemented and monitored) and assigning to each a precise duration. Whilst in the work implementation phase, no particular risks have been envisaged, Portofino demo cluster is but fully aware about possible delays due to administrative practices (e.g. public bids for assigning works, environmental impact assessment). To avoid substantial delays in the finalization of NBS interventions, in the timeline the duration of NBS works has been extended for some additional months in order to deal with possible constraints and delays due to regional administrative procedures and authorization.

### 4.2.5 *"People" – socioeconomic aspects*

The Natural Park of Portofino has an extension of 10,55 $km^2$ of protected area with less than 700 inhabitants, although it is frequented by about 4,000,000 visitors per year. The environmental quality is crucial for the local economy and the interventions in the area must have an ecological and landscape function. Maintenance of terraced landscapes is, for example, important, apart from agriculture, for some habitats including semi-natural dry grasslands and shrub facies on limestone substrates (Festuco-Brometalia), where orchids are relevant (to this aim the Park is developing a LIFE NAT 2017 Life Orchids Project).

The planned NBS for geo-hydrological risk mitigation will enhance the economic value of properties, improving landscape and its use for recreational and touristic purposes.

The elevate touristic value of the coastal areas (Paraggi e San Fruttuoso di Camogli) that are annually visited by some 4,000,000 people and the high importance as cultural heritage of San

Fruttuoso village (the ancient Abbey, the monastic complex and historical buildings as the Casa dell'Arco) suggest a positive social and economic impact of the planned activities.

All the maintenance cost will need to be scheduled by the Park, the municipalities and the private owners.

## 4.3 Project Scope: NBS to be demonstrated in RECONECT

### *4.3.1 Scope summary*

Expected impacts and benefits from the implementation of NBS in the Portofino Demonstrator are:

- To reduce the geo-hydrological vulnerability of cultural heritage, real estate and in general natural and urbanized areas within the Park.
- To decrease the risk of injuries among the Portofino Park visitors due to the instability of slopes in hiking paths.
- To promote a "new culture" for land planning and climate change adaptation and integrate NBS into strategies and policies.
- To improve the collaboration between the Park Authority and the main local actors, (model of "governance")

### *4.3.2 Project phases and planning*

1. Preparation and planning - **3 months** (January (M5) - March (M7) 2019. This phase includes appointment of a working group of professionals and the preparation of a preliminary project)
2. Creation, co-creation, (co-)design - **6 months** (From March (M7) to August (M12) 2019. This phase includes the project design up to final version, also by applying co-creation and co-design methodologies provide by RECONECT project)
3. Land acquisition (if applicable) – Not applicable
4. Environmental impact assessments & Permitting - **6 months** (From March (M7) to August (M12) 2019. This phase is done in parallel with phase No. 2. Therefore, since it implies administrative procedures and institutional decisions, can take more time than expected not depending by Portofino Demo partners)
5. Tendering, procurement and contracting - **3 months** (from M13 September to M15 November 2019)
6. Execution of works – **12 months** (From December '19 (M16) to November '20 (M28))
7. Baseline situation & Monitoring - (From February 2019 (M6) to Project end (M60)) – if WP3 indicators for the Portofino Demonstrator are approved in January, monitoring sensors will be installed by end of M6 (February)
8. Evaluation & Closure (3rd, 4th and 5th project year)

*Table 4-5 Protofino NBS Project phases and planning*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

### 4.3.3 Planning & Design

Portofino Park authority is responsible for the application of NBS in geo-hydrological risk mitigation: planning and design of the solutions are going to be assigned to professionals with experiences in that field. CNR-IRPI (and its subcontractor, University of Genoa) is giving scientific support to identify the priority areas of interventions and of the more suitable NBS.

Co-creation and co-design methodologies will be applied according to indications and methodologies provided by RECONECT consortium and partners responsible for developing that.

Abandoned stone terraces represent an important possible source of instability and of solid transport in the hydrographical network (Brancucci and Paliaga 2006; Tarolli et al., 2014; Paliaga et al. 2016; Giordan et al. 2018) as with dead trees of floating transport. Besides, erosion threaten even the highly frequented tracks in the area: NBS will be applied even to reducing instability and for recovering.

The areas are going to be selected applying a set of spatial criteria with the scope of reducing the possible source of debris and hyperconcentrated flows along the slopes that threaten infrastructures, historical heritages, buildings and tourist facilities. The criteria comprise the possible discharge of heavy debris into the hydrographical network and the possible saturation of the low capacity culvert that are at the mouth of the main streams of the three catchments.

The criteria are based primarily on the identification of stone terraces through LIDAR survey, due to the frequent canopy effect of the wild vegetation, and on the model of volume assessment recently developed at CNR IRPI (Paliaga et al., 2018) to evaluate the more critical areas.

This model will be a crucial element of up scaling of the project, as instability of man-made terraces is a critical element in many Mediterranean areas and caused recently damage and even casualties (2011 flash flood and associated debris flow in 5 Terre, two casualties occurred; 2014 in Gazzo di Leivi near Chiavari city, where two casualties occurred after the collapse of terraces).

### 4.3.4 Procurement and contracting

All the restoration activities in the Park are conducted by the Park authority and by the respective municipalities. The contract works have been published openly through public notice or through the competition of selected association of professionals for the design. The tasks have fixed budget opportunely allocated.

The Park, as public subject, must apply the code of contract regulation.

#### 4.3.4.1 Finance

Total cost of the Portofino Demonstrator is €1.750.000.

Installation and construction of Nature-Based Solutions in the area are expected to be financed in the following way:

- € 700.000 is covered by RECONECT;
- € 1.000.000 is covered by external funds (Regional Funds and Rural Development Funds).

Cost related to monitoring are equal to € 50.000 and relates to purchasing and installation of monitoring stations and covered by RECONECT.
Commissioner of works and monitoring activities is the Portofino Park Authority.

### 4.3.5 Construction

The planned works will constitute mainly the recovery of stone terraces with NBS and then the improve of stream-bed conditions, removing the dead trees in excess, compatibly with the ecosystem. Works along the tracks will be even realized.

### 4.3.6 Monitoring

#### 4.3.6.1 Indicators

DA-4 Portofino has selected 15 Indicators to monitor, of which 3 in category Water, 7 in category Nature, and 5 in category People, as presented here below in Table 4-6. In addition, they suggest 3 "site-specific" indicators, 2 in Water category, 1 in People category, as presented below.

Table 4-6 *Portofino NBS Indicators and Monitoring*

| NBS | RECOMMENDED INDICATORS | DESCRIPTION OF INDICATOR | VARIABLES | EXAMPLE OF METHODS | REFERENCES |
|---|---|---|---|---|---|
| WATER | Landslide hazard | Landslide refers to a variety of processes that result in the downward and outward movement of slope-forming materials, including rock, soil, artificial fill, or a combination of these | - Slope angle<br>- Geology<br>- Land use<br>- Earthquakes<br>- Precipitation | | Abella, E. A. C., & Van Westen, C. J. (2007). Generation of a landslide risk index map for Cuba using spatial multi-criteria evaluation. Landslides, 4(4), 311–325. https://doi.org/10.1007/s10346-007-0087-y |
| | Vulnerability | Vulnerability is the state of being prone to or susceptible to harm. In this respect, we can distinguish different forms of vulnerability (e.g., social, economic, environmental and so on). | - Land use<br>- Infrastructure data<br>- Population<br>- Building/Housing | | Abella, E. A. C., & Van Westen, C. J. (2007). Generation of a landslide risk index map for Cuba using spatial multi-criteria evaluation. Landslides, 4(4), 311–325. https://doi.org/10.1007/s10346-007-0087-y |
| | Sediment deposition | Sediment (e.g., silt) resulting from soil erosion can be carried into water bodies by surface runoff. Sediment interferes with the penetration of sunlight and upsets the ecological balance of a body of water. Also, it can disrupt the reproductive cycles of fish and other forms of life, and when it settles out of suspension it can smother bottom-dwelling organisms. | - Suspended Solids (TSS)<br>- Total dissolved solid (TDS)<br>- Turbidity (NTU)<br>- Sediment Composition<br>- Sediment characteristics | Collect samples and test in laboratory | |
| NATURE | Changes in riparian habitat | A riparian habitat is the habitat that are associated with bodies of water. It is found along the bank of a river, stream, or other actively moving source of water such as a | - Riparian habitat area (km2) | - GPS<br>- Aerial images | |

| | | | | | |
|---|---|---|---|---|---|
| | | spring or waterfall. | | | |
| | Changes in terrestrial habitat | Terrestrial habitat can only find on land such as forests, grasslands, deserts, shorelines and wetlands. Terrestrial habitat also includes man mad habitats such as farms, towns, cities. | - terrestrial habitat area (km2) | - GPS<br>- Aerial images | |
| | Change in vegetation along watercourses | Changes in riparian vegetation can have significant effects on aquatic biodiversity through direct (change in water temperature and light availability) and indirect ( increased run-off, situation, etc.) impacts. | - Vegetation along watercourses using remote sensing or transect, quadrat survey | - Remote sensing or transect, quadrat survey | |
| | Conservation status of habitats | Conservation status is physically protected habitats | Trends and status of range,<br>Trends and status of the area,<br>Structure and function including typical species<br>Future prospects. | The conservation status can be illustrated in three 'traffic light' categories ('favourable'- green, 'unfavourable inadequate' - amber, 'unfavourable bad' - red, plus unknown) | - |
| | Change in land cover | This indicator can give information on the trend in area of several ecosystems through the trend in extent of the related land cover. | - Land cover data | - Satellite imagery | |
| | Change in land use | | - Compatible use of area | - Remote sensing /land use map | |
| | Number and type of protected species | Protected species refers to species that are protected by law, meaning that it can be illegal to kill, injure, take a protected species, or to pick , or damage, destroy or obstruct certain wild plants. | -Type of protected species<br>- Number of protected species | | |
| PEOPLE | Increasing recreational opportunities of NBS area | Recreational opportunity is an opportunity that people can do during their leisure. Recreation is a necessary element of human biology and psychology. | - Number of recreation activity in the area | | Bastian et al.,2012(Handley et al., 2003; De Vries et al., 2003; Chiesura, 2004; Li et al., 2005; Jim and Chen, 2006; Comber et al., 2008; Mazuoka and Kaplan, 2008) |
| | Number of tourists | NBS area do not provide recreational setting only to local residents, but also to visitors from out of town. | - Number of tourists | - Data collection methods: surveys; existing data sources<br>- Data analysis methods: IMPLAN or other regional economic modelling, such as | (Petrosillo et al., 2006; Voyer et al., 2013) |

| | | | | | |
|---|---|---|---|---|---|
| | | | | input/output models | |
| | Provision of NBS sites for education and research | NBS has been used as a valuable education resource. | - Number of student benefiting from education and research about NBS | | |
| | Loss of cultural heritage due to hydro-metrological events/ due to land take | | - Economic and properties loss during hydro-metrological events<br>- Cultural heritage loss | Data collection methods: surveys; existing data sources; Data analysis methods | |
| | Reduced need for management and maintenance | | Maintenance and management cost of grey infrastructures (if implemented)<br>- Maintenance and management cost of NBS | | |

*OTHER INDICATORS PROPOSED BY PORTOFINO DEMOSTRATOR A (TO INTEGRATE THE PROPOSED ONES)*

| NBS | RECOMMENDED INDICATORS | DESCRIPTION OF INDICATOR | VARIABLES | EXAMPLE OF METHODS | REFERENCES |
|---|---|---|---|---|---|
| WATER | Possible source of debris/ hyper-concentrated flow | Artificially immobilized sediments and debris in man-made terraces may be source of debris/ hyper-concentrated flow. | Maintenance level of man made terraces | LIDAR detection of abandoned terraces, assessment of stability and maintenance conditions and connections with hydrographical network. Priority scale of recovery interventions. | Paliaga G., Luino F., Faccini F., Turconi L, Tarolli P. "Man-made Terraces: From Ancient Anthropic Landscape Modification to Value at Risk. The Example of 5 Terre and Portofino, Italy" iD Published Online:Fri, 11 Jan 2019 https://doi.org/10.1002/essoar.10500510.1 AGU Fall meeting 2018.<br><br>Giordan et alii "Rapid mapping application of vegetated terraces based on high resolution airborne LiDAR" Geomatics, Natural Hazards and Risk 9(1):970-985 · October 2018 DOI: 10.1080/19475705.2018.1478893<br><br>Paliaga G, Giostrella P, Faccini F. (2016) “Terraced landscape as cultural and environmental heritage at risk: an example from Portofino Park (Italy)”. ANNALES · Ser. hist. sociol. · 26 · 2016 · 3 - DOI 10.19233/ASHS.2016.32. •<br><br>G. Brancucci and G. Paliaga, "The Hazard Assessment in a Terraced Landscape: Preliminary Result of the Liguria (Italy) Case Study in the Interreg III Alpter Project" in "Geohazards", Farrokh Nadim, Rudolf Pöttler, Herbert Einstein, Herbert Klapperich, and Steven Kramer Eds, ECI Symposium Series, Volume P7 (2006). |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | http://services.bepress.com/eci/geohazards/16 |
| | Floating transport in hydrographical network | Assessment of dead trees that may be transported into the hydrographical network magnifying the effects of flooding and blocking culverts in case of heavy rain. | - Dead trees in 20 m buffer areas along the hydrographical network | Direct survey | |
| PEOPLE | Footpath network recover through erosion reduction and improvement of path smoothness | Assessment of footpath lengths to be recovered and improved | Length of improved path - water drainage improvement (n°) | Direct survey | Mark C. Jewell William E. Hammitt "Assessing Soil Erosion on Trails: A Comparison of Techniques", USDA Forest Service Proceedings RMRS-P-15-VOL-5. 2000 |

#### *4.3.6.2 Monitoring approach*

Monitoring of the pilot area actually regards only a weather station at the top of Portofino mountain (610 m asl) and ecosystem in the Park and Natura 2000 site. The implementation of other weather stations dedicated to monitoring the parameters in different microclimatic conditions of the pilot areas will allow a better definition of the very local conditions; besides it will allow the possible implementation in a nowcasting and alert system dedicated to the more exposed areas at the mouth of the streams: the touristic facilities and main road in catchment 3 and historical heritages and touristic facilities in catchments 1 and 2.

The improved monitoring system will be publicly diffused through a web platform, enhancing the distribution of the information to the public that intensively visit the area.

LIDAR data are a consistent element of monitoring due to the highly dynamical processes active in the area: erosion and instability are hardly driven by the high gradient of the slopes and conditions, including terraces, will be precisely assessed through the use of detailed survey data.

#### 4.3.6.3 *Monitoring planning*

*Table 4-7 Portofino NBS monitoring plan*

*Indicators are sequentially coded from the Portofino indicators selection; the additional proposed indicators follow the supplied list (W4, W5, P6).*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| Water | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| | W3 | | | | | | | | | | | | | | | | | | | | |
| | W4 | | | | | | | | | | | | | | | | | | | | |
| | W5 | | | | | | | | | | | | | | | | | | | | |
| Nature | N1 | | | | | | | | | | | | | | | | | | | | |
| | N2 | | | | | | | | | | | | | | | | | | | | |
| | N3 | | | | | | | | | | | | | | | | | | | | |
| | N4 | | | | | | | | | | | | | | | | | | | | |
| | N5 | | | | | | | | | | | | | | | | | | | | |
| | N6 | | | | | | | | | | | | | | | | | | | | |
| | N7 | | | | | | | | | | | | | | | | | | | | |
| People | P1 | | | | | | | | | | | | | | | | | | | | |
| | P2 | | | | | | | | | | | | | | | | | | | | |
| | P3 | | | | | | | | | | | | | | | | | | | | |
| | P4 | | | | | | | | | | | | | | | | | | | | |
| | P5 | | | | | | | | | | | | | | | | | | | | |
| | P6 | | | | | | | | | | | | | | | | | | | | |

A monitoring of Natura 2000 habitats and species present in Portofino Park is already carried out by Liguria Regional Authorities, and on line available.

Two weather stations from the Regional Monitoring Network (ARPAL) are present in the Park area (but outside the RECONECT catchments), on line accessible and also regularly consulted by the park.

Finally, number of visitors and tourists along hiking paths are measured through counters installed in the park area and regularly monitored by the park.

#### 4.3.6.4 Data management system

Portofino Demo bases its development on already existing data, whilst other will be acquired in the coming months within RECONECT. Current situation of data can be two folded in:

**Data from Portofino Park Authority**, directly managed by the park. They are:

- Data from meteorological stations coming from Regional Monitoring Network (ARPAL). Periodically, data from the two stations in the park area are automatically downloaded on a local server. Storing of data is manually.
- Data related to visitor accesses to the Park: they are detected through a step-meter and locally stored. Periodically data are on-site manually downloaded and uploaded on a web site (www.eco-visio.net/Ecovisio) where it is possible viewing and processing data.

As far as Park infrastructure is concerned, local servers are available as well as a MapInfo license, used for managing geo-spatial data.

**Data from the Liguria Regional Information Systems,** they are geospatial and environmental data downloadable via web services (WMS and WFS), compliant with standards.

- geospatial data
- http://srvcarto.regione.liguria.it/geoviewer2/pages/apps/geoportale/index.html)
- Data on Natura 2000 by the Regional Environmental Agency and on-line available at: http://www.banchedati.ambienteinliguria.it/index.php/natura/biodiversita?_ga=2.178974180.1765742873.1548749143-215546432.1544714268

Work to integrate data in the RECONECT platform has not yet started. It will begin once the technical specifications, standards and formats requested by the platform are known.

### 4.3.7 Evaluation

The main expected benefit is the geo-hydrological risk reduction, which means preventing the possible loss of non-renewable and invaluable cultural heritages and possible damage to infrastructure and buildings that are increasing in the whole region due to an increasing number of extreme meteorological events.

Co-benefits are enhancing tourist’s security, preventing tourism facilities damage and then improving resilience of socio-economic system in the area.

### 4.3.8 References& Sources

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Bastian et al.,2012(Handley et al., 2003; De Vries et al., 2003; Chiesura, 2004; Li et al., 2005; Jim and Chen, 2006; Comber et al., 2008; Mazuoka and Kaplan, 2008).

Brancucci G. and Paliaga G., "The Hazard Assessment in a Terraced Landscape: Preliminary Result of the Liguria (Italy) Case Study in the Interreg III Alpter Project" in "Geohazards", Farrokh Nadim, Rudolf Pöttler, Herbert Einstein, Herbert Klapperich, and Steven Kramer Eds, ECI Symposium Series, Volume P7 (2006). http://services.bepress.com/eci/geohazards/16

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Paliaga G., Luino F., Faccini F., Turconi L, Tarolli P. "Man-made Terraces: From Ancient Anthropic Landscape Modification to Value at Risk. The Example of 5 Terre and Portofino, Italy" iD Published Online:Fri, 11 Jan 2019 https://doi.org/10.1002/essoar.10500510.1 AGU Fall meeting 2018

Paliaga G, Giostrella P, Faccini F. (2016) “Terraced landscape as cultural and environmental heritage at risk: an example from Portofino Park (Italy)”. ANNALES · Ser. hist. sociol. · 26 · 2016 · 3 - DOI 10.19233/ASHS.2016.32.

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# IV. SPECIFYING BASELINES & SCOPE OF WORKS FOR DEMONSTRATORS “B”

# 5 Demonstrator DB-1 Ijssel River Basin, The Netherlands

## 5.1 Overview

### *5.1.1 Summary of the NBS case*

The Ijssel River basin project (‘Stroomlijn”) is implemented under the banner of the ‘Room for the River’ Programme. Room for the River involves large scale (NBS) measures (for example parallel waterways, shortcuts, by-passes) to increase river discharge during periods of high water levels and improve water safety.

Programma Stroomlijn ‘Ijssel’ is a sub-programme for Room for the river and is 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 reduce 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 project consisted of the following main tasks

- Design of the measures (vegetation/landscape management and vegetation removal)
- Stakeholder and land owner management (approvals, access, communication)
- Obtaining formal permits and authorization
- Execution of the work: removal of trees, shrubs, reed areas, transfer into grasslands, and additional measures to ensure sustainable landscape/nature management in flood plains)

The project took roughly 5 years. At the busiest time, 20 people were active every day.

### *5.1.2 RECONECT – innovation potential*

The largest innovation used during the Stroomlijn project was the implementation of a GIS-system. The size of the study area, amount of stakeholders and different expert fields required a common denominator; the geographical location. Every aspect of the project was put in a geographical information system (GIS). Every expert was required to put their conclusions, questions, research result, etcetera into this GIS-system, ranging from ecological information to information obtained through talks with stakeholders. At the same time the information in GIS was made available to the whole project team with a web-viewer. This made sure that every team member had the same up-to-date information available and that all the information was specified for one of the 300+ locations.

With the use of GIS it was possible to portray relevant project data by location. Relations between different aspects became immediately apparent, more so than by reading trough different reports. For instance, a designer could look at all the protected species in one area, read the agreements with an owner, check for explosives and dangerous cables, etcetera, and change the design accordingly. Another example is that once permits were acquired for a design, these were also put in GIS so contractors were able to read the permits with all the stipulations in the field during work.

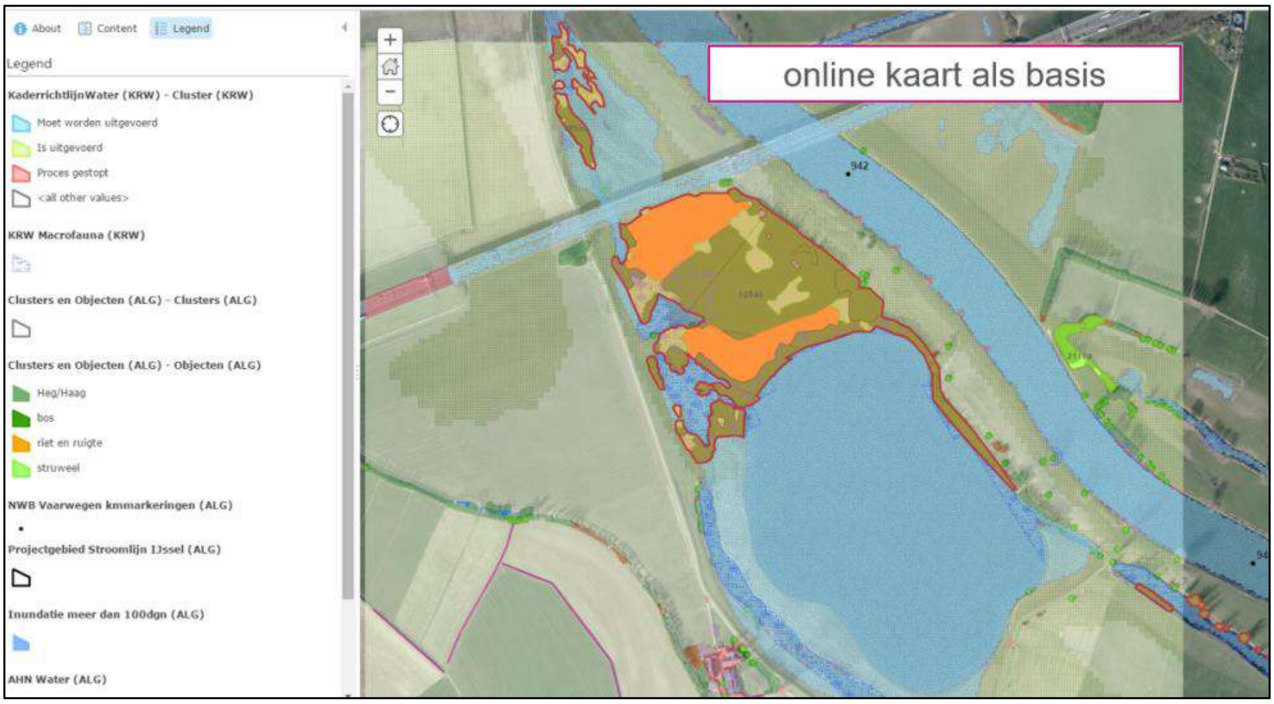



*Figure 5-1 Display of GIS system used during the Stroomlijn project.*

Another advantage of this system was the possibility of automating the process of reporting results. Almost all the required information was present in the GIS-system. Consulting and engineering firm Tauw, involved in the project, created scripts which were able to convert the information into a 90% version of a design report. These reports made use of input provided by different experts and only required a careful read-through and minor adjustment before these could be sent to the client.

### *5.1.3 Geomorphological characteristics*

The Stroomlijn project area encompassed the floodplains of the Ijssel river. 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 project area is divided into two areas; “stroombaan” (in English: flow path) and “stroomluw” (outside of the stroombaan area) area. Stroombaan is defined as the area in the floodplain where the flow rate is higher than 1 m/s during normative high water levels.

The project mainly focuses on the flow path, which is located in the lower and wetter parts of the floodplains. Because these parts are difficult to manage and less suitable for agriculture, causing more natural vegetations such as reed beds and riparian forests to develop. For this project, a distinction is made in the vegetation types:

- agricultural grassland and arable farming lands
- reeds /roughness (0-2m)
- thicket / shrubs (2-5m)
- forest (5m)

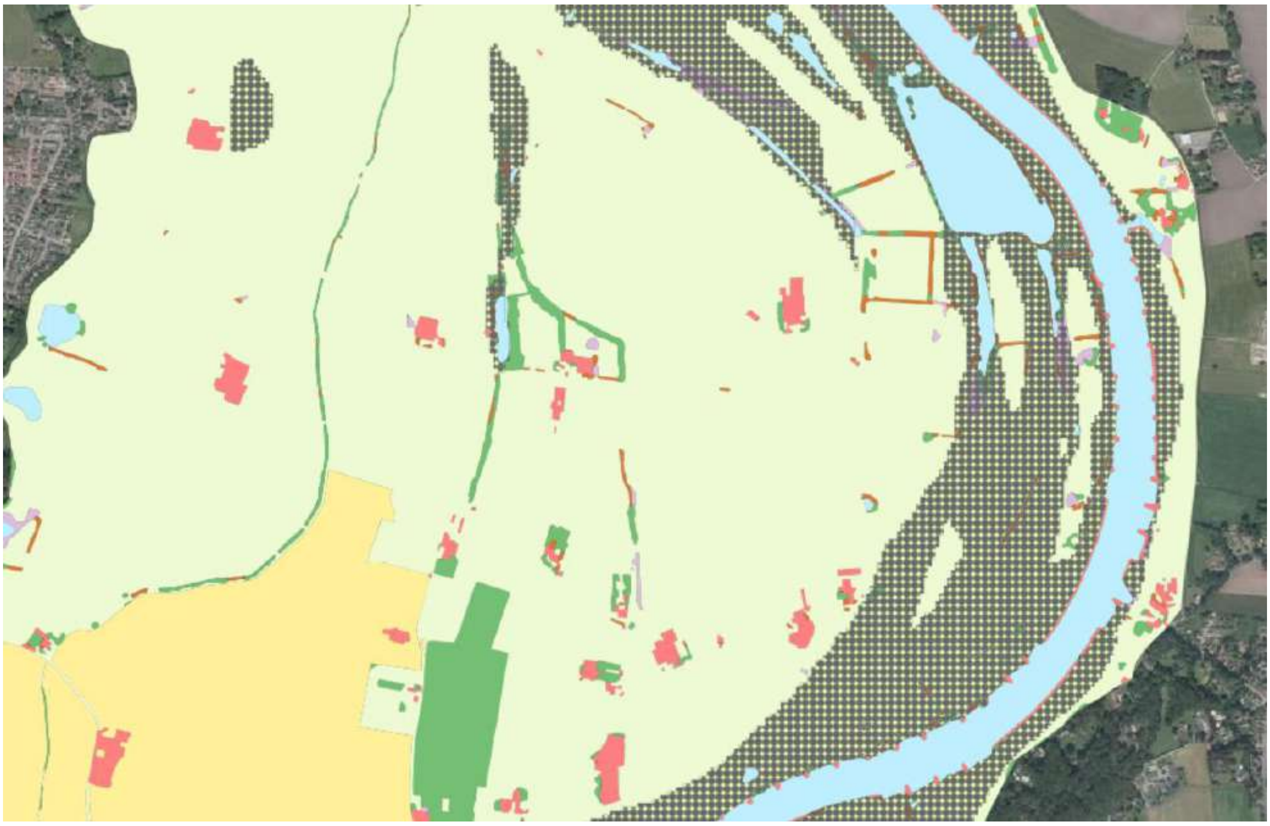


*Figure 5-2 Map of part of the Stroomlijn project area*

### 5.1.4 Climatic conditions

According to the Köppen climate classification, the Netherlands has a temperate oceanic climate (Cfb) with relative mild winters, mild summers and precipitation during the whole year. The coldest month averages above 0 °C , at least one month's temperature averages above 22 °C and at least four months average above 10 °C.

Locally, in Zwolle, a place near the Ijssel river, the annual, winter and summer average temperatures are respectively 9.1 °C, 3 °C and 15.5 °C. The average precipitation is 778 mm. Measured in De Bilt from 1981-2010, an average of 25 snow days occur yearly.

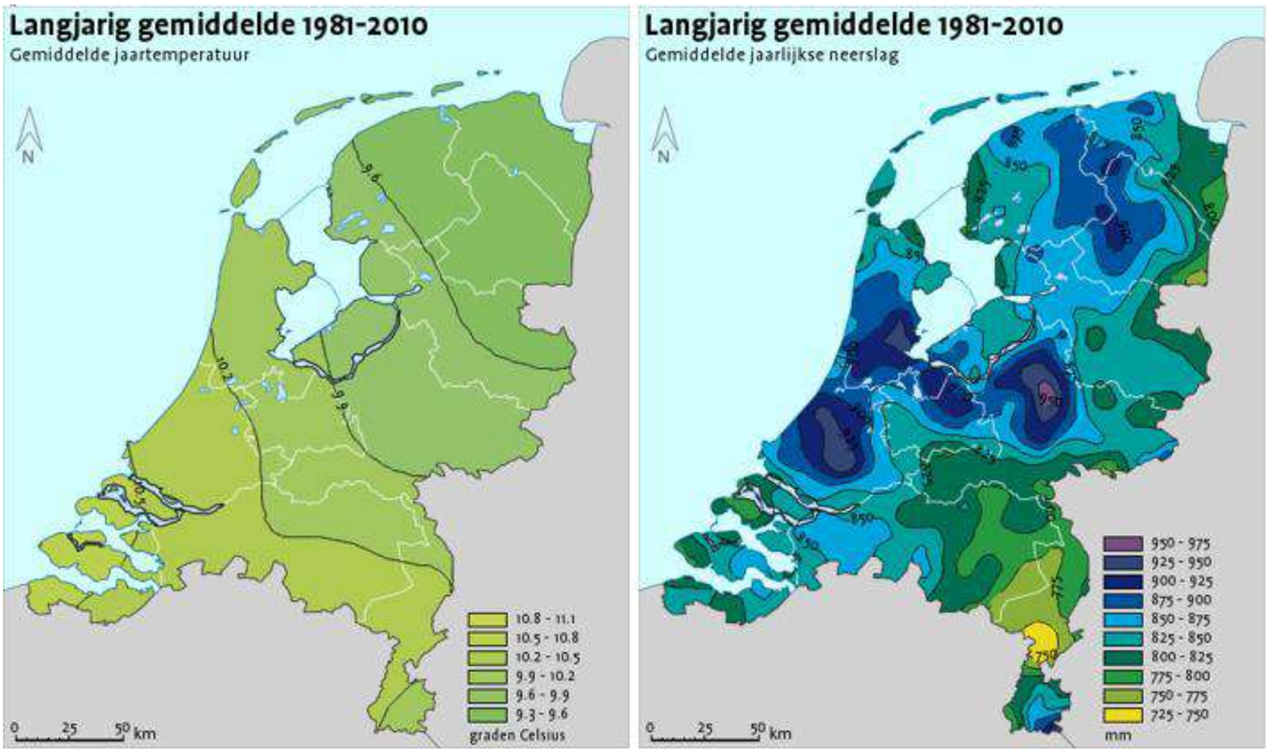



*Figure 5-3 On the left, yearly average temperature in degrees Celsius (1981-2010). On the right, yearly average precipitation in millimeters (1981-2010). Source: KNMI*

As the Stroomlijn project focuses on making vegetation "flowable" to decrease flood risks, the important climate parameters are precipitation and wind. Precipitation is directly linked to the discharge in the river, and the wind has an influence on the flow velocity.

### *5.1.5 Hydrological conditions*

The (Gelderse) Ijssel river is the third major (after the Waal and the Nederrijn-Lek) distributaries of the river Rhine, with a length of approximately 127 km, a width of 70-140 m, a depth of about -3,20 NAP and a catchment area of 4270 $km^2$. The Ijssel receives about 15 – 20% of the Rhine discharge, which is regulated by a weir situated in Driel.

### *5.1.6 Hydro-meteorological hazard and problem description*

The Rhine and IJssel delta experiences annual flooding. 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 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. Therefore project Stroomlijn IJssel focuses on the removal of vegetation within the floodplains in places where the river flows fastest at high water levels.

### *5.1.7 Nature*

Both landscape and natural values were important for the Stroomlijn project. The aim of the project was to leave a "good" landscape in its entirety after all the activities. In addition, protected plant- and animal species must considered. Nature areas, such as the N2000 areas, where subordinate to the activities of the Stroomlijn project because priority is given to flood risk safety priority.

For landscape in its entirety, a landscape architect was involved. Responsible for the design, the landscape architect carefully considered, among other things, old landscape structures. Old hedges and hedgerows were looked up on a map and in the field, and checked by a historical geographer before being excluded from the project.

Various ecological researches were conducted for protected plant- and animal species. For every protected species encountered, regulations have been drawn up. For example, when a beaver lodge was encountered, an area of 100 m around the lodge was exempted from the Stroomlijn activities. In the vicinity of the beaver lodge, 800 m of plants was preserved as food for the beaver. These plants are along a waterway, with preference to bypasses instead of the main stream. Similar areas have been maintained for protected bird species, depending on the species. For example, for a buzzard 25 m of plants were preserved, while 200 m was preserved for the hawk.

Because the project lasted for many years, ecological research were updated regularly. It was mandatory to carry out a final ecological research after every activity. During these final researches, protected species were found that have settled in the area during the design process.

Ecological restrictions in the form of protected species, particularly the beaver, are the main reason to preserve planting within the project.

## 5.2 Stakeholders and governance

### *5.2.1 Stakeholders*

The program directorate Room for the River of Rijkswaterstaat is in charge of the Stroomlijn project. Other important stakeholders include:

1. 170 entitled to the floodplains (landowners, -renters and -users);
2. Interest groups (nature organisations, landscape organisations, cultural-historical heritage, flora and fauna organisations)
3. Permit authorities and enforcers (Water board, province, municipalities for nature protection law permits, flora and fauna law permits, project plan water law permit).
4. Direct stakeholders (managers, residents, users; about 400 involved)

Table 5-1 depicts an influence and interest matrix of the stakeholders.

*Table 5-1 Influence and interest matrix of the stakeholders.*

| Influence | | Interest | |
|---|---|---|---|
| | | Low | High |
| | High | Press | Ministry of Infrastructure and Environment Directorate General Spatial Development and Water Affairs (DG Ruimte en Water) |
| | | Gas Union (Gasunie) | Ministry of Infrastructure and Environment Human Environment and Transport Inspectorate (ILT) |
| | | Utility companies | Ministry of Economic Affairs government Service for Land and Water Management (DLG) |
| | | Government real estate company (RVB) | Dutch Water Board - Rijkswaterstaat (client) |
| | | | Dutch Water Board - Rijkswaterstaat (other services) |
| | | | Dutch Federation of Agriculture and Horticulture (LTO) |
| | | | Municipalities |

| | | | |
|---|---|---|---|
| | | | Province of Gelderland |
| | | | Province of Overijssel |
| | | | Waterboard Vallei en Veluwe |
| | | | Waterboard Groot Salland |
| | | | Waterboard Rijn en Ijssel |
| | | | SOVON/Das en Boom/ Milieudefensie |
| | | | Terrain management organisations (SBB/ Natuurmonumenten) |
| | | | |
| | Low | Association of Recreation Entrepreneurs Netherlands (RECRON) | Ministerie van OC&W (RCE) |
| | | Free Recreation Foundation (SVR) | Ministerie van Defensie |
| | | Royal Dutch Tourist Association (ANWB) | Land owners |
| | | VEKABO | Camp site owners |
| | | Knowledge institutes | Farmers |
| | | Fisheries | Private owners |
| | | | Marinas |
| | | Citizens and users of the area | Land renters |
| | | | Investors |

**Stakeholder management**

One of the largest project challenges was managing the many land owners and other stakeholders. These, in general, provided a lot of 'resistance' to the implementation of the project. Stakeholder communication involved many citizen information evenings (at least 1 per community), meetings with land owners (3-6 meetings per land owner), and meetings and discussion with the many other stakeholders (authorities, nature or cultural interest groups and protection agencies). The project put a large focus on communication of plans and designs prior to permit applications, to try to prevent citizens/stakeholders objecting to the plans in the formal permitting procedure.

Resistance to the plans/design resulted from the following:

- Land owners not wanting to change the landscape/vegetation on their property
- Local authorities objecting to the national authorities' plans
- Nature interest and protection groups/associations trying to protect natural areas or specific trees (though they were not the land owners)

A coordinated permit procedure (aligning the timing of applying for all permits) was used, where one public procedure for all permits for a certain set of designs is applied. Citizens/stakeholders were able to 'object' against the permit application/plans by means of submitting their 'view', requiring an official response. In the formal permit procedure, only parties that had already submitted a 'view' were allowed to submit a formal objection/appeal to the 'Council of State' (Raad van State), which is the highest court in administrative law.

### *5.2.2 Governance*

The governance structure of the Stroomlijn project include several authorities with their own roles. The program directorate Room for the River of Rijkswaterstaat was in charge as the client. A project bureau called Courant was formed by Tauw, Eelerwoude and Bruins en Kwast, which provided for the different permits/exemptions, and reported the following to the supervising authorities; compliance with the coordination obligations for all permits, exemptions, authorizations, notifications and decisions. There were also government authorities involved who are also landowners (for example: State Forestry Service, Rijkswaterstaat, ministry of Defense).

### 5.2.3 *Ownership*

There were about 170 parties entitled to the floodplains (landowners, -renters and users). In 52% of the area there was large landownership where a government organization (e.g. State Forest Service, Rijkswaterstaat, Ministry of Defense) or foundation (e.g. Nature Monuments, Ijssel Landscape Foundation, etc.) was the owner. Aside from these government related owners, there were also private owners. Beside the landownership, more than 400 direct stakeholders are involved (managers, land renters, residents and users) but the landowner is responsible for the management.

Initially, the owners would be responsible for the management plan. They would receive a compensation, but did not agree because the compensation was not cost-effective. The scope of the Stroomlijn project did not include signing management contracts with owners. There are standard management agreements which are often not signed.

### 5.2.4 *Project organisation and management*

Regarding project organization and management, a project team from Rijkswaterstaat and a project team from Courant took the role of contractor.

Both the client and contractor worked according to the integral project management model (IPM) which was developed by Rijkswaterstaat, where 5 roles of the IPM core team were fulfilled by different persons:

- Project manager
- Project control manager
- Contract manager
- Environmental manager
- Technical manager

Aside from the IPM core team, Courant deployed other staff, which include the following:

- Support project control manager
- Stewards
- Design leader
- Quality coordinator
- Other project staff, including ecologist, designers, documentalists and executors.

There was a board of directors consisting of representatives of the 3 combined parties (Rijkswaterstaat, Courant, IPM team), who was responsible for monitoring overarching control and formed a so-called escalation line in case of (threatening) conflicts or far-reaching decisions (time and money). De tasks and roles and replacements of employees as well as escalation boundaries are declared in the project-management plan.

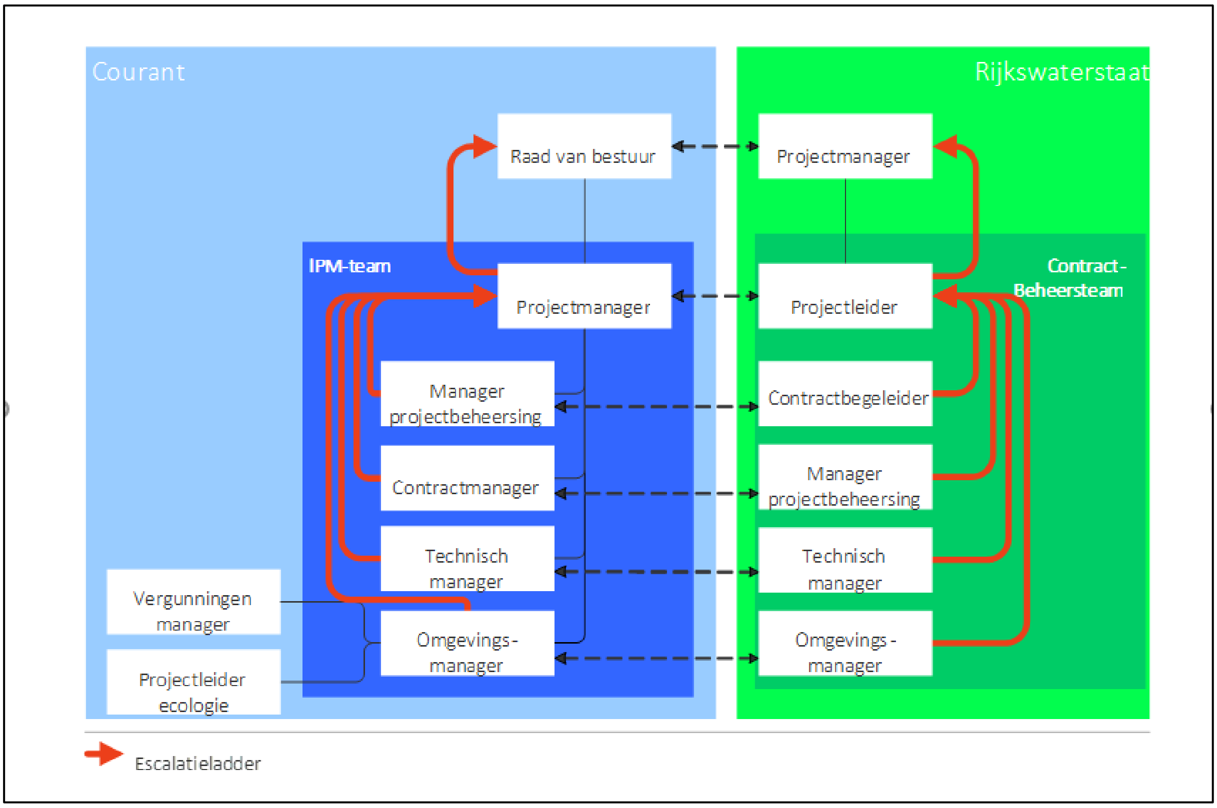



*Figure 5-4 Stroomlijn project organisation and management.*

#### *5.2.5 "People" – socioeconomic aspects*

The Stroomlijn project is executed in the floodplain of the Ijssel (from mid Arnhem to Kampen), with rural villages of the provinces Overijssel and Gelderland on its edges.

Land-use in the floodplain is generally agricultural and livestock (grazing and hay meadows) in combination with nature and recreational use. Cultural-historical and landscape values (e.g. hedges and hedgerows) had to be retained as much as possible or included in the design. The project area contained many (protected) flora and fauna values that had to be retained or mitigated.

The project affected the landscape and land use type along the rivers. In general this should have resulted in lower maintenance cost. 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. In some instances, the project conflicted with recreational use of the area. For example, in some cases camp sites had to 'give up' their green surroundings, as these were partly cut down.

In general, formally protected areas and species, as well as trees, hedges, and landscape sections that had cultural value or heritage, were protected from vegetation management. Areas designated for nature development were excluded. Also, areas that were used for (public) infrastructure were exempted from any vegetation removal.

### 5.3 Project Scope: NBS to be demonstrated in RECONECT

#### *5.3.1 Scope summary*

Overall, the project's main task were:

- Technical landscape design (re-designation of vegetation type)
- Gaining approval of land owners

- Land owner and other stakeholder management and communication
- Obtaining formal permits / approvals
- Execution of the work (cutting of vegetation)
- Prescribing maintenance plans

For the design and preparation, first conditioning research had to be conducted regarding ecological conditions (flora and fauna) and unexploded ordnance in the project locations. Then the technical design had to be made with a prescription of the desired vegetation types, and it had to be determined what needs to be cut down. Following the technical design, permit preparations and applications had to be done, taking into account the environmental process and stakeholders agreements (stakeholder management and communications).

Implementation included the removal of trees ( incidental crowning), reed/roughness and thicket/ shrubs, removal or correction of hedges and hedgerows, and sustainable river bank management measures (for example, restoration ditches and trenches).

Implementation took place in 3 phases:

- Phase 1: land parcels where flora and fauna data are known, and with stakeholders agreements, started in 2015 for an estimate of 40% of the area.
- Phase 2: land parcels where flora and fauna data are known, but where more effort was needed to reach agreements with stakeholders, started at the end of 2015 for another estimate of 40% of the area.
- Phase 3: parcels where the flora and fauna data still had to be (further) explored and risks of appeal procedures in the permit applications existed, started in 2016 for an estimate of 20% of the area

**Maintenance**

Maintenance plans were drafter and proposed to land owners. However, signing, arranging, monitoring and controlling maintenance work was not part of the project.

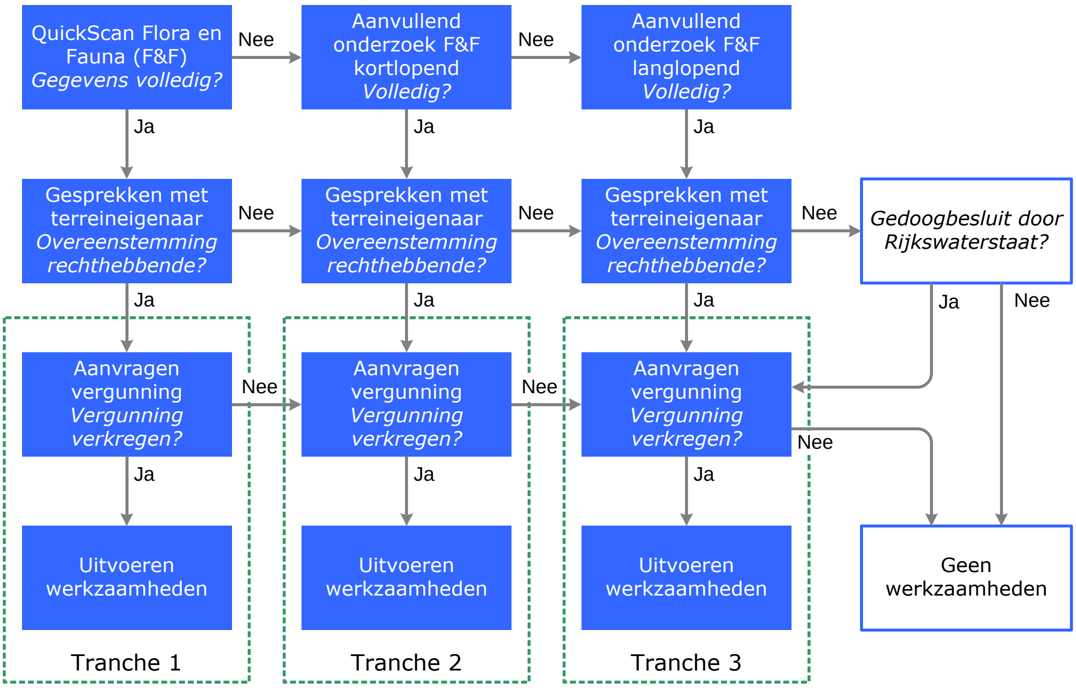



*Figure 5-5 Activities in the Stroomlijn project*

### 5.3.2 *Project phases and planning*

*Table 5-2 Ijssel River Basin NBS Project phases and planning*

| | | | Year 1 2014 | | | | Year 2 2015 | | | | Year 3 2016 | | | | Year 4 2017 | | | | Year 5 2018 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | | Feb | May | Aug | Nov | Feb | May | Aug | Nov | Feb | May | Aug | Nov | Feb | May | Aug | Nov | Feb | May | Aug | Nov |
| 0 | Baseline monitoring | | | | | *Start* | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | | | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | *Tauw as contractor* | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | *T1* | | | | | *T2* | | | *T3* | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | | |

### 5.3.3 *Planning & Design*

The Stroomlijn project started to develop when Rijkswaterstaat issued a tender with the aim of carrying out the overdue maintenance task within the floodplains (river flow path) in order to guarantee the high water safety objectives. The subject of the assignment was the design, permit process, environmental communication and realization.

Rijkswaterstaat has not only assessed the lowest price, but also the quality of the proposals. The following quality criteria were important for the tender:

- Vision on the environmental process and control of the risks that are present from the environment
- Vision on planning and management of the planning risks.

Under the name Courant (combination of consultancy bureau Tauw, consultancy bureau Eelerwoude and vegetation management company Bruins&Kwast), Tauw was able to meet the requirements (level 5 on the CO2 ladder, references) and make the best quality plan to win the tender. Remarkable is that a consultancy firm (Tauw) took a risk-bearing role as the main contractor.

The design process is set in the following ways:

- conversations with stakeholders to obtain permission (implementation agreements)
- coordinated license application (instead of per municipality) where the design process was detailed

In addition, conditioning research have been carried out for the permit procedure (among others, flora and fauna, unexploded ordnance, soil research, etc.).

Tauw was responsible for the design, which did not necessarily include a participatory process with citizens. However, the owners had to be taken into account. A KES (customer requirements specifications) has been drawn up per design. (by owners to set hard/soft conditions). Conversations took place to clarify where there is room (if requirements were contrary to design / contract requirements) to convince owners and to search for ways to combine contract and owner demands (for example, which trees can be left standing). The requirements of the client has to be met as well as the owner's (to prevent objection during the permit procedure).

The project started with a scope of about 300 hectares of upward vegetation. This vegetation was divided over 17 municipalities, 2 provinces, 3 water boards and 350 owners.

In the end, 134 designs were made in which about 60% of the vegetation was made 'flowable'. Around 30% of the vegetation has been removed and converted into grass-/farmland, and for the other 30% the forest is crowned and thicket/shrubs is removed from the reeds/roughness. The remaining 40% is mainly retained due to ecological restrictions.

The designs were based on the following rules: All vegetation had to be converted to grass- or farmland, except if:

- protected plant or animal species is present
- restrictive cables and pipes are present
- restrictions are present due to permit-technical rules
- the location has a monumental status
- other projects with a higher status (e.g. bypasses of the EU Water Framework Directive) are implemented on location

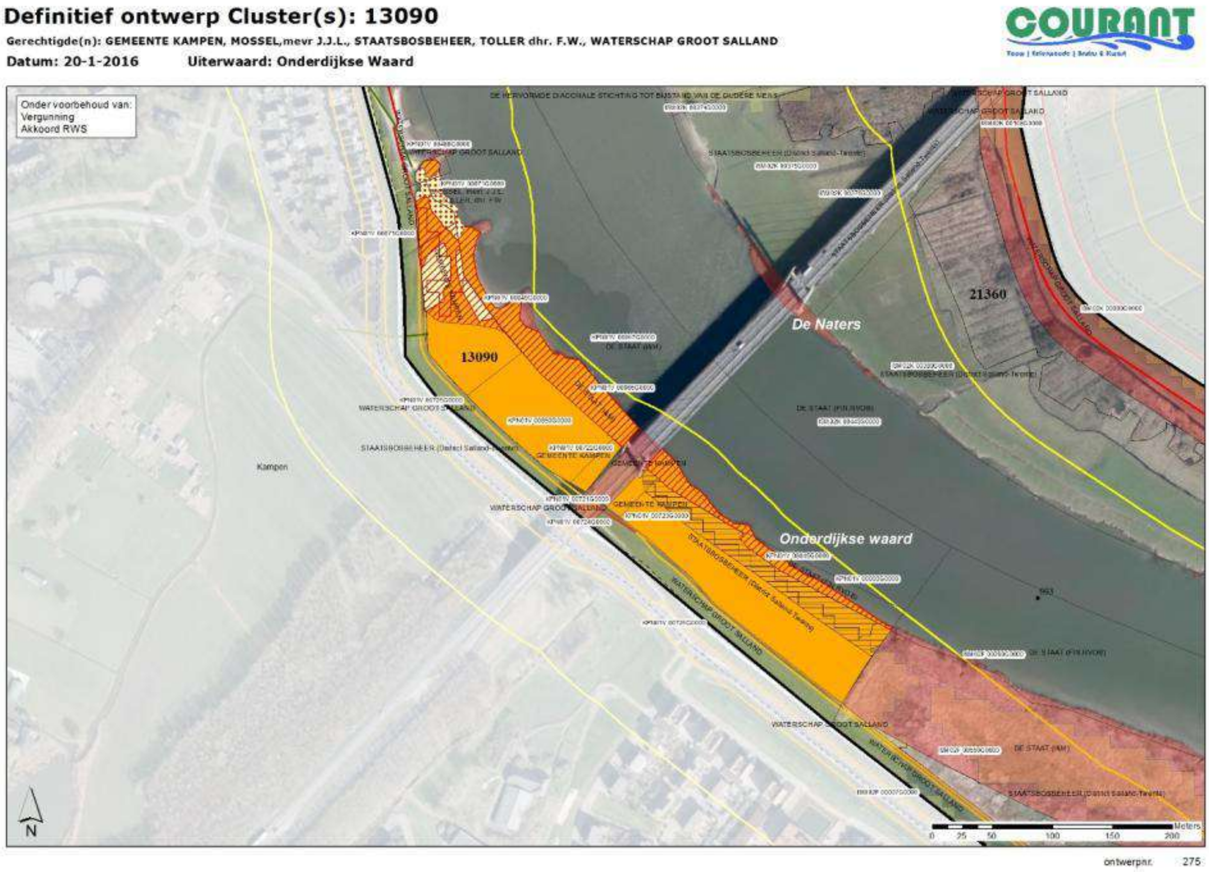



*Figure 5-6 Design for the works to be implemented at the new bridge in Kampen.*

*Along the IJssel river, part of the reed (orange) will be converted to grassland. The thicket on the North side will be removed and converted to grassland. To comply to the WFD rules, some trees will be retained along the water's edge.*

The GIS model used in this project included 1 card layer with the river / water flow lines / direction, so that the landscape design could take into account which areas were most important in river discharge and vegetation removal was prioritized for this area.

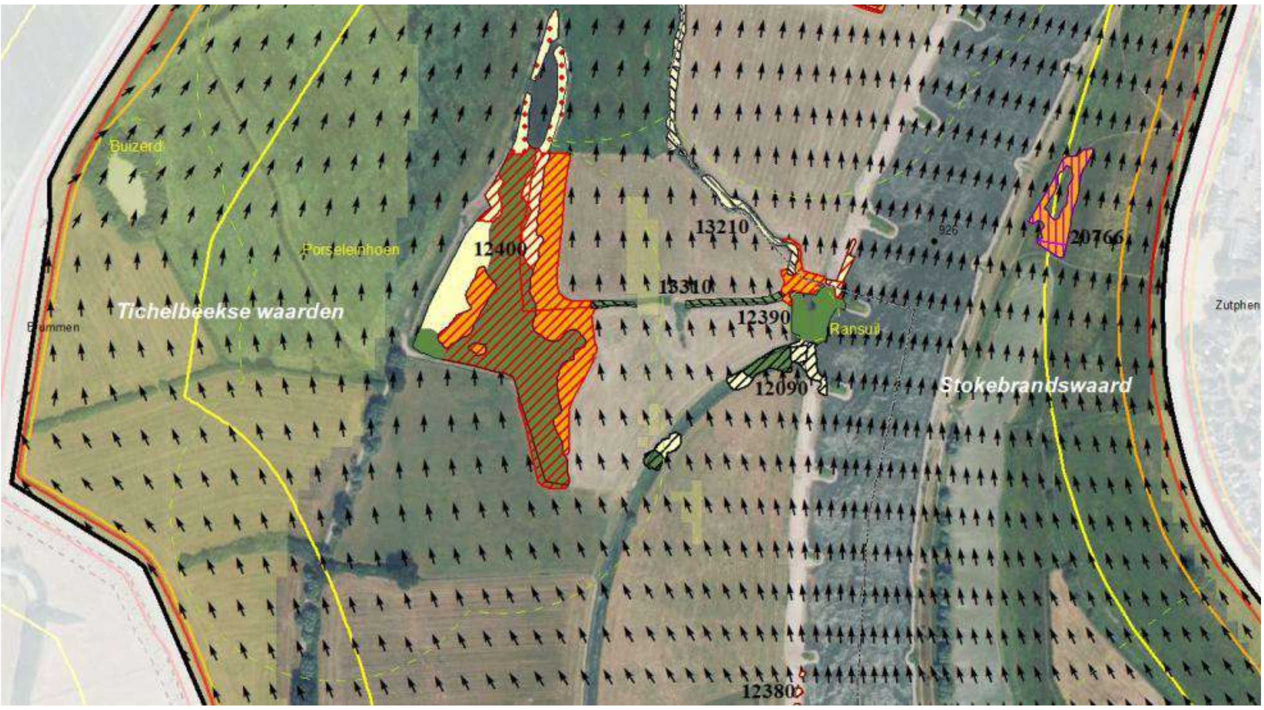
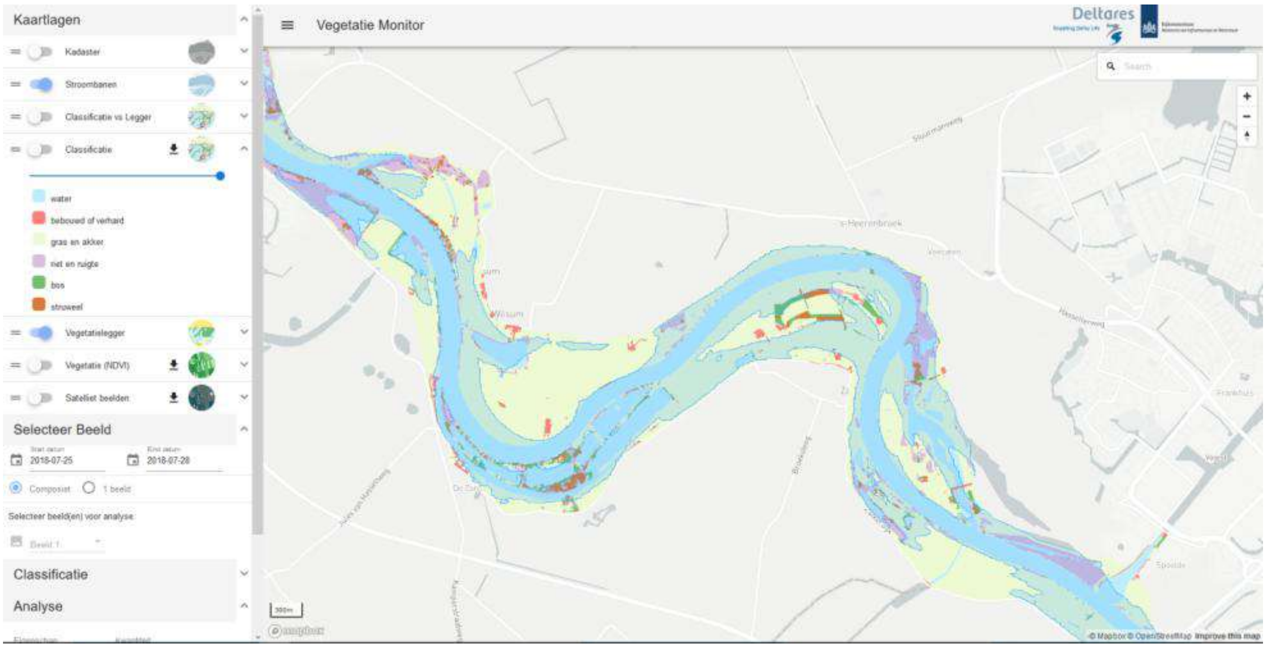



*Figure 5-7 Display of flow direction in GIS for a Stroomlijn project location.*

The main challenge for the design was obtaining permission from owners. Owners had to agree to the design before it was possible to proceed with the removal of vegetation. It was important to communicate clearly with the owners and clarify what their requirements and wishes were, and where it was possible to match these. For example, there was a buzzard nest may not be removed unless there is an alternative nesting location, and the owner did want all trees removed. Some trees were retained (in accordance with the owner), while the buzzard got an alternative nesting location.

The entire project took 4 years, of which the implementation (removing vegetation) took 3 years.

RWS has their monitoring system on vegetation growth and hydraulic parameters in the Ijssel with Deltares.




https://www.openearth.nl/vegetatiemonitor/

### 5.3.4 *Procurement and contracting*

RWS published the tender (public tender procedure). The bids were evaluated based on EMVI criteria (economically most attractive offer). In addition to the price, the tender was assessed based on quality criteria. In this project, the most important focus in evaluation the bids was on stakeholder management and planning (securing in time delivery).

Tauw (consultant), in a project combination/team with Eelerwoude (consultant) and Bruins&Kwast (vegetation maintenance company), acted as the **contractor** in this project. The combination won the contract in a public tendering procedure published by RWS (Public Authorities). The contract used was “UAVGC”, a design and construct contract, including a fixed price for the preparation and design, and flexible tariffs of ‘volume’ of actual vegetation removal. Tauw (the combination) subcontracted several parties.

- Executive contractor GMB for carrying out the sustainable management measures (grids and earthwork on banks)

- Research agency Bombs Away for carrying out literature research on unexploded ordnance

- Research agency Armaex for conducting field research on unexploded ordnance

The contracts with the subcontractors were not drawn up in a tendering procedure, but from the existing network. The coordination of the subcontractors was largely done by Tauw.

#### 5.3.4.1 *Finance*

The project was financed by Rijkswaterstaat (commissioner/client). The budget for the Stroomlijn project was 5.2 million Euros, including a provisional sum of 1.3 million Euros (of which only 850 000 Euros was used). It was managed to implement the project within the budget. The full budget was not used because less vegetation was removed. Still, the requirements were fulfilled (of the assumed 70% vegetation removal, between 50-60 % is realized).

There were no other financial contributions.

### 5.3.5 Construction

The main construction work consisted of the removal of vegetation (trees, reeds and roughness) and landscaping (cutting hedges and crowning solitary trees). In a number of situations poorly maintained gullies/trenches have been restored. Some small waterways have been constructed to reduce the terrain suitable for vegetation growth.

The main challenge in the implementation phase were the weather and terrain conditions (too wet or too dry). According to the nature law, it is not allowed to work from March to August in Natura 2000 areas. In the period January to May it was too wet (because of high water) and the owner did not agree on working on his terrain (because of land deterioration by used vehicles). September to December was the only option to implement the project, which was also difficult due to terrain conditions (clay too wet and difficult to reach parts), but also high water. A general height map of the Netherlands is used to prioritize lowest parts in the floodplain, with which implementation started in September.

For supervision of the work, Rijkswaterstaat used a system-based contract management during the execution. This is a method of conducting supervision that fits in an integrated contract and assumes risk-based implementation of audits at the organizational level (e.g. ISO certifications), (work) processes and products.

Tauw was responsible for the verification and validation of process components. For each deliverable, a verification and validation report had to be submitted. Rijkswaterstaat checked through office (project management plan, verification plan, etc.) and field (technical requirements) audits if the process was in right order.

### 5.3.6 Monitoring

In terms of monitoring, the progress of the implementation was determined. This includes checking whether vegetation was removed properly. Drones and photographs were used to compare the vegetation before and after work. Contractors (who removed the vegetation) had to take photos before, during and after the removal. Digital forms (linked to GIS) were used to obtain data of each location.

Redevelopment of the vegetation was not monitored. Tauw offered this to the commissioner, but this was not accepted. It is unclear if RWS has implemented any maintenance plans and / or has been monitored the results.

It is unclear if RWS has monitored the hydrological effects of this (landscaping) measure.

#### 5.3.6.1 Indicators

DB-1 Odense has selected 19 Indicators to monitor, of which 3 in category Water, 13 in category Nature, and 3 in category People, as presented here below in Table 5-3.

*Table 5-3 Ijssel River Basin NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | Surface run-off reduction | We modelled surface runoff during extreme rainfall events in cities as Zwolle and Deventer with the model CLOUDS | CLOUD model updated with new LIDAR data | n/a |
| | Slowing and storing runoff | Roughness coefficient<br>Storage capacity | Yearly checks with areal photographs | If needed, checks were made in the field. |

| | | | | |
|---|---|---|---|---|
| | Flood hazard | Roughness coefficient<br>Storage capacity<br>Flow velocity<br>Flood volume<br>Water depth<br>Height map | Gis model, connected to water depth prediction model. | The model gave the predicted water depths for every part of the project area for the coming two weeks. With this we were able to create a safe working condition for fieldworkers and inhabitants |
| NATURE | Changes in riparian habitat | Habitat area in $m^2$<br>Locations and shape of area | Field check<br>Talk with landowners<br>Aerial photography | Nature is checked with organisations as Prolander, IVN |
| | Changes in aquatic habitat | Habitat area in $m^2$<br>Locations and shape of area | Field check<br>Talk with landowners<br>Aerial photography | |
| | Change in wetland habitat | Habitat area in $m^2$<br>Locations and shape of area | Field check<br>Talk with landowners<br>Aerial photography | |
| | Changes in terrestrial habitat | Habitat area in $m^2$<br>Locations and shape of area | Field check<br>Talk with landowners<br>Aerial photography | |
| | Change in location of habitat boundaries | Habitat area in $m^2$<br>Locations and shape of area | Field check<br>Talk with landowners<br>Aerial photography | |
| | Change in vegetation along watercourses | Habitat area in $m^2$<br>Locations and shape of area | Field check<br>Talk with landowners<br>Aerial photography | |
| | Conservation status of habitats | Living areas of specific species | Connection with national flora and fauna database<br>Yearly field visits by ecologists | |
| | Shoreline characteristics and erosion protection | Flow speeds<br>Flow direction | n/a | |
| | Change in land cover | Area of specific land cover types in $m^2$ | Field check<br>Talk with landowners<br>Aerial photography | |
| | Change in land use | Area of specific land use types in $m^2$ | Field check<br>Talk with landowners<br>Aerial photography | |

| | | | | |
|---|---|---|---|---|
| | Restricted-range species | Locations of hibernating species<br>living/feeding area of hibernating species | Field check by ecologist<br>Connection with national database<br>Talks with landowners | |
| | Number and type of protected species | Locations of protected species<br>Living/feeding area of protected species | Field check by ecologist<br>Connection with national database<br>Talks with landowners | |
| | Number, area, location, of invasive non-native animal and planted species that are threatening to ecosystem, habitats or species | Locations of invasive species | Field check by ecologist | If any invasive species were detected, this would be noted by the ecologist and taken into account when design were made. |
| PEOPLE | Loss of cultural heritage due to hydro-metrological events/ due to land take | List and locations of culturally valuable hedgerows and trees | Field check<br>Talks with landowners<br>Historical analyses by historical geographer | The project area is known for its hedgerows. These needed to be protected in all circumstances. |
| | Reduced need for management and maintenance | Land use in $m^2$<br>design principles, focused on lower maintenance | Field check<br>Talks with landowners | Design were made in such a way that maintenance cost were reduced for land owners. |
| | Change in land and/or property values | list of areas were subsidies were received by land owners | Talks with landowners | Change of landuse could affect the amount of subsidies a land owner would receive. These were excempted from designs if subsidies were lost otherwise. |

#### *5.3.6.2 Monitoring approach*

Describe your monitoring approach in short:

- How is monitoring organized or how do you plan to organise monitoring (internally/external partners, mention roles and responsibilities)?

Regular monitoring is performed by Rijkswaterstaat and partners (such as Deltares) and data is shared on platformed as discussed earlier in this document (such as https://waterinfo.rws.nl/#!/nav/bulkdownload/huidige-selectie).

- Describe any links / synergies to already established national or EU monitoring network/facilities

Rijkswaterstaat is involved in many national programs (eg data exchange with KNMI) and has links with EU monitoring network/facilities in projects such as RECONECT.

- Is your monitoring system going to contribute to any Early warning system, or other information systems?

Our plans and executed monitoring involves connecting remote sensing with high tech measurements, this can be used for early warning systems. Tauw's contribution is the Stream Line project which forms part of the wider 'Ruimte voor de Rivier' ('Room for the River') program. The 'Room for the River' program will demonstrate new innovative techniques for monitoring rivers.

The aim of the measurements is to obtain data concerning the cross section of the river, the river slope, the degree of vegetation in relation to the discharge of the river and the water quality.

- What (innovative) monitoring/measurement techniques are (or will be) deployed? Mention any advanced sensor technologies, real-time data systems; hydrological/hydrodynamic simulation models, risk mapping tools, etc.

The high-quality equipment to be employed is listed below.

- The width of three cross sections will be measured with a total station as well as a high-end Global Navigation Satellite System (GNSS) GPS device. This will also allow us to measure the water surface slope over a section of 300 meters.
- The measurements will also be made by an aerial drone to map the dry flood plains next to the river. A DSM (digital surface model) can be made by processing the pictures with photogrammetry software. We will also experiment with using an aerial drone to try to estimate the surface flow velocity.
- The discharge and wet perimeter will be measured using an ADCP (Acoustic Doppler Current Profiler) attached to a Jet-ski.
- Finally an underwater drone equipped with water quality sensors will be used to map the quality parameters of a section of the river.

*5.3.6.3 Monitoring planning*

*Table 5-4 Ijssel River Basin monitoring plan*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| Water | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| | W3 | | | | | | | | | | | | | | | | | | | | |
| Nature | N2 | | | | | | | | | | | | | | | | | | | | |
| People | P1 | | | | | | | | | | | | | | | | | | | | |

Monitoring was carried out in December 2018 and February 2019 and the following measurements were conducted:

- The width of three cross sections measured with a total station as well as a high-end Global Navigation Satellite System (GNSS) GPS device. This will also allow us to measure the water surface slope over a section of 300 meters
- Measurements made by an aerial drone to map the dry flood plains next to the river. A DSM (digital surface model) can be made by processing the pictures with photogrammetry software. We will also experiment with using an aerial drone to try to estimate the surface flow velocity
- The discharge and wet perimeter measured using an ADCP (Acoustic Doppler Current Profiler) attached to a Jet-ski
- Finally an underwater drone equipped with water quality sensors used to map the quality parameters of a section of the river.

#### 5.3.6.4 *Data management system*

For data management, GIS is used linked to an SQL database and web viewers. All relevant data has been placed in GIS. The most important data consisted of the design layer, which indicated the following per specific piece of vegetation:

- Vegetation type
- Location of the flow path
- Owner
- Parcel number
- Location, municipality, water board, province
- Provisional design + underlying reason
- Final design + underlying reason
- Implementation design + underlying reason
- Vegetation type after carrying out work

This data was adjusted by comparing it with input from experts and studies. Experts were required to sum up their conclusion in GIS format. Ecologists had to indicate which vegetation was to be preserved and why, stewards had communicate with owners and link the property card, etc. These were supplemented with conditioning research such as KLIC (underlying cables and pipes) and NGE (unexploded ordnance).

All formation was summarized in 1 GIS file, in which all layers were visible to the designer. The designer could then call up all information and adjust the design file accordingly. In the end, hundreds of layers have been made and used for the Stroomlijn project. The most important of these were:

- Design layer
- Vegetation layer
- Ecological limitations layer
- Aerial photos (10 years)
- Elevation map
- Property card
- Protected vegetation (hedges, monuments)
- Overlapping projects (WFD, climate park, havikerwaard)
- Temporary and sustainable management measures
- Communication layer
- Remarks layer (to be completed by each project member)
- Permit status
- Protection zones
- Klic (cables and pipes)
- Unexploded ordnance

All data is integrated in the on line platform: https://www.openearth.nl/vegetatiemonitor/

### 5.3.7 *Evaluation*

#### *Technical evaluation*

All designs were approved by the commissioner RWS. Curing implementation, the design was available on tables in the GIS viewer. The contractor was required to make photographs before, during and after the works. These were all geotagged and linked in the GIS system. RWS visited sites (in the field) to check the works. GIS data, status updates, photographs, transcripts of the weight of cut vegetation were requested and delivered. The design file was update in a 'completion file', a map with the result of the work (new vegetation type) and approved by RWS.

#### *Project evaluation*

The project was monitored by Courant and reported in KPI's and a four weekly progress report and consultation with the client (Rijkswaterstaat). With this, also the quality of the collaboration is put on the agenda. A tool called 'performance measurement' is used, in which the client and contractor filled out a questionnaire about the quality of the collaboration.

Together with Rijkswaterstaat (client), the project was evaluated several times in Project-Follow Ups. These were supervised by an independent expert in which, in addition to the KPI's, attention was also paid to the collaboration. At the end of the project in November 2018, a final evaluation was carried out with Rijkswaterstaat. In January 2019, a final evaluation was conducted at consultancy firm Tauw to sum up the lessons learned for future projects.

### 5.3.8 *References & Sources*

Project Stroomlijn website (Dutch): https://stroomlijnijssel.nl/

Room for the River (Dutch): https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/programma-stroomlijn/index.aspx

Project Climate Scan page (English): https://www.climatescan.nl/projects/2687/detail

https://www.openearth.nl/vegetatiemonitor/

# 6 Demonstrator DB-2 Inn River Basin, Austria

## 6.1 Overview

### *6.1.1 Summary of the NBS case*

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 $km^2$ at this location.

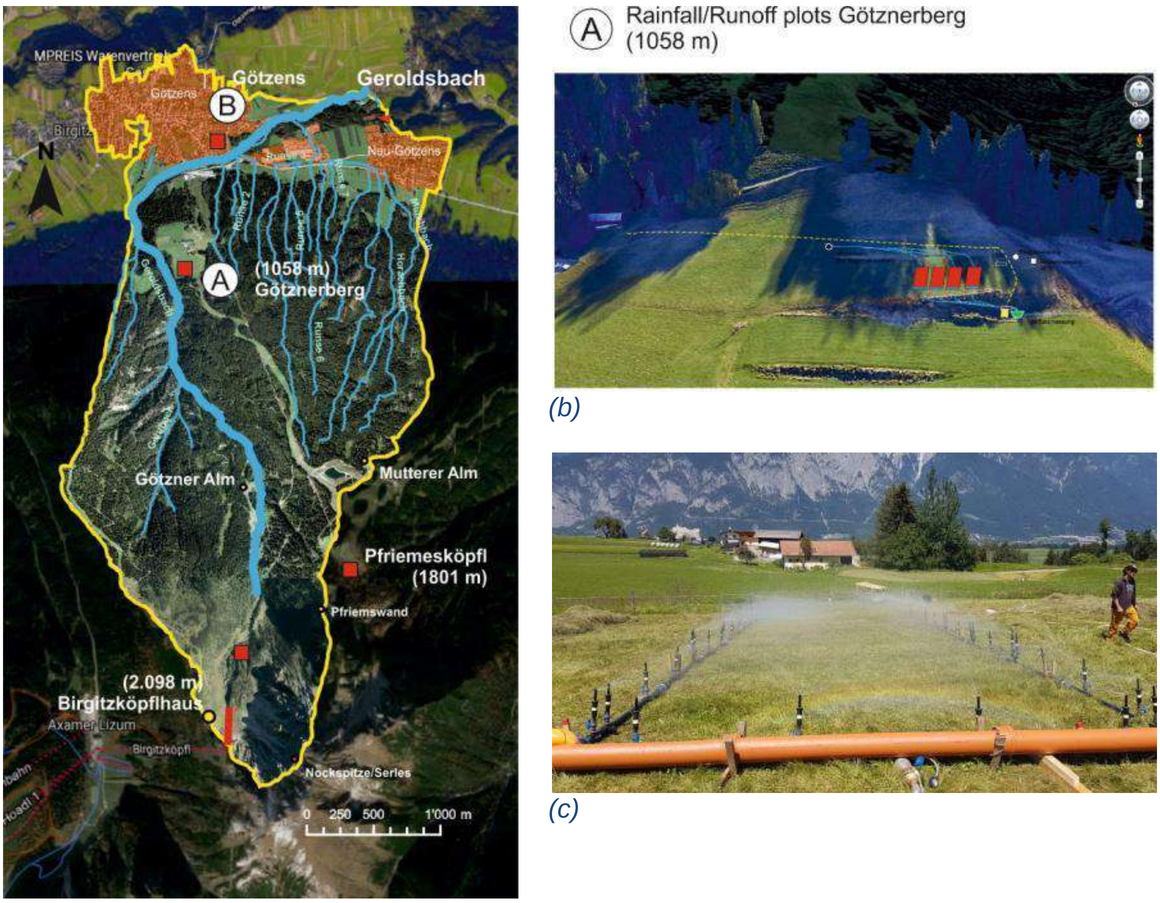
Focus in this case study is on the upstream part of the Geroldsbach until it reaches Götzens dealing with the interaction of urban and torrential features in alpine environment. This Demonstrator Type B catchments comprises different types of NBS being installed in the torrent since the early 1950ies.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

- Afforestation of high-altitude areas
- buffer strips and hedges along water courses
- Driftwood management
- slope stabilization by means of greening
- Protection forest management

Since then, the municipality increased in population and size. Potential installation of NBS in the urban parts versus increased settlement density are considered as second impact onto the overall runoff situation. Potential NBS in the urban part can be

- Green roofs
- Infiltration swales
- Retention ponds

Using field test approaches and modelling the different NBS are evaluated post-ex. Measurements at plot and catchment scale support modelling and generalization to assess other catchments.




*(a)* *(b)* *(c)*

*Figure 6-1 (a) Overview on the torrential/urban catchment, (b) and (c) Setup of the field test site for surface runoff testing.*

- The catchment Geroldsbach- Götzens is used as a lead catchment, being typical for numerous similar urban/rural configuration.
- All installations regarding monitoring and process assessment is made there where finding are transferred to all other investigated catchments on a modelling basis.

#### *6.1.2 RECONECT – innovation potential*

For generalizing and up scaling of the findings, especially with regard to (a) land use in torrents (b) land use at the urban scale , models are realized as well for different other torrential/urban catchments.

Beyond realizing historic and current situation exclusively, land use scenarios for assessing the change over time and potential future scenarios are set up. A novel aspect here is, the quantification of benefits and limitations by urban vs. torrential NBS together with technical measures. For both, impacts varying over time and for different catchment configurations are elaborated.

Evaluation of NBS are not exclusively valid for the investigated catchment but can as well be transferred to other catchments. This supports the decision of stakeholder in other catchments, specifically when implementing NBS that have effects on the long term (decades).

Responsible stakeholder benefiting from the finding are

- State forests - forestry land-use planning, Province of Tyrol
- Austrian Service for Torrent and Avalanche Control

- Community forester as support for the torrent monitoring and documentation system
- Local Municipalities (responsible for urban planning, urban drainage and operation of torrential retention measures)

The NBS tested and evaluated in the case study catchments are in general transferable to other sites. Their effectiveness is dependent on the specific local situation. Cleary the findings are limited to the alpine environment.

The real life implementation is subject to financial and personal possibilities given within the stakeholder organizations, primarily Torrent and Avalanche Control and states authorities.

### *6.1.3 Geomorphological characteristics*

The catchment is located near Innsbruck, Austria, in south-west direction. The overall catchment comprises of the torrential catchments Geroldsbach (12 km2) and Marbach (1.2 km2) with two urban catchment parts (Götzens and Neu-Götzens) located in the downstream part. Neu-Götzens is part of the municipality of Götzens with partly industrial and partly new settlement area. Until now the population has grown up to 4.062 (2018). Runoffs interact with the receiving water of both torrent watersheds.

The torrential catchment Geroldsbach is located above Götzens (~868 m.a.s.l.). Its river spring is at an elevation of ~1920 m.a.s.l. near the mountain Birgitzköpfl and is enclosed at the top by the mountain peaks Nockspitze (Saile; ~2404 m.a.s.l.) and Birgitzköpfl (~1982 m.a.s.l.). Total length of the torrent main channel is 8 km, whereas after 9.4 km the Geroldsbach joins the river Inn. Along its pathway the river merges with several small side rivers and tributaries, like Gehrbach, Grosser Blaikenbach, Tödersbach, Kirchbach, Horachbach and Marchbach and some other (nameless) tributaries.

The main element of the mountain massif is the crystalline slate of the Stubai and Ötztal Alps. The crystalline slate is developed out of clayey and sandy sediments. The main parts are quartz, mica and some alkali feldspars (Mutschlechner, 1961). This material is likely to weather and supports surface runoff according to the high mica content (Bunza, 2016).

The former glacial debris is located either on the debris cone, which is estimated to be around 8 million m3 and partly forms the foundation of the municipality Götzens, or in the steep ’Blaiken’ of the river Geroldsbach and Gehrbach According to Bunza (2016) and WLV (2005) this debris is a reason for the frequent mudslides in the past listed in the torrent chronic.

### *6.1.4 Climatic conditions*

The Alpine region with its steep mountain valleys and high peaks creates complex weather patterns for each region. The weather for the Inn Valley is characterized by its East-West direction and its topographic circumstances (Nicolaiden, 2008). The proximity to Innsbruck (7 km) and the lack of measured data in Götzens itself requires to compare the catchment area to the measured data from the city Innsbruck and surroundings.

Figure 4 shows the minimum, maximum and average temperature for a year, based on data from 1906 to 2015.

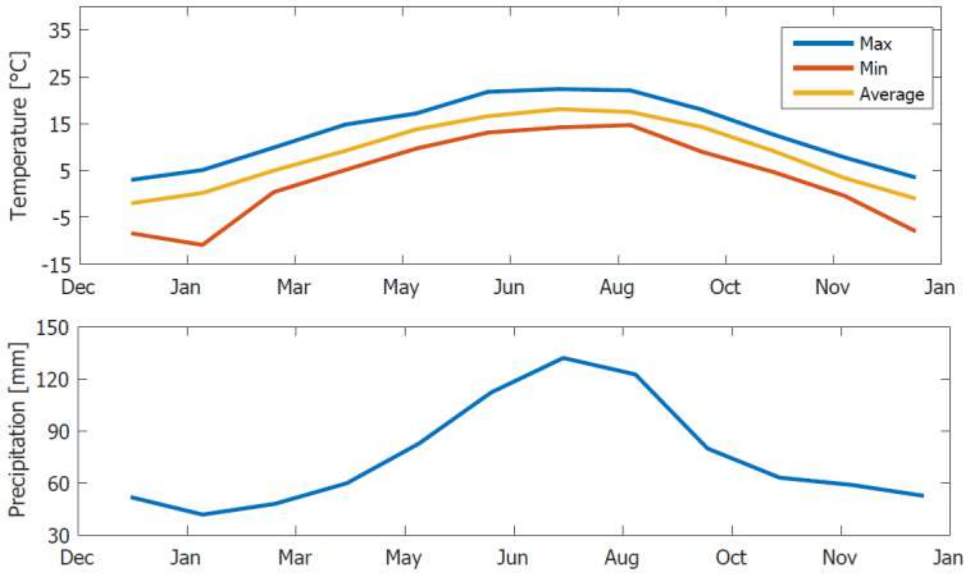



*Figure 6-1 Monthly averaged temperature and precipitation rates for the city Innsbruck*

#### *6.1.5 Hydrological conditions*

Total length of the torrent main catchment is 8 km, whereas after 9.4 km the Geroldsbach joins the river Inn. NBS are located in the upper part of the torrential catchment.

The catchment is - as most other torrential catchments - ungauged. Thus, simulations are generally process driven, considering the surface and to some extend the interflow runoff.

Gauging of the mean and medium/high flows is planned within the project duration. Still, this is dependent on the support of associated stakeholders and subject of negotiations.

#### *6.1.6 Hydro-meteorological hazard and problem description*

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.

Clearly precipitation, most preferable of high spatial resolution is required. Beside the use of measured data for reproducing events measured on the plot scale during the project phase - design rainfall is used.

Typically the hazard potential involves discharge and associated sediment transport. Where simulations intent to cover the discharge phase only, a reduction of sediment introduced is inherently given by the NBS implemented.

#### *6.1.7 Nature*

The main part of the catchment area, around 73.2 %, is overgrown with forest. The main types of trees dominating in the area are spruce, sporadically permeated by firs and larches. Along the river, as well as on moist and wet places, deciduous species are settled like alder. Wide parts of the forest are ranked by a low discharge coefficient in range of SRCL 1-2, due to the vegetation ground layer, which is characterized in most cases by a thick layer of dwarf shrubs, such as blueberry (fig. 6-3a) and raspberry, alternating with a high incidence of moss (fig.6-3b).

(a) Blueberry field (b) Moss growth

*Figure 6-2 (a) Blueberry fields and (b) Moss growth*

## 6.2 Stakeholders and governance

### *6.2.1 Stakeholders*

- State forests - forestry land-use planning, state of Tyrol
- Local Municipalities (responsible for urban planning, urban drainage and operation of torrential retention measures)

### *6.2.2 Governance*

- Austrian Service for Torrent and Avalanche Control (Wildbachverbauung)
- State of Tyrol
- Community forester  as support for the torrent monitory and documentation system

For torrential catchments, the Austrian Service for Torrent and Avalanche Control (WLV) is the responsible governance organization .In extend to that, the community forester - employed at different municipalities - supports the permanent monitoring and documentation for the WLV.

Depending on the catchment size and attribution within respective laws, the state of Tyrol is responsible for larger catchment units and rivers. In case of torrents, the state of Tyrol may as well be interpreted as stakeholder as their responsibility is linked to downstream locations.

### *6.2.3 Ownership*

The land is owned by the different municipalities. In case of Götzens/Geroldsbach, the catchment is in the ownership of the communities Mutters and Götzens.

Any technical measures are built by the avalanche and torrent control unit. The ownership of the structure are with the land owner, respectively the communities. With regard to the monitoring, maintenance and repair, WLV and Communities are responsible. The general requirement of WLV to monitory that thereby not exclude the responsibilities attributed to the communities.

As similar regulation is assumed to apply for NBS, forest also. given in the catchment.

### 6.2.4 Project organisation and management

The case study Geroldsbach/Götzens is run by the following partners within RECONECT:

Univ. of Innsbruck - Department of Infrastructure Engineering

- Manfred Kleidorfer (Unit of Environmental Engineering)
- Stefan Achleitner (Unit of Hydraulic Engineering)

BFW - Austrian Research Center of Forests Department of Natural Hazards

- Bernhard Kohl

BOKU-MET Department of Meteorology, BOKU- University of Natural Resources and Life Sciences

- Herbert Formayer
- David Leidinger

The overall management for the case study Götzens is made by the project responsible personnel at the University of Innsbruck (UIBK). Similar, project management is taken care of at UIBK. Technical support with regard to afforestation scenarios, field works is attributed to BFW. Similar, BOKU-MET supports the project by means of rainfall scenario modelling and realization of local design rainfall.

### 6.2.5 "People" – socioeconomic aspects

The municipality of Götzens has 4.062 (Jan 2018) inhabitants, Mutters 2.202 (Jan 2018) inhabitants. For both municipalities the torrential risk is highly relevant as it defines limitations for available land which can be used for settlements. Both municipalities are close to the provincial capital Innsbruck, meaning that they expect a population increase in the next years. Already today land price is high and the pressure to provide affordable living space is increasing.

Additionally both municipalities are touristic regions in both summer and winter tourism. Consequently this means, that there is the demand to reduce the torrential risk (to protect urban settlements) while at the same time providing a high quality recreation area.

## 6.3 Project Scope: NBS to be demonstrated in RECONECT

### 6.3.1 Scope summary

The demonstration concept applied is a mix of monitoring and modelling based approach. In the lead catchment the rural/torrential catchment as well as the urban catchment are assesses with regard to runoff processes linked to various land use options. The development and effects of measures over time are addressed on a modelling basis using the monitoring data. Historic data sets and the thereby covered changes in land use given in the torrential and urban catchments are quantified an evaluated. Implementing hydrological models covering the total catchment allows to quantify the benefits for different event magnitudes and spatial distributions of storm events.

For generalising and up scaling of the findings, especially with regard to (a) land use in torrents (b) land use at the urban scale , models are realized as well for different other torrential/urban catchments.

Beyond realizing historic and current situation exclusively, dynamic land use change over time and potential future scenarios are set up. Novell aspect here is, the quantification of benefits and limitations gain able by urban vs. torrential NBS together with technical measures. For both, impacts varying over time and for different catchment configurations a elaborated.

### 6.3.2 *Project phases and planning*

Monitoring of runoff a different catchment scales are implemented to catch the events given during and past the project duration.
On the one hand, the measurements medium to high events are required for model parameterisation. Further, extreme events potentially occurring in his period can be documented. In all other cases, extremes are simulated based on the parameterisation. The monitoring includes rainfall runoff experiments in the catchments, including permanent installation. The installations are planned to be used to continuously monitor metrological parameters as well as resulting surface and subsurface runoff throughout the year. Runoff is planned to be as well measured in side tributaries to clearly locate the source of flows. The same is done in urban part as a part of the integrated catchment. In addition to discharge measurements, associated fluxes of sediments are planned to be monitored. This is foreseen at neuralgic locations such as in the or downstream of the given retention basins. No new constructions are planned in this case study. Potential newly construction retention measures are considered for scenario building in catchments.
Monitoring shall start roughly 6 months after projects start and finished during 1st project year. Model building and setup starts in project year 2. The initial period is required for design and installation.
The monitoring period used in the project are:

- Month 6 - 30 : Monitoring period for calibration of model setups
- Month 31 - 54 : Monitoring period for validation of model setups
- Month 55 - ongoing: Permanent monitoring to capture potential extremes in and after the project period.

*Table 6-1 Inn River Basin NBS Project phases and planning*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

### 6.3.3 Planning & Design

No new constructions are planned within RECONECT. Instead, existing measures are evaluated.

In the following a complete overview on the technical and Nature based solutions implemented is given (BUNZA 2016):

The construction of control structures of Geroldsbach started in 1908:

- Construction of protection wall by state construction
- Construction of an 8m barrier at the valley exit
- Elaboration of a general project which suggested securing the large failure scars by a number of transverse works in connection with drainage and ground stabilisation works. In addition the existing barrier should be increased and an additional barrier should be constructed (estimated investment 157.000 crowns). The project was not realized due to the war.
- 1950 development of a new project consisting of a gravity damn and greening of failure scars (estimated investment 340.000 ATS)
- 1950-1955: Sloping of the 'Großen Blaike', 107 drainage creeks, 2 supporting structures, 8 walls, 3ha greened and fenced (to protect from animals), multiple river bed stabilization bands (investment 455.000 ATS)

An investigation of in 1959 showed, that the biological measures were successful, especially when combined with technical measures. It was decided that the project should continue:

- Rounding of fracture edges, sloping of failure scar surfaces
- Greening and goat willows
- 2 concrete barriers
- Reforestation with larches and fencing
- Increase of the debris retention barrier to 2.500 m³
- Construction of 7 concrete barriers at the 'Bärenmaisblaike" in case of a deterioration

(Investments 2,3 Mio ATS)

In April 2010 an investigation of the 'Großen Blaike' by STERN & MARKART showed the bioengineering measures of the 60ies were partly successful but require continuous maintenance and a combination of natural and technical measures

The exact areal extends is planned to be evaluated within the project. Similar urban extends are evaluated for past situations. Both rely on series of areal photogrammetric being earliest available in the 1950ies.

Procurement and contracting, financing, as well as construction issues are not reflected as long as no new constructions are planned within RECONECT.

### 6.3.4 Procurement and contracting

#### 6.3.4.1 Finance

In the Geroldsbach catchment, a number of measures were implemented over the last 100+ years. The construction of NBS was under the responsibility of the WLV (Wildbach und Lawinenverbauung; Torrent and Avalanche Control Unit of the Ministry).

### 6.3.5 Construction

No new constructions are planned within RECONECT but existing measures are evaluated.

### 6.3.6 Monitoring

#### 6.3.6.1 Indicators

DB-2 Inn River has selected 9 Indicators to monitor, of which 6 in category Water, 2 in category Nature, and 1 in category People, as presented here below in Table 6-2.

*Table 6-2 Inn NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | Surface run-off reduction | Precipitation (meteorological station), and model parameterization based on artificial irrigation tests | Use hydrological model to compute surface run-off | |
| | Slowing and storing runoff | Precipitation (meteorological station), and model parameterization based on artificial irrigation tests | Use hydrological model to compute surface run-off | |
| | Flood hazard | Precipitation (meteorological station), and model parameterization based on artificial irrigation tests | Model results combined with expert opinion (qualitative description) | |
| | Delay time to peak | Precipitation (meteorological station), and model parameterization based on artificial irrigation tests | Use hydrological model to compute surface run-off | |
| | Flood peak reduction | Precipitation (meteorological station), and model parameterization based on artificial irrigation tests | Use hydrological model to compute surface run-off | |
| | Landslide risk reduction | | Qualitative assessment by experts based on land-use change (reforestation) | |
| NATURE | Change in land cover | Land cover data | Evaluation of aerial photos and satellite data | |
| | Change in land use | Land cover data | Evaluation of aerial photos and satellite data | |
| PEOPLE | Reduced/avoided damage cost from hydro-meteorological risk reduction | | Qualitative assessment by experts based on model results, building structure and land-price | |

The indicator list is continuously reviewed during different project steps and will be adapted.

#### 6.3.6.2 Monitoring approach

The monitoring includes rainfall runoff experiments in the catchments, including permanent installation. The installations are planned to be used to continuously monitor metrological parameters as well as resulting surface and subsurface runoff throughout the year.

Runoff is planned to be as well measured in side tributaries to clearly locate the source of flows. The same is done in urban part as a part of the integrated catchment. In addition to discharge measurements, associated fluxes of sediments are planned to be monitored. This is foreseen at neuralgic locations such as in the or downstream of the given retention basins.

Consequently the monitoring consists of four parts:

- Artificial irrigation (torrential / urban) with runoff measurement
- Discharge measurements in torrent and sewers (measurement campaigns)
- Metrological monitoring (rainfall, temperature, humidity)
- Spatially distributed soil humidity sensors in the catchment

The monitoring is conducted by partner UIBK together with subcontractor BFW.

In contrast to existing rainfall runoff tests, the here foreseen investigations include several novel aspects:

(1) The event based artificial rainfall tests are examined for very high rainfall intensities.

Where past test are limited to intensities of 50 to 100 mm per hour, up to 200m per hour are envisaged in this project.

(2) In extend to state of the art rainfall test, the here planned installations include runoff from upstream (RunOn) to simulate more realistic field conditions. Conditions in the lead catchment are unique, since high quantity water supply in an alpine environment is given. Supported by the Muttereralm mountain ski-park, water supply is granted via an automated artificial snowmaking systems. Water supply from the snow-making facilities only, allows multiple repeated artificial rainfall simulations with extreme intensities on the hillside scale.

(3) The here planned approach aims for a long term monitoring and process research. A novel aspect is, that in contrast to existing site, continuous measurements and operation is planned.

The collected data is used to set up and paramterize a hydrological model in order to test different NBS solutions (e.g. reforestation) based on model results.

#### 6.3.6.3 Monitoring planning

During project year 1 the monitoring equipment is installed, in project year 2 the set up and parametrization of the hydrological model(s) starts. Most indicators are evaluated based on model results, so this evaluation starts after model building and development of NBS scenarios which are tested in the model (project year 3)

*Table 6-3 Inn River Basin monitoring plan*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| Water | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| | W3 | | | | | | | | | | | | | | | | | | | | |
| | W4 | | | | | | | | | | | | | | | | | | | | |
| | W5 | | | | | | | | | | | | | | | | | | | | |
| | W6 | | | | | | | | | | | | | | | | | | | | |
| Nature | N2 | | | | | | | | | | | | | | | | | | | | |
| | N2 | | | | | | | | | | | | | | | | | | | | |
| People | P1 | | | | | | | | | | | | | | | | | | | | |

#### 6.3.6.4 Data management system

Data is stored in data loggers and transferred central data storage. Ideas to use internal data management system (https://umwelttechnik-swc.uibk.ac.at/) exist but are not fixed (depending on online data transfer capabilities of loggers)

Work to integrate data into RECONECT Services platform has not started

### 6.3.7 Evaluation

The NBS and technical measures to reduce hydrological risk (see 6.3.3) are implemented with the motivation to protect and enable urban settlements. However typically it is difficult to evaluate and quantify the effectiveness of such measures. In RECONECT the evaluation of the measures is based on model results and the model is parametrized based on local measurements. In the last phase (upscaling) the findings are transferred to similar catchments.

### 6.3.8 References & Sources


http://www.reconect.eu/network-of-cases/inn-river-basin/

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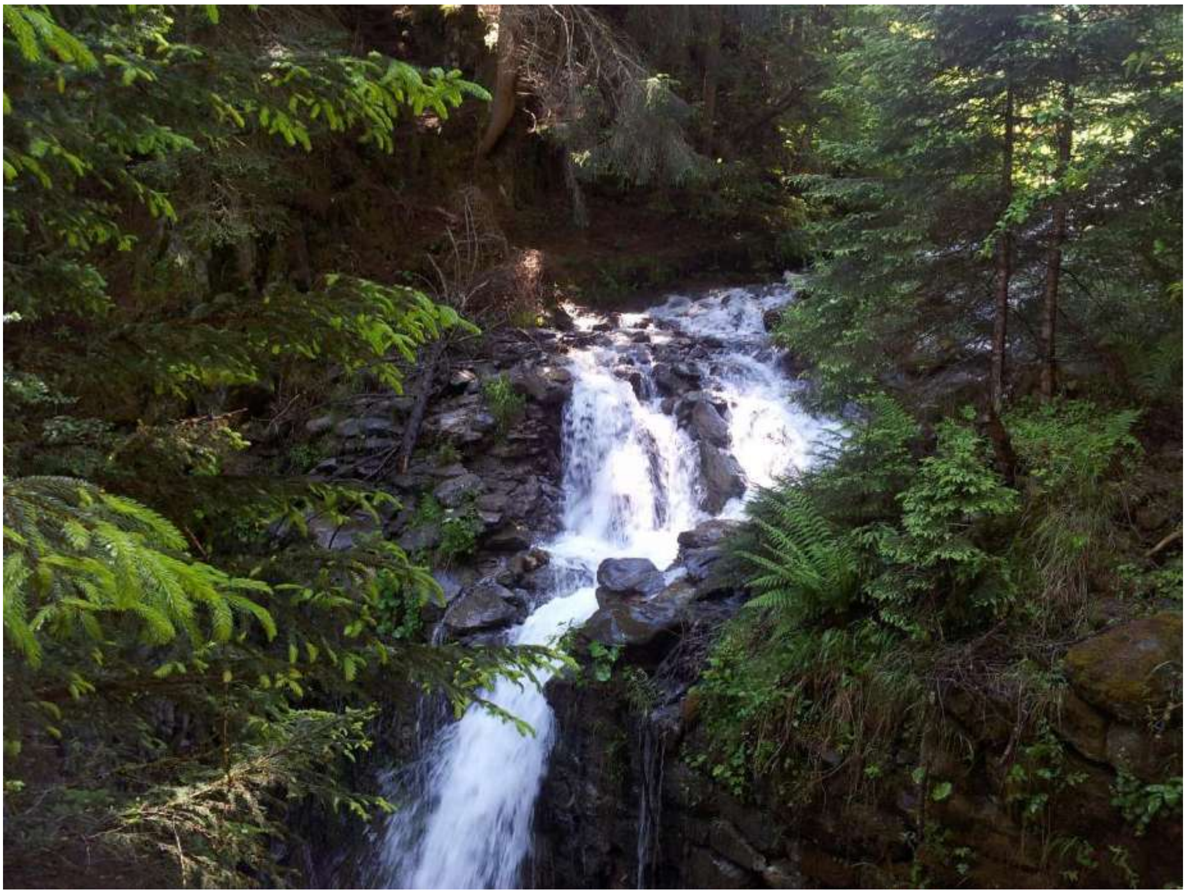

Photo 1, Inn River Basin, Austria

Photo 2, Inn River Basin, Austria

Photo 3, Inn River Basin, Austria

Photo 4, Inn River Basin, Austria

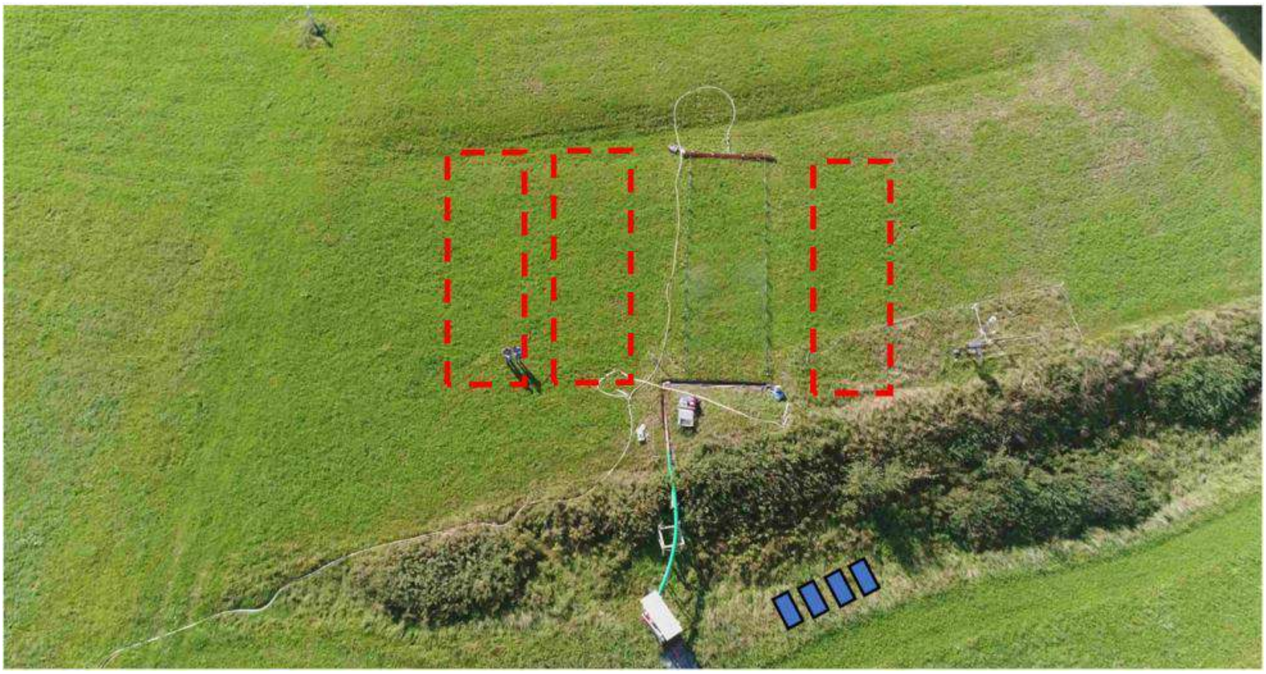

Photo 5, Inn River Basin, Austria

Photo 6, Inn River Basin, Austria

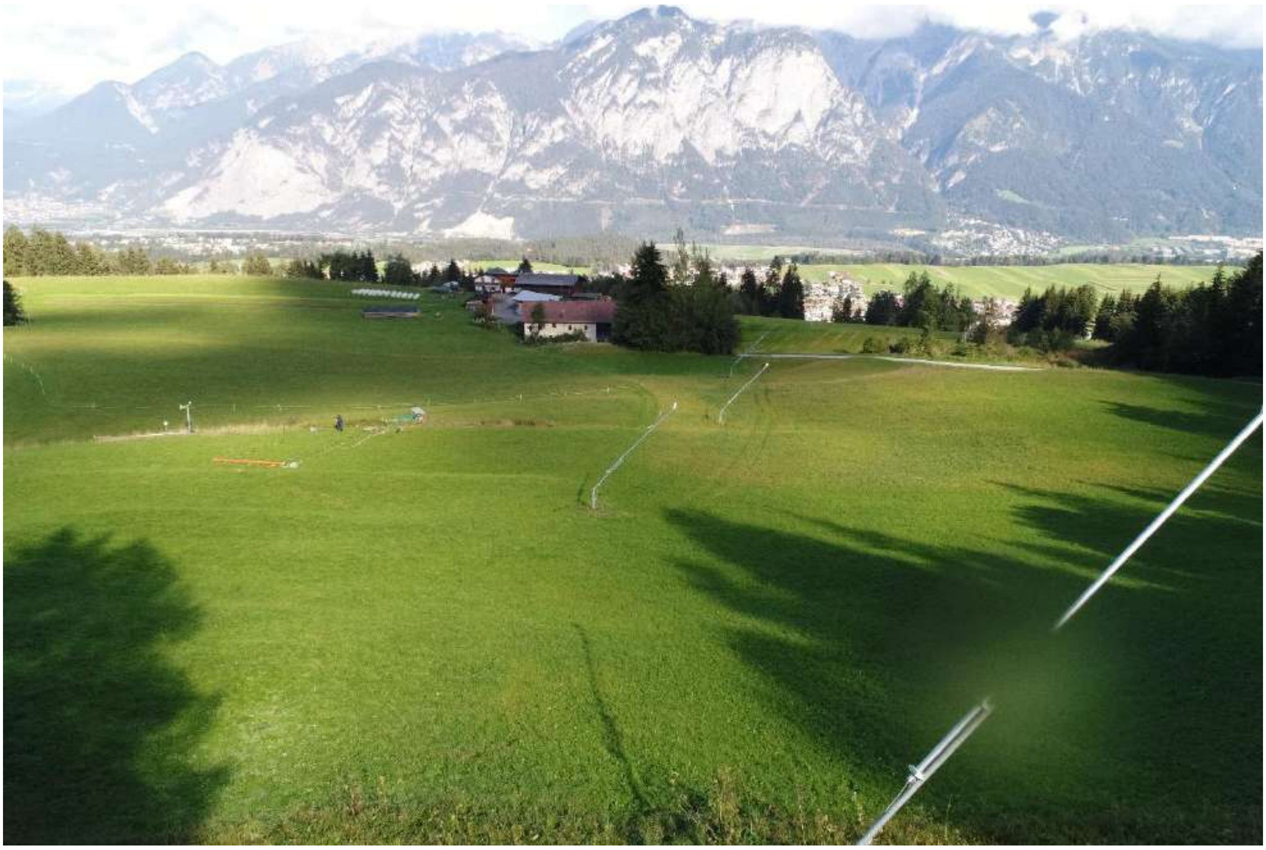
Photo 7, Inn River Basin, Austria

# 7 Demonstrator DB-3 Aarhus, Egå Engsø and Lystrup, Denmark

## 7.1 Overview

### 7.1.1 Summary of the NBS case

The demonstration site "Egå Engsø" (Lake Egå) lies in a low situated and former drained area immediatelynorth of Aarhus. The area now consists of a shallow lake surrounded by meadows.The purpose of establishing the wetland "Egå Engsø" was to reduce the nitrogen supply to Aarhus Bay, to improve the natural conditions in and around Egådalen (the valley of Egå) and to reduce the flood risk from the river Egå. In addition, the wetland provides the basis for a better recreative utilization of the area.

*Figure 7-1 The shallow lake Egå Engsø surrounded by grazed meadows looking southeast. The bay of Aarhus in the background.*

The demonstration site Lystrup is a suburb that lies on a hillslope just north of Egå Ensø in the catchment-area of river Egå. Between Lystrup and Egå Engsø the landscape is intersected by a highway that lies as a barrier disturbing the biological and hydrological.

*Figure 7-2 Lystrup, a suburb to Aarhus - Egå Engø is lying in the backgruond and the bay of Aarhus in the upper left of the picture*

The main problem is the lack of hydrological connectivity between Lystrup and Egå Engsø. It is addressed by two sub-projects (two big pibes), that improve the passage of surface water below the highway.

In the upper part of Lystrup the main problem is that during intense rainfall the relatively steep and impermeable surface (paved areas and claysoil) leads to surface runoff that might exceed the capacity in the sewage system. Here the solutions consist of varied types of local surface modulations e.g. basins, gullies, speed bumps, changing of street profiles and rainbeds that all together represents a large scale solution for the whole suburb. All in all 12 subprojects were planned for, but only 11 of the subprojects was realized due to difficulties in getting the necessary agreements for the 12th.

*Figure 7-3 Green surface to a grey solution - a huge pipe is hidden behind the 'amphi-theatre'*

*Figure 7-4 Green surface to a grey solution - a huge pipe is hidden behind the 'amphi-theatre'*

#### 7.1.2 RECONECT – innovation potential

The demonstration site Egå Engsø is an example of created wetlands that reduces the risk of flooding from rivers by acting as a buffer that holds water during and after rainfalls. The solution is relative low cost and has many positive side effects in relation to environment, nature and recreational activities.

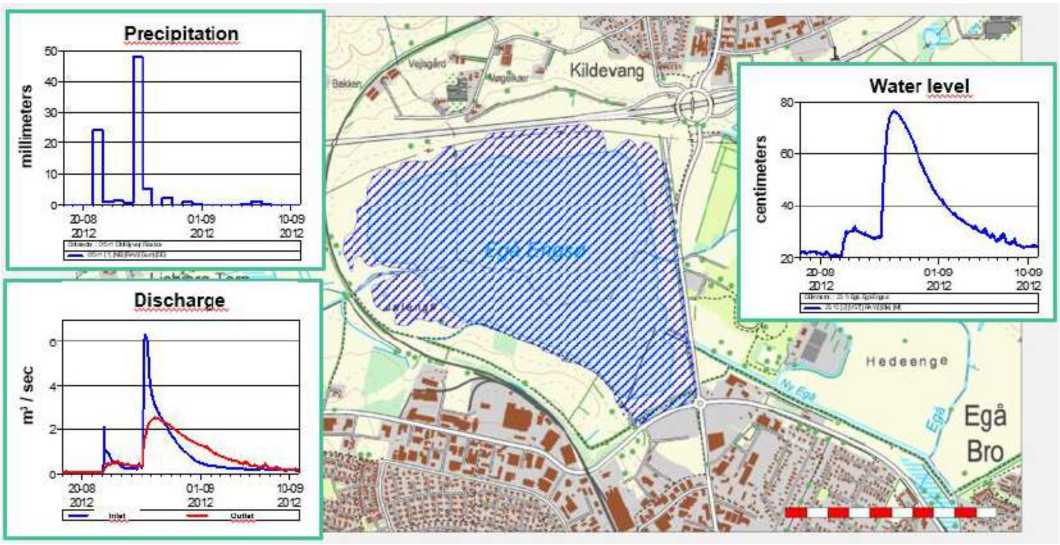


*Figure 7-5 Egå Engsø's effect on discharge incident 2012.*

*Precipitation registered on nearby station. River discharge at lake inlet (blue), river discharge at outlet (red). Shown waterlevel is in the lake. The area reduces the river discharge by more than 50%, and thus reduce the risk of flooding the downstream settlements.*

The climate adaptation projects in Lystrup was the first of its kind in the Municipality of Aarhus. And only a few other places in Denmark had experiences with similar adaptation projects at that time. The principle builds on modifying the surface using suitable green spaces, watercourses and roads in an ordinary Danish suburb where rainwater is separate from sewage to delay the run-off of excess water during heavy rainfall. The main innovation potentials area:

-Cost effective green surface solutions compared to the usual grey solutions

-Using of MIKE Flood and MIKE Urban in the detailed design process

-The co-creation process between the water utility and the municipality (both the nature department, and the traffic department)

-Involvement of the University in creating citizens-processes and biodiversity in the projects

-Involvement of the citizens in the design processes with the purpose of creating added values.

### *7.1.3 Geomorphological characteristics*

Egå Engsø is located immediately close to Aarhus (56⁰12'5844''N, 10⁰13'2603''E). It covers 1,6 km$^2$ (1.1 km$^2$ shallow lake and 0.5 km$^2$ meadow of witch some 0.03 km$^2$ is used recreationally as paths and living spaces). The river Egå passes through the area. The lake and meadows now function as a great retention basin after a dike was constructed with a lifted outlet (bypass riffle) from the lake. The soil type in the area is dominated by marine sand deposits, as the area is an old stone age seabed.

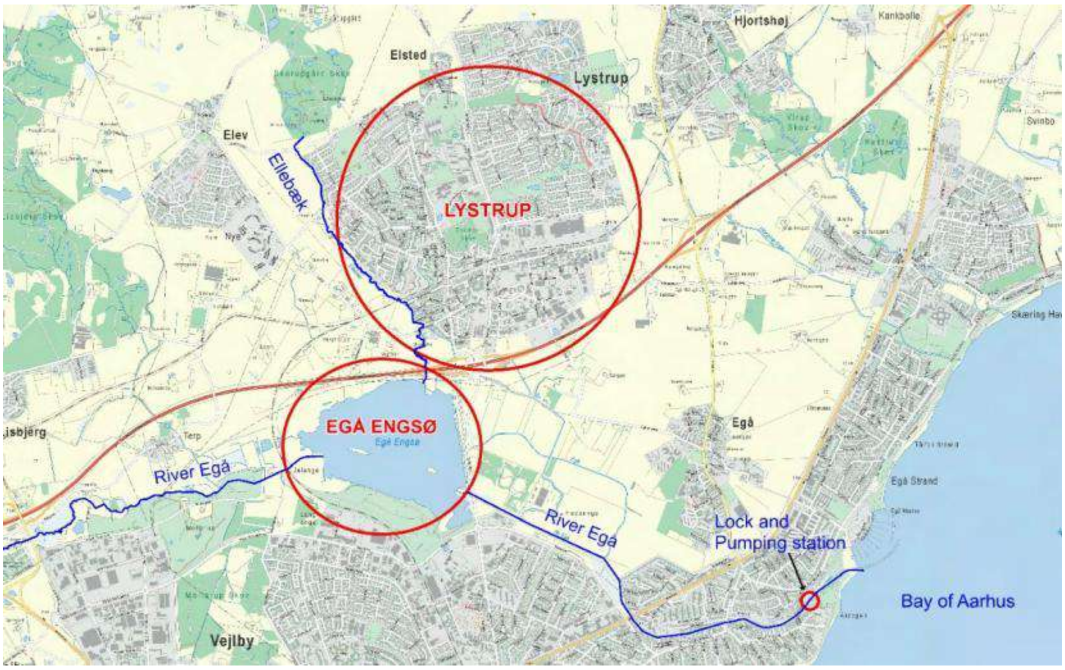


*Figure 7-6 Location of the demonstration project Egå Engsø and Lystrup*

Lystrup is subdivided into 12 subprojects. Close to the bay of Aarhus lies a lock with a pumping station in the river Egå.

*Figure 7-7 Lock and pumping station i river Egå near the Bay of Aarhus*

Lystrup is a suburb with 10.500 inhabitants. It is located close to Aarhus (56°13'54.22"N and 10°13'48.59"E) and is situated in the north-eastern part of the catchment-area of River Egå (see photo in figure 7-2). The dominant soil type is moraine (boulder) clay. The total size of the suburb is 5 km2, and the catchment area for the lowest part of the suburb just north of Egå Engsø estimated for surface runoff in a 100-years incident was estimated to be around 9 km2. The settlement is a mix of single family houses, public housings and small and middle-sized industries, and quite a large part of green space (mainly lawn) between the housings. The sewage system is based on separation of wastewater and rainwater, which means that the rainwater sewer is dimensioned to a statistical 5-years event.


*Figure 7-8  Blue spots and the 12 climate adaption sub-projects localities in Lystrup.*

#### *7.1.4 Climatic conditions*

Both demonstration areas, <u>Egå Engsø</u> and <u>Lystrup</u>, lies in a humid continental climate zone. Weather influenced by low-pressure systems from the Atlantic, which means unstable conditions throughout the year. Average annual temperature 8.8 degrees (average summer 18 degrees, average winter 3 degrees), average annual precipitation 630 mm.

The most important climate driven hazards are river flooding in connection with increased precipitation in winter and more heavy precipitation events in summer.

#### *7.1.5 Hydrological conditions*

<u>Egå Engsø</u> is part of the Egå river system. The Egå river is 9 km long upstream the demonstration area and has a catchment area of 56 $km^2$. Some 1.6 km of the river passes through the demonstration area. The rivers mean annual discharge is 0.45 $m^3$/sec with a winter median maximum of 3.1 $m^3$/sec. 100 years maximum is estimated to 9 $m^3$/sec.

Rising water level of surface water in the project area result in rice of secondary groundwater level in nearby surrounding areas. In this case no settlements are affected by the rise in groundwater level. The shallow lake is eutrophicated due to land based phosphorus load.

Egå Engsø reduces the amount of nitrogen and phosphorus transported to the bay of Aarhus by

natural processes, thereby resulting in a positive environmental response on the coastal environment.

<u>Lystrup</u> lies on a 'steep' hill slope receiving runoff-water from a rather large, partly paved and partly cultivated area (se figure 9 below) before it runs via 'Ellebækken' and Egå Engsø to the river Egå. Ellebækken is a 3,2 km long watercourse, that represents the western rim of the case area. Only some of the catchment to Ellebækken contributes to surface runoff in Lystrup.

In Lystrup rainwater is separated from sewage water and the rainwater system (grey system) are designed to cope with a 5-years (29 mm/4 hours) incident of rain according to Danish standards.

Rise of secondary groundwater level in Lystrup is not an issue covered by the project and is not at this moment considered to be a risk.

### 7.1.6 *Hydro-meteorological hazard and problem description*

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'.

### 7.1.7 *Nature*

Before the project the Egå Engsø area consisted of 160 acres af agricultural land. The project turned the arable land into115 acres of shallow lake and 50 acres of grazed meadow. There is a continuing landscaping in form of cattle grazing. The area is now protected by provisions in the Danish Nature Act.

*Figure 7-9 Grazing cattle on the meadows surrounding the shallow lake Egå Engsø.*

*Figure 7-10 Geese at the shallow lake Egå Engsø*

Although Lystrup is a relatively 'green' suburb, the nature content of Lystrup is rather limited, since the main part of the public green areas is lawn. There are only a few areas protected by national regulations, mainly small lakes/ponds. Furthermore there're one meadow and one in connection to Ellebækken. The total protected nature areas are very limited. Therefore the climate adaption aimed to create green solutions and more biodiversity as an added value if possible. In some of the projects were (mainly basins and watergullies) where finished spreading poor mineral soil instead (raw soil) of nutrient rich topsoil. And in one of the projects rare species was introduced from nutrient poor environments in Jutland. The purpose, was to enhance the conditions for rare flora and hence to introduce more biodiversity in an ordinary Danish suburb.

*Figure 7-11 Green basin in Lystrup*

*Figure 7-12 Water gully in Lystrup - biodiversity*

## 7.2 Stakeholders and governance

### *7.2.1 Stakeholders*

In Egå Engsø, the key stakeholders besides the three partners was the 23 local farmers, local residents and interest groups such as Denmark's Angler Association and The Danish Society for mNature Conservation.

In Lystrup the key stakeholders are Aarhus Water (the water utility), The Municipality, specifically the traffic department, Lystrup School and the department of nature and environment, and the citizens of Lystrup.

### *7.2.2 Governance*

In Egå Engsø The County of Aarhus had the authorities to give all permission according to the different Danish Nature- and Environmental Acts. Permissions was given before Construction works began.

In Lystrup the Municipality of Aarhus gave the necessary permissions according to environmental legislation, traffic legislation and watercourse legislation. However, the overall economic authority was the National 'Supply Secretariat' in the Ministry of Business and Industry, who gave the water company the essential permission to execute the projects, because they were estimated to be cost effective compared to normal (grey) solutions. Certain of the sub-projects were subsequently adopted in the municipality's Waste Water Plan.

### *7.2.3 Ownership*

Originally the demonstration area Egå Engsø was owned by 23 private farmers. In connection with the implementation of the project a land consolidation was executed, whereby the demonstration area came into public ownership (Municipality of Aarhus). The municipality is now responsible for the maintenance of the area and the project.

In Lystrup 11 of the 12 sub-projects are situated on public owned areas and only one sub-project

are situated on private property. The project-ownership of the sub-projects are determined by their status according to the economic water-legislation and are thus divided by the Municipality, who owns 5 sub-projects and Aarhus Water who owns 7 sub-projects.

The maintenance of the water management parts of the projects are paid by Aarhus Water, that means by the water-taxes, and the maintenance of the parts of the projects that concerns added values accrues to the owner of the area except if any special maintenance-agreement has been made.

### 7.2.4 *Project organisation and management*

The project at Egå Engsø was executed by the former Aarhus County (project manager) in cooperation with the municipality of Aarhus. The project was financed by Aarhus County, the municipality of Aarhus and the state of Denmark.

Project organization in the Lystrup Project was quite complex and changed character during the project phases.

Phase 1: Start-up (analysis of the area, planning, overall design of the subprojects, implementing the projects in the Sewage Water Plan, preparing the application to the national Supply Secretariat)

Phase 2: Political adoption in the city council

Phase 3: Sending application to the national Supply Secretariat)

Phase 4: Detailed design and establishing of the sub-projects.

In the start up phase a small but decision-strong project-group with participants from Aarhus Municipality and from Aarhus Water was established.

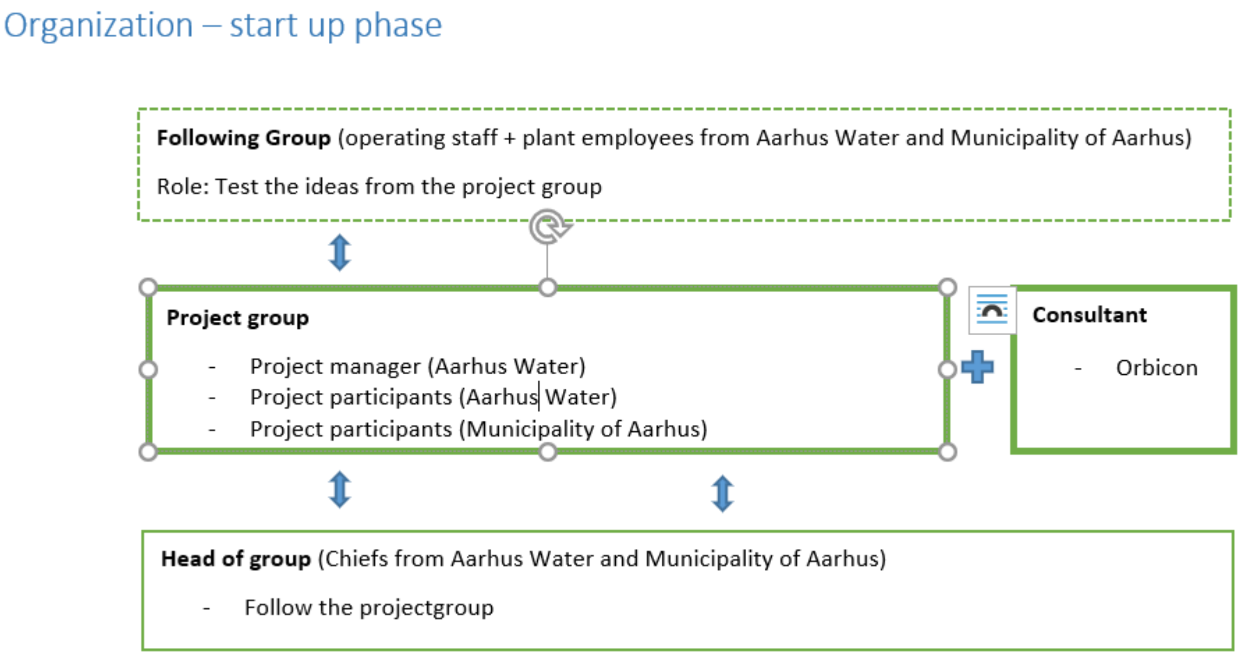


*Figure 7-13 Aarhus organization start up phase*

During the execution phases the organization varied from sub-project to sub-project. The organization established minor project-groups with separate project Managers for each of the twelve sub-projects, who all still referred to the Head of Group.

### 7.2.5 *"People" – socioeconomic aspects*

The project Egå Engsø directly affected the agricultural land-use in the area. The 23 farmers were compensated economically or by replacement land in connection with the land consolidation.

The project now reduces the risk of flooding that could affect part of the settlements in downstream Risskov and Egå, as well as important infrastructural facilities such as roads and Wastewater Treatment Plants.

The demonstration area also has important positive effect on the areas recreational value, education, public accessibility, carbon savings and probably also public health and wellbeing.

*Figure 7-14 Free space with shelters at Egå Engsø*

As described earlier the Lystrup projects lies in a suburb with 10.500 inhabitants and a typical Danish composition of one-family housings, non-profit apartment housings and small to middle sized industries. The demographics are mostly families and older people who owns their own house. The amount of industries/business'es in Lystrup is 1.200, mainly trade, transport and services. There are also public institutions like schools, kinder gardens and nursing homes.

The land use are typical for a Danish suburb partly paved, and partly green public areas.

In Lystrup it has been very important to involve the local citizens, because the climate adaption projects are situated on public green areas which means that their local environment is affected. It has also been important to adapt the projects to the needs and the concerns of the citizens. Therefore the local joint council consisting of local interest organisations has been closely involved. Especially in the sub-project 'Hovmarksparken', the citizens involvement has been strong. The result is, for example, the establishment of local cow grazer union, the setting up of book and insect hotel, which is also used as a starting point for local nature tours, as well as the experiments with the establishment of low-nutrient biotopes and the planting of rare species around the rainwater pond.

*Figure 7-15 Wildflowers in Hovmarksparken - Lystrup*

## 7.3 Project Scope: NBS to be demonstrated in RECONECT

### *7.3.1 Scope summary*

The purpose of establishing Egå Engsø was originally to reduce discharge of nutrients into River Egå and Aarhus Bay. Furthermore Egå Engsø serves as a reservoir where excess water can be stored preventing flooding of downstream areas.

The purpose of the climate adaption projects in Lystrup is to adapt the surface of the suburb to handle a 100 years rain incident in 2110 and thereby preventing flooding of housing areas in the suburb.

### 7.3.2 *Project phases and planning*

*Table 7-1 Egå Engsø NBS Project phases (completed)*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Before'98 | Apr'03 | Jul'03 | Oct'03 | Jan'04 | Apr'04 | Jul'04 | Oct'04 | Jan'05 | Apr'05 | Jul'05 | Oct'05 | Jan'06 | Apr'06 | Jul'06 | Oct'06 | Jan'07 | Apr'07 | Jul'07 | Oct'07 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | | | | | | | | | | | | | | | | |
| 4 | Permitting | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring (rain end water flow) | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

Note: There has been a continuous hydrological monitoring in Egå Engså and river Egå on site since the beginning of the project. And some single biologically monitoring.

*Table 7-2 Lystrup NBS Project phases (completed)*

*Because of the complexity and because of the many sub-projects, the planning and carrying out, was done simultaneously, each phase overlapping each other.*

| | | Year 1 - 2012 | | | | Year 2 - 2013 | | | | Year 3 - 2014 | | | | Year 4 - 2015 | | | | Year 5 - 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | | | Aug' 12 | Oct'12 | Jan'13 | Apr'13 | Jul'13 | Oct'13 | Jan'14 | Apr'14 | Jul'14 | Oct'14 | Jan'15 | Apr'15 | Jul'15 | Oct'15 | Jan'16 | Apr'16 | Jul'16 | Oct'16 |
| 0 | Initiating incident (cloudburst) | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Decisions in city council | | | | | | | | | | | | | | | | | | | | |
| 3 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 4 | Land acquisition (not necessary) | | | | | | | | | | | | | | | | | | | | |
| 5 | Permitting | | | | | | | | | | | | | | | | | | | | |
| 6 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 7 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 8 | Monitoring (only rainwater) | | | | | | | | | | | | | | | | | | | | |
| 9 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

Note: There has been no base-line monitoring in Lystrup except from continuously monitoring of precipitation on the waste water treatment plant of Egå.

### *7.3.3 Planning & Design*

The Egå Engsø project was designed using the experience achieved in a former similar project in the municipality (Årslev Engsø).

The main civil engineering consisted of removal of existing dikes, channels and pumping stations in the former land reclamation area and the construction of a new water course and new dikes to protect the surroundings. Two islands for bird breeding was also created in the lake besides new recreational facilities like paths, living spaces and a bird observation tower.

In order to design the project, we used Danish standard methods to calculate the retention of nitrogen in the wetland and commercial digital river models to calculate the water level in the area at different water flows.

The Lystrup project were initiated by a severe flooding of the suburb of Lystrup due to a cloudburst the 26th of august 2012. After the flooding the city council decided to adapt the area to more water in the future and thus the area became a pilot climate adaption project in Aarhus.


*Figure 7-16 Flooding in Lystrup the 26th of august 2012*

The project was planned and designed in a co-creation process in close cooperation between the Aarhus Water (the water utility in Aarhus) and the Municipality of Aarhus, department of Nature and Environment, and the traffic Departure. And technical advisors were used in the detailed design-process. Furthermore the citizens and the university of Aarhus were involved in the design-process with the specific aim of creating added-value and biodiversity in the projects.

During the design of the project dynamic surface flood modelling MIKE Urban (for incorporating the sewage system)) and MIKE Flood (for incorporating the surface flow) was used on the catchment shown in the figure below. With all the 12 sub-projects Lystrup are adapted to cope with a 100-years rain-incident in 2110 without causing severe damages to material and people.

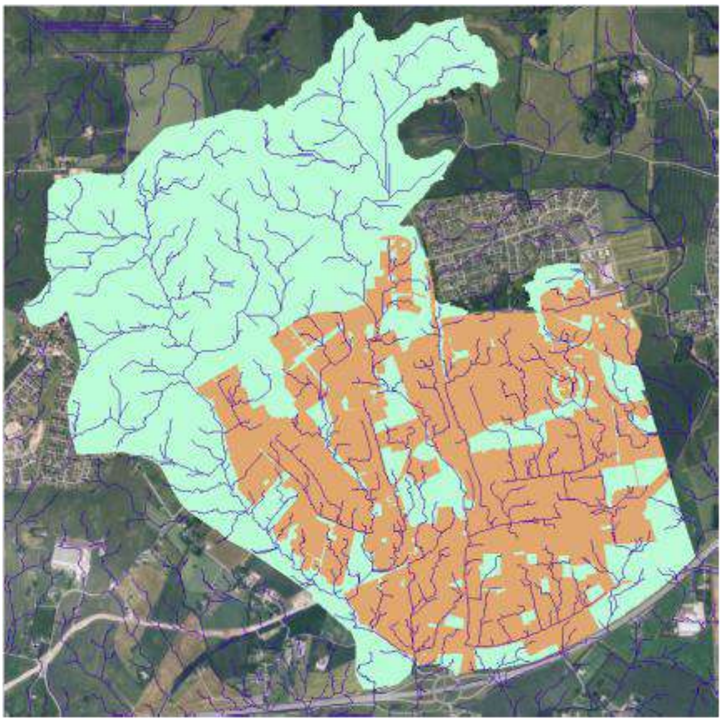

*Figure 7-17 Small catchments in MIKE Urban; Green polygons: unpaved areas; Orange polygons: paved areas; blue lines: water flows*

### *7.3.4 Procurement and contracting*

In Egå Engsø the County of Aarhus was responsible for procurement of services and works. Besides agreements relating to finance contribution, two contracts were signed with private companies. One contract with a consulting engineer mainly based on fixed price (1.3 mio. DKK) and one quantity-based with an entrepreneur (9.5 mio. DKK). The procurement followed the Danish Procurement Act.

In Lystrup both Aarhus Water and the Municipality of Aarhus was responsible of procurement and contracting of services and works. Contracts were signed with private companies, both consulting engineers based on fixed prices, and entrepreneurs.

#### *7.3.4.1 Finance*

Budget for Egå Engsø was 16.7 millions DKK. Real cost Egå Engsø was 17 millions DKK with following contributions: County of Aarhus 7.4 millions DKK, State of Denmark 5.3 millions DKK and Municipality of Aarhus 4.3 millions DKK. The bird observation tower was paid by a private company. Budget for the subprojects in Lystrup was all in all 30 millions DKK.

### *7.3.5 Construction*

The main construction works of Egå Engsø consisted of removal of existing dikes, channels and pumping stations in the former land reclamation area and the construction of a new water course and new dikes to protect the surroundings. Two islands for bird breeding was also created in the lake besides new recreational facilities like trails, living spaces and a bird observation tower. The largest obstacles were financial and getting voluntary agreements with the landowners. The voluntary agreements with the 23 landowners were overcome by land consolidation.

The main construction works of Lystrup varied from sub-project to sub-project. Construction works consisted of green surface-basins/ponds, ditches, rainbeeds, changing of road profiles and then two large pipes to create hydrological connectivity between Lystrup and Egå Engsø.

The largest obstacle concerned communication and the ‘art of agreeing. One of the planned sub-projects (a small dyke on private cultivated land in the northern part of the area ‘Elsted’) was never realized because in the end the landowner was not interested in delivering land into the project. Further obstacles were due to difficulties in agreeing in maintenance plans, and other administrative tasks when collaborating with other Municipal sectors e.g. the school administration.

### *7.3.6 Monitoring*

#### *7.3.6.1 Indicators*

DB-3 Aarhus AAKS have not finally decided exactly which indicators and variables they will be able to monitor at Egå Engsø and Lystrup. Here below in Table 7-3 an indicative list is given for the purpose of the general assessment of scope of works, counting for e.g. 11 indicators, of which 4 in category Water, 2 in category Nature, and 5 in category People.

*Table 7-3 Aarhus NBS indicative list of Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | - Surface run-off reduction | Precipitation (mm)<br>Data taken from official reports of Danish Meteorological Institute (DMI) | | |
| | - Water level | Water level (mDVR) in river Egå monitored with pressure sensor | | Monitoring according to Danish technical guidelines |
| | - River discharge | Discharge measured with water flow meter<br>Continuous discharge is calculated automatically (stage/discharge relationship) | | Monitoring according to Danish technical guidelines. |
| | - Retention time | Hypsograph based on digital terrain model | Retention time evaluated based on water level/volume and discharge | |
| NATURE | *To be decided*<br>- presence of certain species (biodiversity),<br>- changes in habitats | Expected: Birdlife, flora and sea trout | | |
| PEOPLE | *To be decided*<br>- recreational opportunities,<br>- physicals health,<br>- visits in the NBS’s,<br>- change in land and property values<br>- values of carbon sequestration. | Expected: number of visitors, perception of the NBS, change in property value divided into local and large scale added values | | |

#### 7.3.6.2 Monitoring approach

- AAKS have not finally decided exactly which indicators and variables we will be able to monitor within our limited RECONECT-budget. We are planning a decision-process during 2nd quarter of 2019. However, we will build our monitoring program on former and existing monitoring in the case area. In the excel-indicator list (RECONECT Toll for Election of Indicators) we have marked 'potential (gross) applicable indicators'. It means that we will select appropriate indicators and variables from the 'AAKS-gross-list'.
- Former monitoring activities in Egå Engsø includes monitoring of birdlife, aquatic biodiversity (flora + fauna), terrestrial biodiversity (flora), the migration of smolt, content of nutrients in the water, continuously monitoring of water-flow.
- There have been no former monitoring activities in Lystrup. However, since enhancing biodiversity was one of the purposes of the climate adaption project, we can base our monitoring on the knowledge of replanted species.
- The monitoring approach at Egå Engsø will mainly be based on the overall principles:
- Water: continuous monitoring of hydrometrics and precipitation (measuring stations in River Egå). Measuring stations on the inlet and outlet of Egå Engsø gives us a good opportunity to monitor the function og Egå Engsø as a risk reducing water reservoir.
- Nature: monitoring of presence of certain species (biodiversity), monitoring of changes in habitats
- People: recreational opportunities, physicals health, visits in the NBS's, change in land and property values, values of carbon sequestration.
- The monitoring approach at Lystrup will mainly be based on the overall principles:
- Water: Monitoring of precipitation and of the NBS's capability to store water (e.g. the number of overflows from the NBS's and/or waterflow in 'Ellebæk').
- Nature: monitoring of presence of certain species (biodiversity)
- People: recreational opportunities, visits in the NBS's, change in land and property values.

There are currently no links to EU monitoring networks.

The continuous measurements of water levels and water flow on specific stations in River Egå contributes to the authorities' assessment of risks linked to rising water levels in River Egå.

Water: Automatic monitoring of water level and flow and data are filled into Hymerdatabase

Nature: Demonstration the development of flora and fauna will be supported by registrations and by eDNA methods where appropriate.

#### *7.3.6.3 Monitoring planning*

*Table7-4 indicating the whole monitoring period. The period is not yet divided into specific monitoring periods/categories.*

*Table 7-4 Aarhus Coastal Lake NBS monitoring plan*

| | | **Year 1** | | | | **Year 2** | | | | **Year 3** | | | | **Year 4** | | | | **Year 5** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov’18 | Feb’19 | May’19 | Aug’19 | Nov’19 | Feb’20 | May’20 | Aug’20 | Nov’20 | Feb’21 | May’21 | Aug’21 | Nov’21 | Feb’22 | May’22 | Aug’22 | Nov’22 | Feb’23 | May’23 | Aug’23 |
| **Water** | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| | W3 | | | | | | | | | | | | | | | | | | | | |
| **Nature** | N2 | | | | | | | | | | | | | | | | | | | | |
| **People** | P1 | | | | | | | | | | | | | | | | | | | | |

#### *7.3.6.4 Data management system*

Hymerdatabase collects data from the monitoring of stream flow on the inlet and outlet of River Egå.

Data are automatically collected from the system **Hymerdatabase** facilitated and owned by Orbicon. The database collects data from monitoring in Aarhus Municipality directly from **monitoring (stations)**.

Once the data are on line and validated, it can be used for modelling e.g. in the programs VASP or MIKE.

There are different types of methods for monitoring of streams: **Doppler stations, automatic monitoring of water level and flow, and for some of the stations there are an auto generated flow from a QH** relation which is often calibrated and validated. All stations are logging data and sending them to the Hymerdatabase.

### *7.3.7 Evaluation*

We expect to see that the suburb of Lystrup is now adapted to a 100 years incident of rain. It means that if such an incident will happen in the future, then the damage cost will be sizable smaller than the damaged caused by the cloudburst in August 2012.

We also expect, that Egå Engsø again will show its capacity to store excess-water in periods with high water flows in River Egå, thus preventing downstream areas being flooded.

An internal evaluation of Lystrup has been carried out in 2017 mainly focusing on the organisational experiences from the process. The case-area has not yet been tested in 'real-time'.

# 8 Demonstrator DB-4 Thur River Basin, Switzerland

## 8.1 Overview

#### *8.1.8 Summary of the NBS case*

The Thur catchment is prone to flooding and has very sensitive areas, e.g. urbanized areas with industries and camping sites. To reduce flooding risk and to enhance the ecological status, NBS have been and are currently being implemented throughout the entire catchment.

The hydraulic measures currently being implemented, as well as the additional planned actions included in the flood risk management plan were comprehensively evaluated in terms of economic, ecological and hydraulic impacts. Examples of such measures are: river restoration projects, and construction of retention areas for flood protection and artificial groundwater recharge. These measures, in addition to reduce flood risk, they aim also to ensure the provision of enough water during dry periods.

Figure 1 shows a river restoration example at Niederneunforn where Eawag and its research team with the water management partners, has worked for the last 10 years. This work was performed within the framework of the transdisciplinary RECORD and RECORD Catchment projects (http://www.eawag.ch/en/department/wut/projects/record-catchment). These two project outcomes and constructed infrastructure in the entire Thur catchment with its comprehensive monitoring and evaluation system is open to all RECONECT partners; this Swiss approach will be adopted to other economic, ecological and hydraulic conditions as necessary.

*Figure 8-1 Thur river at Niederneunforn. Left panel: before restoration started in 2002. Right panel: after restoration in 2008. (© BHAteam, Frauenfeld)*

#### 8.1.9 RECONECT – innovation potential

The RECONECT Eawag case study focuses on the Thur river catchment (Figure 8-2) and aims to extrapolate the methodology, analysis and results to other catchments and basins. Currently, the Thur catchment monitoring, evaluation and flood protection system is being further developed. The objectives are to create an adaptive, self-learning monitoring system that is linked to a real-time distributed hydraulic model. The goal is to have an optimized flood protection plan with a early-warning system in place for the hydrological response units (HRU) which constitute the entire Thur catchment. Besides flood protection, the second overall goal is efficient water distribution during wet conditions in the form of artificial groundwater recharge to account for future dry conditions and water shortage; this work is planned to be finished by 2020. After that, the developed methods and the model can be used by the other RECONECT partners and be adapted to other catchments and basins.

In Switzerland, river restoration for the improvement of the ecosystem and flood prevention is a national priority task, implemented by the Federal government, the Cantons and Municipalities. The actions required for the implementations are binding by Swiss Federal law. The law defines that over the next 80 years, 4000 km of water courses within Switzerland need to be restored. This results in a large potential for implementation of the measures deployed in the Thur catchment on other catchments.

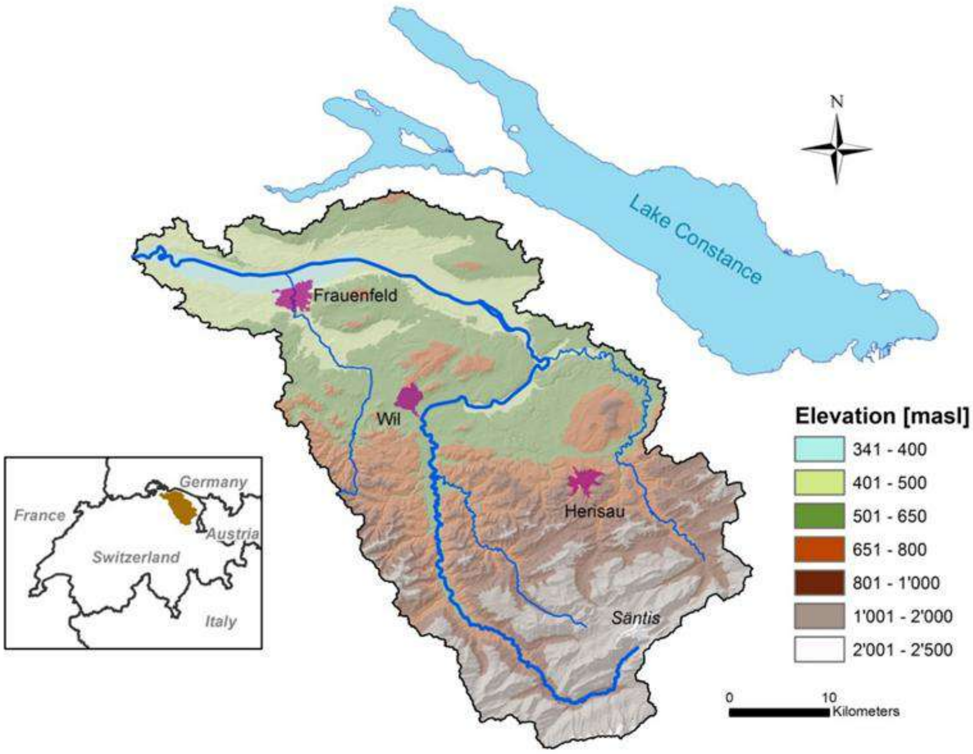


*Figure 8-2 The Thur catchment in NE Switzerland with Mt. Säntis (2502 m).*

#### 8.1.10 Geomorphological characteristics

The river Thur is located in NE Switzerland, draining the front ranges of the Swiss NE Limestone Alps (S of the Lake Constance basin) (Fig.8- 2). 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 geology is mainly formed by limestone dominated alpine headwaters with high annual rainfall

(Mt. Säntis about 2500 mm $yr^{-1}$), whereas the lowlands are dominated by Molasse sandstones and Pleistocene unconsolidated sediments.

The Thur valley and its aquifer are dominated by glacio-fluvial sandy gravels overlaying lacustrine clays. In some parts of the valley, natural alluvial fines of up to 3 m thickness act as a confining layer. In the lower Thur valley, the river cuts into sandy gravel sediments. It is primarily a rural catchment with agricultural activity and scattered settlements focussed on the lowlands. St. Gallen (72,000 inhabitants) and Frauenfeld (23,000 inhabitants) are the largest towns in the Thur catchment. More information can be found in Schneider et al. (2011).

#### 8.1.11 Climatic conditions

The Thur catchment has a continental climate. The average temperature in summer is 18ºC and in winter 1ºC. The annual average temperature is 9.4ºC. The annual rainfall (Thur catchment) is 1413 mm (1961–1990) and for the Thur valley the annual rainfall amounts to 883 mm (1961–1990).

#### 8.1.12 Hydrological conditions

The Thur river is the largest Swiss river (127 km) without a natural or artificial reservoir and exhibits fluctuations in discharge and water table similar to unregulated alpine rivers (low discharge: 3 $m^3s^{-1}$; annual mean discharge: 23.3 - 76.4 $m^3s^{-1}$; peak flows up to 1100 $m^3s^{-1}$). Snowmelt and strong rain events in the pre-alpine headwaters cause short but rapid increase of discharge. During base flow outflows of sewage treatment plants are significant flow contributors. Due to flood protection in the 1890s, the river was straightened and confined to a narrow channel with 50 – 150 m wide overbanks defined by levees, behind which side channels were installed on either side to capture discharge from tributaries and drain agricultural land. In the last years river restoration measures were established, e.g. several 1–3 km long river sections were widened, with the aim to improve flood protection and the ecological status of the river and the riparian zone.

#### 8.1.13 Hydro-meteorological hazard and problem description

The existing NBS have their main impact in terms of flood risk management. Examples of such measures are river restoration projects, construction of retention areas for flood protection, and artificial groundwater recharge. In addition to the flood risk mitigation objective, the ecological status of the restored river reaches is improved, which consequently will lead to a significant increase of recreational activities.

#### 8.1.14 Nature

There is a floodplain forest (about 1 km2) of Swiss national importance at the Niederneunforn site. This is a protected area. Before restoration, the forest was cut off from regular flooding. After restoration took place in close vicinity of the forest regular flooding is again possible. This large widening of the river in this area also increased sediment deposition, re-established dynamic fluvio-morphological processes with frequently forming and alternating gravel bars, and created physical habitats for pioneer fauna and flora.

## 8.2 Stakeholders and governance

### 8.2.1 Stakeholders

The technical and administrative key stakeholders are:

- Swiss Federal Office for the Environment (FOEN)
- Agency for the Environment of Canton Thurgau

- Agency for the Environment of Canton Zurich
- Agency for the Environment of Canton St. Gallen

The scientific key stakeholder is: Eawag (Swiss Federal Institute of Aquatic Science and Technology).

### 8.2.2 Governance

The Swiss Federal Office for the Environment (FOEN) provides resources to study and implement the river restoration measures for the entire Thur catchment. For the different stretches of the Thur river and its tributaries, the cantons are the responsible institutions, planning and supervising the on-site works. For the Niederneunforn site, two cantons are involved, the Cantons of Thurgau and Zurich. For the technical and administrative work, the cantons involve their Environment agencies: the Agency for the Environment of Canton Thurgau and the Agency for the Environment of Canton Zurich. Eawag (Swiss Federal Institute of Aquatic Science and Technology) is scientifically following the process.

### 8.2.3 Ownership

The northern part of the Niederneunforn site where most of the restoration measures took place is owned by the Canton of Thurgau. The canton bought the land before restoration. The canton and, therefore the cantonal authorities are responsible for maintenance and operation of the site and the implemented NBS.

In the other sites faced restoration measures, the respective cantons along the Thur river are the owners of those sites and responsible for the implementation, maintenance and operation of NBS measures.

### 8.2.4 Project organisation and management

The Swiss Federal Office for the Environment (FOEN) provides resources to study and implement the river restoration measures for the entire Thur catchment. For the different stretches of the Thur river and its tributaries, the cantons are the responsible institutions, planning and supervising the on-site works. For the Niederneunforn site, two cantons are involved, the Cantons of Thurgau and Zurich. For the technical and administrative work, the cantons involve their Environment agencies: the Agency for the Environment of Canton Thurgau and the Agency for the Environment of Canton Zurich. Eawag (Swiss Federal Institute of Aquatic Science and Technology) is scientifically following the process.

The risk is shared between the cantons. Regular stakeholder meetings with the communities close by were organized.

### 8.2.5 "People" – socioeconomic aspects

Seidl and Stauffacher (2013) investigated the acceptance among local residents for the restoration project since the measures impact the local infrastructure and also the landscape. The question addressed in their work was whether local residents have different opinions regarding the river restoration project. They also investigated whether there are differences regarding the reasons for this evaluation, such as improved flood protection, higher perceived naturalness, increased biodiversity and aesthetics. Results showed that flood protection and naturalness are more important factors for farmers than for residents, and that there are also differences among the local villages.

Furthermore, Logar et al. (2019) performed a cost-benefit analysis for the restoration measures that took place at the Niederneunforn site. Their analysis demonstrated that in this case the social benefits outweighed the costs for the restoration efforts.

## 8.3 Project Scope: NBS to be demonstrated in RECONECT

### *8.3.1 Scope summary*

The already implemented hydraulic measures, the works currently underway, and the additionally planned actions in the flood risk management plan, have been evaluated in terms of economic, ecological and hydraulic impact. Examples of such measures are river restoration projects, construction of retention areas for flood protection and artificial groundwater recharge. All actions are planned to better distribute the water to reduce flood risks and, at the same time, to provide enough water during dry-weather periods.

At the moment, the Thur catchment monitoring, evaluation and flood protection system is being further developed. The objectives are 1) to create an adaptive, self-learning monitoring system that is linked to a real-time hydrological distributed model. The goal is to have an optimized flood protection plan with an early warning system in place for the hydrological response units (HRU) that constitute the entire Thur catchment. Besides flood protection, the second overall goal is efficient water distribution during wet conditions in the form of artificial groundwater recharge to account for dry conditions and water shortage; and 2) to make the evaluation framework already used available for cross checking and for being further enhanced.

### *8.3.2 Project phases and planning*

The restoration measures at the Niederneunforn site several research projects were performed and the river restoration measures were already implemented. Currently, the monitoring phase is in place at the site, which will continue during the RECONECT project. For the last year of the project, a comprehensive evaluation of the impact of the implemented NBS measures is planned.

*Table 8-1 The Thur NBS Project phases and planning*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| 0 | Baseline monitoring | | | | | | | | | | | | | | | | | | | | |
| 1 | Preparation and Planning | | | | | | | | | | | | | | | | | | | | |
| 2 | Creation, co-creation, (co)-design | | | | | | | | | | | | | | | | | | | | |
| 3 | Land acquisition | | | | | | | | | | | | | | | | | | | | |
| 4 | EIA and permitting | | | | | | | | | | | | | | | | | | | | |
| 5 | Tendering, Procurement, contracting | | | | | | | | | | | | | | | | | | | | |
| 6 | Execution of the works | | | | | | | | | | | | | | | | | | | | |
| 7 | Monitoring | | | | | | | | | | | | | | | | | | | | |
| 8 | Evaluation and Closure | | | | | | | | | | | | | | | | | | | | |

### 8.3.3 Planning & Design

For the Niederneunforn site, the Cantons of Thurgau and Zurich were responsible for planning and the design of the restoration measures, which included several NBS. For the technical and administrative work, the cantons involved their Environment agencies: the Agency for the Environment of Canton Thurgau and the Agency for the Environment of Canton Zurich. For the detailed planning and design of the restoration measures, the two Environment Agencies subcontracted an engineering company to study the measures. After the measures were studied, the work was introduced to the general public. Received objections and wishes for changes in the project were discussed and eventually the project was finalized and implemented.

Several hydrodynamic and hydro geological models have been developed and used in the Thur catchment and at the demonstration site. Diem et al. (2013) developed a new model to estimate two-dimensional (2D) water level distributions for dynamic rivers. The modelling of river-groundwater systems is of high practical relevance in order to assess the impact of restoration measures on the exchange flux between a river and groundwater or on the residence times between a river and a pumping well. However, the model input includes a proper definition of the river boundary condition, which requires a detailed spatial and temporal river water level distribution. The developed model uses two methods to estimate river water level distributions that are based directly on measured data. Comparing generated time series of water levels with those obtained by a hydraulic model as a reference, the new methods proved to offer an accurate and faster alternative with a simpler implementation.

Moreover, Doulatyari et al. (2017) developed a modelling framework for point-wise prediction of the probability density function and flow duration curve of stream flows along complex river networks. The predictions are based on catchment-scale climatic and morphological features, without calibration on observed discharge time series. The framework was applied to the Thur catchment as a test basin. Spatial patterns of flow regime exhibit a strong climatic signature, mostly driven by reduced rainfall depths and increasing effective rainfall frequency in the downstream areas.

Our research group at Eawag is currently in the process of developing a hydrological semi-distributed model for the entire Thur catchment. The main aim is to achieve reliable predictions of stream flow and water quality indicators at the stream gauging stations of the catchment.

### 8.3.4 Procurement and contracting

Restoration along the Niederneunforn site took place from 1993 to 2003. The large widening was conducted between 2000 and 2003. The two responsible cantons, the Cantons of Thurgau and Zurich, worked together, planning and supervising the implementation of the technical measures. For the combined technical and administrative work, the cantons involved their Environment agencies: the Agency for the Environment of Canton Thurgau and the Agency for the Environment of Canton Zurich. The risk management was shared between the cantons. Regular stakeholder meetings with the communities close by were organized. The contract work was published openly and companies were competing for the execution of the project. There were fixed amounts of money allocated to the different tasks.

#### 8.3.4.1 Finance

For the Niederneunforn site, the total non-recurring costs for the restoration project were about 6.4 Mio CHF (5.7 Mio €). Total recurring costs for a 35-year period are about 1.2 Mio CHF (1.1 Mio €). The annual maintenance costs are about 34,500 CHF (30,500 €). The costs were shared between the Cantons of Thurgau and Zurich with some smaller contribution from the communities in the vicinity of the site.

### 8.3.5 *Construction*

Originally, the lower Thur River was a braided gravel-bed river characterized by a shifting mosaic of channels, ponds, bars and islands occupying most of the valley floor. Like most major rivers in central Europe, the lower Thur River was channelized by the end of the 19th century to gain arable land and to avoid frequent flooding. Thus, the Thur River was converted into a double trapezoidal channel with stabilized banks and bounded by levees. The Niederneunforn site was restored by completely removing the northern overbank, so that the nearby alluvial forest became again part of the active floodplain. This large widening increased sediment deposition, Re-establishing the dynamic fluvio-morphological processes with frequently forming and alternating gravel bars, and creating physical habitats for pioneer fauna and flora. The work was supervised by the Agencies for the Environment of Canton Thurgau and Canton Zurich.

### 8.3.6 *Monitoring*

#### 8.3.6.1 *Indicators*

Using the Indicator Selection Tool, the DB-4 Thur river has selected 9 indicators in all categories (3 for Water, 2 for Nature and 4 for People). Information on selected indicators, as well as on the relevant variables that will be monitored is presented here below in table 8-2.

*Table 8-2 The Thur NBS Indicators and Monitoring*

| Category | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| **WATER** | Flood peak reduction | - Discharge time series<br>- Water level time series | Time-series analyses,<br>hydrograph evaluation<br>Snapshot sampling events | Chittoor Viswanathan et al. (2015, 2016)<br>Chittoor Viswanathan et al. (2015, 2016);<br>Huntscha et al. (2014)<br>Schirmer et al. (2014) |
| | Change in Groundwater level/water table | - Groundwater level | | |
| | Attenuation of pollution in groundwater | - Snapshot sampling measurements | | |
| **NATURE** | Shoreline characteristics and erosion protection | - Characteristics of shoreline<br>- Type of erosion protection | Comparison restored versus non-restored area<br><br>Measuring campaigns | Fournier et al. (2012)<br><br>Samaritani et al. (2011);<br><br>Bullinger-Weber et al. (2014) |
| | Number and type of protected species | - Type of protected species<br>- Number of protected species | | |
| **PEOPLE** | Increasing recreational opportunities of NBS area | - Number of recreation activity in the area | Evaluation of questionnaires<br><br>Cost-benefit analysis | Seidl and Stauffacher (2013)<br><br>Logar et al. (2019); |
| | Number and value of people visit or spend free time in NBS area | - Number of people visit the area<br>- Number of people spend their free time in the area | | |
| | Provision of NBS sites for education and research | - Number of students benefiting from education and research about NBS | | |
| | Change in land and/or property values | - Price of land and/or properties (euro)<br>- Willingness to pay | | |

#### *8.3.6.2 Monitoring approach*

The Thur river catchment was a case study in the two EU-Projects REFORM (http://www.reformrivers.eu/home) and ADVOCATE (http://www.theadvocateproject.eu/). Over a period of 10 years, Eawag and its research, 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

(http://www.eawag.ch/en/department/wut/projects/record-catchment/). In addition, there was a large number of subsequent research projects at Eawag and its partners, which were funded by the Swiss National Science Foundation.

Our existing data platform (a custom geodatabase and WebGIS platform) for water quantity will be further developed. It subdivides the Thur catchment into six sub catchments and fully captures the hydraulic dynamics at the outlets of the sub catchments. This information will help to characterize dominant runoff generation processes and to define Hydrological Response Units (HRUs) within these sub catchments. The goal is to generically include the groundwater flow system into the semi-distributed model. By constantly monitoring electrical conductivity (EC), water temperature and water level at a large number of locations throughout the catchment, an adaptive and event-based water quality monitoring scheme for selected locations will be developed. At these locations, auto-samplers will be installed for subsequent chemical analyses. Based on the event and prior information on the trends in water quality changes, sampling intervals and locations will be adapted. The ultimate goal is to only measure EC, water temperature and water level in the end, and use these measurements as surrogates to predict the changes in water quality during any event.

### 8.3.6.3 *Monitoring planning*

The NBS river restoration measures at the Niederneunforn site are implemented. This went along with detailed monitoring and evaluation of river discharge, groundwater levels, water quality of surface and groundwater, ecology, biodiversity, soil parameters, acceptance of the inhabitants and economical considerations.

Currently, monitoring is ongoing for electrical conductivity (EC), water temperature and water level at many different locations throughout the catchment. This will be further developed to have an adaptive and event-based monitoring scheme for selected locations. At these locations, auto-samplers will be installed for subsequent chemical analyses. Based on the event and prior information on the trends of water quality changes, sampling intervals and locations will be adapted.

*Table 8-3 Thur River Basin NBS monitoring plan*

| | | Year 1 | | | | Year 2 | | | | Year 3 | | | | Year 4 | | | | Year 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| Indicator Variable | | Nov'18 | Feb'19 | May'19 | Aug'19 | Nov'19 | Feb'20 | May'20 | Aug'20 | Nov'20 | Feb'21 | May'21 | Aug'21 | Nov'21 | Feb'22 | May'22 | Aug'22 | Nov'22 | Feb'23 | May'23 | Aug'23 |
| Water | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| | W3 | | | | | | | | | | | | | | | | | | | | |
| Nature | N1 | | | | | | | | | | | | | | | | | | | | |
| | N2 | | | | | | | | | | | | | | | | | | | | |
| People | P1-3 | | | | | | | | | | | | | | | | | | | | |
| | P4 | | | | | | | | | | | | | | | | | | | | |

#### 8.3.6.4 Data management system

Our existing data platform (a custom geodatabase and WebGIS platform) for water quantity will be further developed. Data will be made available for the team members of the RECONECT project. Furthermore, we are working on a PostgreSQL as a database for the Thur. This will link easily with GIS interfaces such as QGIS. PostgreSQL is an open source database (https://www.postgresql.org/)

Work to integrate our data platform in the RECONECT Services platform has not yet started.

### 8.3.7 Evaluation

The main benefits of our NBS along the Thur river are to reduce flooding risk and to enhance the ecological status of the river. Several NBS have been already implemented or are currently under construction throughout the entire catchment. Examples of such NBS include river restoration projects, construction of retention areas for flood protection and artificial groundwater recharge. All actions are planned to better distribute the water to reduce flood risks and to provide enough water during dry periods.

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# 9 Demonstrator DB-5 The Var Éco-Vallée, France

## 9.1 Overview

### *9.1.1 Summary of the NBS case*

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.

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


*Figure 9-1 NBS site, Var low valley, Nice, France*

### *9.1.2 RECONECT – innovation potential*

The innovation potential of the Var NBS (DB5) is in the existing condition and it is expressed in:

1) Monitor the upstream measures to reduce floods (NBS hybrid) and explore their synergies with the measures to improve the ecological condition of the river.
2) The eco-conscious approach applied on the new buildings. Here the concept is applied on bio-climatic office building with green-layered outer facade.
3) Application of HPC modeling within the previous projects. As a result we have a flood maps in high resolution.
4) A progressive embankment system of the Var river. In XIX century the owners of the land, at that time the land was agricultural, were responsible for the protection of the river banks. The protection walls were building using stones (picture left). The stones were destroyed during the flood episodes. In the XX century the new system is invented and applied: the "sugars" (picture right) bricks on the concrete revetment. Today engineers are calling this system rip-rap

*Figure 9-2 Exisitng buidling in the NBS (DB5) representing the bio-climatic concept*

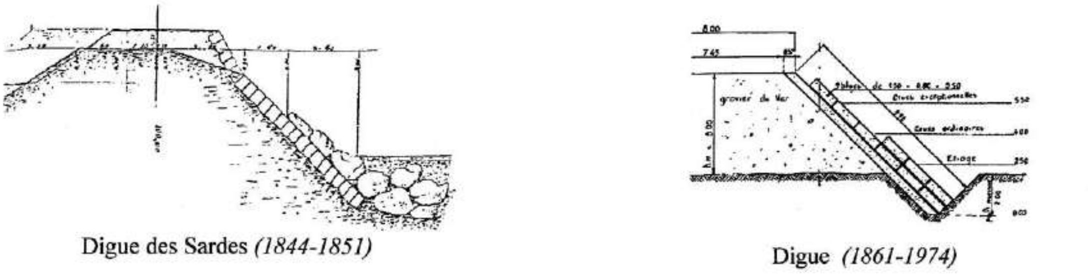


*Figure 9-3 Progressive embankement of the Var NBS (DB5)*

5) Evaluate the benefits of those combined NBS
6) AquaVar project - with the initial goal of to develop a modelling system to study the hydrology, river hydraulics and groundwater hydraulics in the lower Var river valley. Within this project the monitoring stations are set and will be used in RECONECT project.

#### *9.1.3 Geomorphological characteristics*

The Var is located in Alpine area (southeast of France) and its characterized as torrential river with steep slopes. The river Var has a total length of 114 km, with the Tinée, Estéron and Vésubie as its main tributaries cross five main sub-catchments (Tinée, Estéron, Vésubie, Upper Var, and Lower Var).

The river section concerned in this project is the Lower Var in total length of 22km approximately, which was previously running freely between the valley slopes. Those featured large, very mobile gravel bars composed of coarse bed material. From the early 19th century on until the 1960s the river was canalized over the entire length of the lower valley, reducing its width (cross section) from about 1000 m (in average between valley slopes) to a 300 m, and even 200 m in the last cross sections close to the sea. To compensate the lowering of the river bed as a result of the extraction of building materials, fixed weirs were constructed to bring the water table back to its original level.

### 9.1.4 *Climatic conditions*

The area is located in a center of polar and tropical air masses resulting in the alternation of a rainy season during the cold season and a dry season during hot weather. The average annual temperature of 15° and a mean annual rainfall of 826 mm conceal an uneven distribution of temperature and precipitation during the seasonal cycle.

With existing NBS focus is on making space for water, so the most important parameters is precipitation during both periods: winter and summer.

### 9.1.5 *Hydrological conditions*

The maritime influence is an important regulator of heat in the Alpes-Maritimes, which contributes to a moderate climate of Nice. In addition, there is the alternation of night and day flows occurring in the valleys of the Var and Paillon from land to sea at night and the sea to land as a refreshing breeze during the day preventing the formation of mist in the valleys.

The average temperature is 8° for winter period, while recorded maximum rainfall is in November. This phenomenon is explained by the arrival of cold air from central Europe that reaches the warmer waters of the Mediterranean. This interaction of cold air in contact with a warm sea explains the genesis of depression in the Gulf of Genoa, which produces the dominant flow from east to reach the area of Nice. During the summer its characteristic dry period from July to September where average temperature reaches 22°. This phase of the thermal evolution is linked to the Azures, which determines the fine weather on the Cote d'Azur and the rainfall deficit.


*Figure 9-4 Diagnostic of ecological functionalities is Eco Var Valley (Source: Guide of taking into account biodiversity and ecological functions in the Eco-Valley, 2011)*

#### 9.1.6 *Hydro-meteorological hazard and problem description*

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.

#### 9.1.7 *Nature*

The biodiversity of the Plaine du Var has already been quite affected. Some of the considered solution are within Biodiversity Guide produced by the EPA Plaine du Var and which establishes a thorough study of the situation.

The whole area has an recognized ecological interest. Within the Biodiversity guide a five habitats were considered and mapped in order to meet ecological sustainability: rocky, aquatic, humid, forest, open zones (due to the existing urbanization). For each subarea the main obstacles are identified.

### 9.2 Stakeholders and governance

#### 9.2.1 *Stakeholders*

The key stakeholder's involved are:

- Officials of the fifteen municipalities concerned within the Council of Mayors
- The Municipality of Nice

The Public Planning Institution (EPA) Plaine du Var is in charge of the implementation of the Éco-Vallée National Interest Operation. The Public Planning Institution of the plain of Var has set up a concerted organization of project owners and project mode collaboration for each operation. Some projects involve several actors.

A representative Board of Directors of the Public Establishment of the Plaine du Var includes representatives of the State, officials of local authorities and qualified individuals (representatives of the Syndicat Mixte Sophia Antipolis), the Caisse des dépôts and consignment, of a large company of the plain of Var).

The public is also associated with the Éco-Vallée project in its various phases, in a process of continuous consultation.

#### 9.2.2 *Governance*

The Public Planning Institution is administered by a Council that brings together representatives of the State, local authorities, local institutions and qualified individuals. The EPA is organized around a team of planning and urban planning professionals: they are responsible for implementing the projects, ensuring coordination between all the partners and realizing on the ground the orientations set to the operation.

#### 9.2.3 *Ownership*

Focusing on innovation character of Éco-Vallée project, the scale and originality of the Éco-Vallée operation requires an organization that is both effective and innovative. Collective governance and a collaborative decision-making process have been put in place. On each site, collaboration in project mode brings together all stakeholders and owners.

### 9.2.4 *Project organisation and management*

The innovation in this area is reflected on existing risks. By managing risk the highlighted is risk anticipation and focus on prevention. Within the Eco-Vallée, all risks, whether natural or technological, are being fully assessed, and measures taken to ensure the utmost security.

Given its location, the Var valley is exposed to several types of natural risks -floods, forest fires, earthquakes and landslides. Each risk is taken into account and addressed with a range of preventive measures.

#### Floods

A flood prevention plan (PPRI) applies to the whole Var valley. As a first step, an action plan for flood prevention (PAPI) is currently being carried out on the lower *plaine du VAR* area and within the small lower valleys, representing important investments over 5 years (2009 to 2014). A new investment phase will be launched, with a second action plan (PAPI 2).

For the area Grand Arenas, a sensitive zone situated behind protective dikes, an in-depth study phase (*schéma de cohérence hydraulique et d'aménagement d'ensemble (SCHAE)* was elaborated. This initiative, launched by the EPA in the second semester 2011, is in line with the flood prevention plan (PPRI). With this innovative approach, which involves modelling scenarios and simulating floods, the exact water level can be determined as well as the impact on the dikes and the risk of rupturing. The key objective is to help define the rules for urban planning, which will take flood risks into account and ensure that development neither increases the risk factor in the area nor causes it to shift location.

#### Earthquakes

Regarding earthquakes, the whole zone is at average risk. This makes it mandatory, as for all new constructions within the perimeter of Nice, to apply the European regulation which requires the respect of paraseismic rules for new buildings. These rules are defined in Eurocode 8 norm.

#### Technological risks

A prevention plan has been put in place to determine the technological risks within the different zones to best protect people and goods.

### 9.2.5 *"People" – socioeconomical aspects*

Social component in analyzing flood problems in NBS area include characteristic of population in order to anticipate, cope with, resist and recover from flood. Social condition regarding flooding is projected to be on a high level. Since NBS area is located within floodplain the exposure is high on one side, but on the other the proposed development is concerned by existing risk.

Regarding demographic character for Nice, in the dense urban pattern lives almost 85% of population of Nice. In the table below the population density and population structure are presented.

Table 9-1 Demographic data for Nice (Demographic information's for cities in France) http://www.toutes-les-villes.com

| | |
|---|---|
| Population (inhabitants) | 343123 |
| Density (inhabitants/km$^2$) | 4766 |
| Population structure | |
| Men (%) | Woman (%) |
| 45.8 | 54.2 |

## 9.3 Project Scope: NBS to be demonstrated in RECONECT

### *9.3.1 Scope summary*

Along the NBS area the set of hydraulic measures exists. The first is river restoration project in 1960's with main purpose to include set of weirs that will provide sufficient water for agricultural areas located in the valley, flood reduction, increase of storage capacity for flood waves. The downside of these measures resulted on impacting of potential of groundwater tables and increased sediment transport. On the pictures below a satellite view of the river in 2003 and 2018 year is presented.

*Figure 9-5 Satelite view of river Var in 2003 (left) and 2018 (right) - Source: Google Earth*

Flood defence measures for low Var valley are affirmed in PPR plan. According to the plan the river bad and the river banks are in red zone (high risk zones).

Embankments exist along the left and right bank. Behind embankments in flood approached area, the width of the security strip is defined as a function of the difference between the water level in flood reference in the riverbed and the natural ground level at the foot of the embankment. According to PPR the width of the security zone is 100 times height of the embankment. Nice airport is located in red zone since natural delta of Var River runs through the runway.

### 9.3.2 *Project phases and planning*

The restoration measures at the Eco Valley site several research projects were performed and the river restoration measures were already implemented. Currently, the monitoring phase is in place at the site, which will continue during the RECONECT project. For the last year of the project, a comprehensive evaluation of the impact of the implemented NBS measures is planned.

*Table 9-2 The Var NBS Project phases and planning*

| DB5 VAR RIVER BASIN | | YEAR 1 | | | | YEAR 2 | | | | YEAR 3 | | | | YEAR 4 | | | | YEAR 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| **Legend:** | | | | | | | | | | | | | | | | | | | | | |
| Planning | | | | | | | | | | | | | | | | | | | | | |
| Permits | | | | | | | | | | | | | | | | | | | | | |
| Design | | | | | | | | | | | | | | | | | | | | | |
| Land Acquisition | | | | | | | | | | | | | | | | | | | | | |
| Construction | | | | | | | | | | | | | | | | | | | | | |
| Baseline monitoring | | | | | | | | | | | | | | | | | | | | | |
| Maintenance and post-implementation and Monitoring | | | | | | | | | | | | | | | | | | | | | |

#### 9.3.3 Planning & Design

Further information on planning and design is being collected and analysed within Task 2.2 "Establishing baselines, Demand and Supply Analysis" (Demonstrators Survey) and can be found in the relevant documents elaborated within this Task.

#### 9.3.4 Procurement and contracting

The Public Planning Institution is administered by a Council that brings together representatives of the State, local authorities, local institutions and qualified individuals. The EPA is organized around a team of planning and urban planning professionals who are responsible of procurement and contracting of services and works according to French laws.

##### 9.3.4.1 Finance

The project is financed by the State.

#### 9.3.5 Construction

The river restoration measures were already implemented. Along the NBS area the set of hydraulic measures exists. The first is river restoration project in 1960's with main purpose to include set of weirs that will provide sufficient water for agricultural areas located in the valley.

Different measures in the valley and upstream of it have been implemented such as:

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.

Embankments exist along the left and right bank. A flood prevention plan (PPRI) applies to the whole Var valley. As a first step, an action plan for flood prevention (PAPI) is currently being carried out on the lower *plaine du VAR* area and within the small lower valleys, representing important investments over 5 years (2009 to 2014). A new investment phase will be launched, with a second action plan (PAPI 2).

The NBS is a part of Eco Var Valley main project, which is under development until 2035.

#### 9.3.6 Monitoring

##### 9.3.6.1 Indicators

DB-5 Var river basin plans to monitor 8 Indicators, of which 2 in category Water, 3 in category Nature, and 3 in category People, as presented here below in Table 9-3.

*Table 9-3 The Var NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments References |
|---|---|---|---|---|
| WATER | Flood Hazard | - Land use map<br>- Infrastructures data<br>- Population data<br>- Building/Housing | available flood maps for NBS area | |
| | Vulnerability | Calculated flood vulnerability using the methodology from PEARL project | Mapping the NBS area with obtained values | |
| NATURE | Restricted-range species | - The numbers of restricted-range species<br>- The numbers of restricted- | - Surveys and identification of | |

| | | | | |
|---|---|---|---|---|
| | | range the area | species and studies on population trends. | |
| | Number and type of protected species | -Type of protected species<br>- Number of protected species | -existing reports | |
| | Type, density of native species | - Type of native species<br>- Number of native species<br>- Area that native species are located (m2) | | |
| **PEOPLE** | Increasing recreational opportunities of NBS area | - Number of recreation activity in the area | | |
| | Reduced/avoided damage cost from hydro-meteorological risk reduction | - Flood depth<br>- Flood velocity<br>- Land use map<br>- Infrastructure data<br>- Damage data<br>- Inundation map | | |
| | Number of cultural events in NBS area | Number of cultural events | | |

#### *9.3.6.2 Monitoring approach*

The Eco Var Valley project was a case study in two previous related projects:

 CORFU - FP7 project (2010-2014) where the Nice was a case study. Collaborative Research on Flood Resilience in Urban areas (CORFU) is a major project involving 15 European and Asian institutions, funded by a grant from the European Commission, Seventh Framework Programme. The overall aim of CORFU is to enable European and Asian partners to learn from each other through joint investigation, development, implementation and dissemination of short to medium term strategies that will enable more scientifically sound management of the consequences of urban flooding in the future. The focus in this project and related to the NBS was new approach in flood risk assessment and adaptation strategies.

 AquaVar project - Project supported by VEOLIA, UNSA, Polytech Nice Sophia Antipolis, Nice Cote d'Azur, Conseil General Alpes Maritimes and Agence de l'Eau, with the initial goal of to develop a modelling system to study the hydrology, river hydraulics and groundwater hydraulics in the lower Var river valley. The final aim of the project is to develop a deterministic modeling system which is able to simulate the water cycle at the catchment scale and to simulate the river-aquifer exchange at the sub-catchment scale. (https://var.aquacloud.net/)

#### *9.3.6.3 Monitoring planning*

Some monitoring activities on (e.g. water level, number of tourists) have been already carried out within Meteo France and tourist organization.

Data available will be used as baseline data, to support further assessment of the performance of the NBS. Tentative planned monitoring activities are presented in Table 9-4.

*Table 9-4 Planned monitoring activities in the Var (DB5)*

| Indicator / Variable | | YEAR 1 | | | | YEAR 2 | | | | YEAR 3 | | | | YEAR 4 | | | | YEAR 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| WATER | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| NATURE | N1 | | | | | | | | | | | | | | | | | | | | |
| | N2 | | | | | | | | | | | | | | | | | | | | |
| | N3 | | | | | | | | | | | | | | | | | | | | |
| PEOPLE | P1 | | | | | | | | | | | | | | | | | | | | |
| | P2 | | | | | | | | | | | | | | | | | | | | |
| | P3 | | | | | | | | | | | | | | | | | | | | |

#### 9.3.6.4 *Data management system*

Existing hydraulic and hydrological models are available. Collected data will be available and stored in general format within GIS system.

### 9.3.7 *Evaluation*

The main benefits of NBS area located in the Eco Var Valley is reducing flood risk and creating flood friendly environment and enhancing ecological status of the river.

As mentioned, several different NBS solutions are implemented. Several NBS have been already implemented and they are focused on creation of retention areas for flood protection. The actions planed are monitoring the existing NBS during the project (RECONECT).

### 9.3.8 *References*

Guide for biodiversity in the Eco var Valley

(http://www.ecovallee-plaineduvar.fr/sites/default/files/fichiers/oin_guidebiodiversite_complet_light.pdf)

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# 10 Demonstrator DB-6 Les Bouscheleurs, France

## 10.1 Overview

### *10.1.1 Summary of the NBS case*

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).
The purpose of this system is to protect people, goods and activities against the risk of marine flooding. The various actions are carried out within PAPI. The three major themes are taken into account:

1) Prevention and forecasting: Improving knowledge and awareness of risk, surveillance, flood and flood forecasting, crisis alert and management.
2) Spatial planning: Taking risk into account in urban planning, actions to reduce the vulnerability of property and people.
3) The works of protection: Managing flows of water (from the sea and marshes), creation of protective structures (e.g., breakwater, reensablement, enhancement and thickening of existing coastal structures). The structures are designed to withstand a more important event than Xynthia (Xynthia + 20cm).

The demonstration NBS activities include:

4) Multi-purpose wetlands (oyster farming risk reduction)
5) Engineering solutions (hybrid configuration)

### *10.1.2 RECONECT – innovation potential*

Authenticity of the area located in the West - Athlantic coast of France, represents a unique location where structural measures and natural based solutions work together in flood reduction. A holistic approach, we can state at this moment raise from the last event catastrophe, Xynthia, in February 2010.

This event triggered a series of interventions and measures on both national and local level. The existing flood protection wall is reconstructed and dimensioned with respect to mentioned character of disaster in 2010. Also the local community realized the value of risk culture on one side and capacity of natural habitat of oysters and marchland area to accept flood wave.

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.

### *10.1.3 Geomorphological characteristics*

"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.

Storm Xynthia cause 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.

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-constructered 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.


*Figure 10-1 Protection system in Les Boucholeurs*

*Figure 10-2 Protection wall in Les Boucholeurs*

*Figure 10-3 Case study area, Châtelaillon-Plage (Les Boucholeurs), France (Source: Google map)*

### 10.1.4 Climatic conditions

The bay is part of the Aquitaine basin with secondary layers from the Jurassic with limestone and marl materials. The littoral has evolved during the quaternary and influenced by sea level variations. The marshlands were filled up with fine sand and mud.

The bay could be separated in three components:

- The sandy foreshore close to the seawall
- The rocky shore (lower foreshore)
- The rocky and sandy submarine shore changes into muddy bottom

The dominant winds are from the south-west to north-west (50%). The wind speed is more than 8 m/s representing 18%, resulting in a significant wind erosion and sand transport from north to south.

### 10.1.5 Hydrological conditions

The spring tidal range is about 6 meters.

The dominant current is the tidal current. The flood current is directed to the south with a velocity of around 0,6 m/s and the ebb current is directed to the west-northwest with a velocity of around 0,45 m/s.

Only swells from south-west to north-west penetrate into the “Pertuis d’Antioche” Around 45% of the swells have a height less than 2 meter, and 6% more than 6 meters. The frequency of the swells is around 6 to 10 s.

### 10.1.6 Hydro-meteorological hazard and problem description

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 rare extreme event Xynthia occurred in early morning of 28th February 2010 as a result of atmospheric depression created on 27th February morning. This storm hint west coast of France causing large-scale floods with huge damages. Beside France, the storm hint Germany and the Benelux countries. In total 65 people died.

Described as an explosive storm with the depression of 20hpa in more than 24h, Xynthia went through the country very fast. Based on the meteorological parameters (atmospheric pressure Xynthia has not reached the exceptional storms Lothar and Martin in December 1999, neither Klaus in January 2009. Even so, the effect of Xynthia on flooding and erosion is significant, especially in the department Vandee and Charente-Maritime.

Meteorological characteristics of the storm show that the wind gust speed of Xynthia was 242 km/h at the Pic du Midi d'Ossau in the Pyrenees and in the Charente Maritime at 140 km/h.

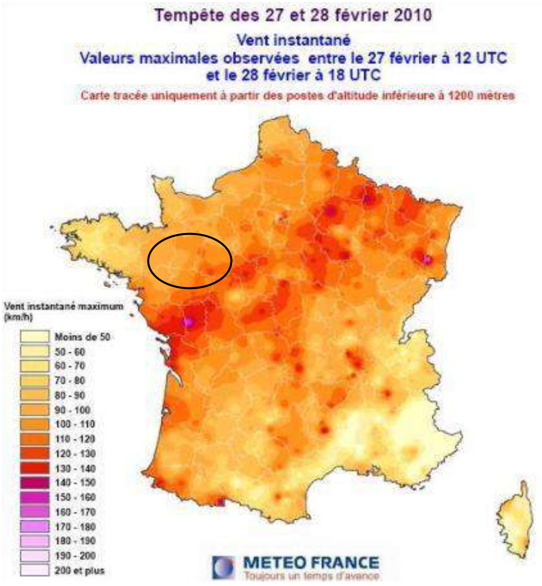



*Figure 10-4 Maximal wind speed during the storm Xynthia (Source: Meteo France)*

Figure 10-4 shows the maximal wind speeds during the storm Xynthia over France. The location of case study area is marked in the figure. The recorded wind speed relevant for case study is in the range from 120 km/h to 130 km/h. Excluding wind effect the tides created show significant values in heights. According to the BRGM (Bureau de Recherches Géologiques et Minières) the measured level of 4.5 m NGF (General Levelling in France) recorded at la Rochelle (northern of case study area) correspond to the very high return period. Up to this moment there is no official statement regarding calculated or estimated return period of this storm. The major threat for the affected area was storm surge and big waves. The storm surge was 1.6 m and the tide approximately 2.75 m.

### 10.1.7 Nature

Land use in total is divided on following: agglomeration 42%, march and coastal dunes (11% and 28%) and limestone plains 13%[7].

The natural environment is defined with two elements: green and blue network. The presence of rich and diversified natural and semi-natural environments makes it possible to offer favourable conditions for the reception of numerous species for the accomplishment of their life cycle (breeding, feeding, movement, refuge). Forests, heaths, meadows and lawns, rivers and wetlands, dunes and beaches ... thus constitute hearts of biodiversity and / or biological corridors. These living environments are the support of the green and blue wefts.

To help you grasp the complexity of the communal environment and to acquire new knowledge, you will find here information on the main environments present in Poitou-Charentes and a map of the natural habitats identified in your area.

[7] Chamber of Agriculture of Poitou-Charentes, Program IGCS (Inventory, Management, Soil Conservation), 2007

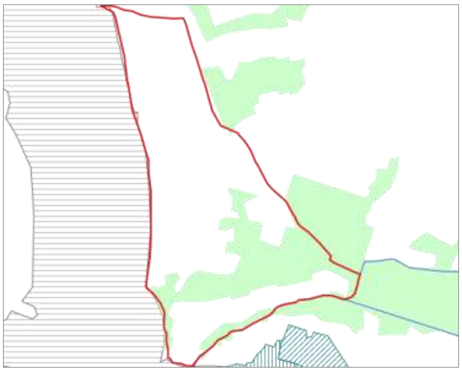


*Figure 10-5 Green frame of the area (Les Boucholeurs)*

Elements of the blue frame are represented by diverse streams, then from the streams to the river. This is defining a network of wetlands that is representing the key element of the blue frame. The biological diversity of rivers depends directly on the quantity and the physicochemical quality of water resources throughout the year and the state of aquatic habitats: for many aquatic species, especially large migratory fish (salmon, eels, trout, shad, lamprey ...), the possibilities of displacements are conditions indispensable to their survival.

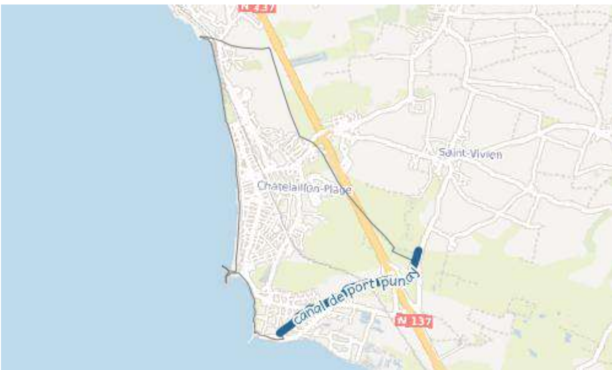



*Figure 10-6  Blue frame of the area (Les Boucholeurs)*

## 10.2 Stakeholders and governance

### 10.2.1 Stakeholders

Various stakeholders (incl. local authorities, sectoral agencies, NGO, the general public, etc.) are involved in this process.

Detailed information on stakeholders' involvement is being collected and analysed within Task 2.1 "Preparing co-creation: stakeholder analysis", (Demonstrators Survey) and can be found in the relevant documents elaborated within this Task.

### 10.2.2 Governance

- Local municipality, Châtelaillon-Plage and the mayor's office.
- The local society SILYCAF (Syndicat du Littoral Yves- Châtelaillon-Aix-Fouras), established after Xynthia as a public structure for the protection of persons and property against the risks of marine submersion. Involved as main stakeholder, coordinates flood protection measures, including NBS.

### 10.2.3 Ownership

"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.

#### 10.2.4 *Project organisation and management*

The crucial support in this project comes from Mayor Office in Châtelaillon-Plage. The relevant data is used from PEARL project (existing flood map produced after Xynthia event). The flood risk management planning for this NBS area is developed after the Xynthia event (2010).

First, the State established in February 2010 a National plan for rapid submersions (Plan Submersions Rapides - PSR) which aims by 2016 to increase the security of people in flood zones. The PSR has created a new dynamic and notably led many communities to carry flood prevention action programs (PAPI).

With the implementation of PAPI, carried by local authorities, the State has driven 81 operational actions contributing to manage urban development, to improve the knowledge of hazards, the development of forecasting and monitoring systems, the information of populations and the reliability of the protection structures. A new regulation for "management of aquatic environments and flood prevention" was created and should be established at the initiative of local communities until the 1st January 2018.

As already mentioned, the Xynthia event is declared as catastrophe by the French government. As a result, the government has adopted various initiatives grouped together into a “rapid submersion plan” (sometimes known as the “plan digues” or “flood defence plan”), published on 17 February 2011.

The plan aims to deliver a more effective response to marine flooding, flash floods and breached flood defenses.

It points forward to the national flood risk management plan, the framework for which was laid down in the 12 July 2010 Act on the national commitment to the environment, known as “Grenelle 2” , transposing the European Directive of 23 October 2007, known as the “Floods Directive”. The purpose of the Directive is to establish a strategic view of flood risks by 2015.

Considering the disaster character the measures at the begging were focused on development of early warning system. Early warning and emergency response systems can save human lives. They also have a limited cost relative to their impact in the event of a crisis. At the end, it was concluded, taking into account the social characteristics of the NBS area that warning that come from Mayor Office have much bigger effect on population than established EWS.

#### 10.2.5 *“People” – socioeconomical aspects*

The population density of the city of Châtelaillon is around 300 inhabitants per square kilometre, with a concentration close to the seaside. Population is 5937 inhabitants for 7 km² or 884 inhabitants per km² (regional average: 69 inhabitants / km²).

This touristic area has a significant number of recreational areas and holiday housing.

## 10.3 Project Scope: NBS to be demonstrated in RECONECT

#### 10.3.1 *Scope summary*

Scope of NBS is on evaluation of the potential to accept flood wave. The capacity of existing natural dune system and marchland area with oyster farms will be monitored during the project as well as protection wall.

### 10.3.2 *Project phases and planning*

*Table 10-1 Les Boucheleurs NBS Project phases and planning*

| DB6 LES BOUCHOLEURS | | YEAR 1 | | | | YEAR 2 | | | | YEAR 3 | | | | YEAR 4 | | | | YEAR 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| **Legend:** | | | | | | | | | | | | | | | | | | | | | |
| Planning | | | | | | | | | | | | | | | | | | | | | |
| Permits | | | | | | | | | | | | | | | | | | | | | |
| Design | | | | | | | | | | | | | | | | | | | | | |
| Land Acquisition | | | | | | | | | | | | | | | | | | | | | |
| Construction | | | | | | | | | | | | | | | | | | | | | |
| Baseline monitoring | | | | | | | | | | | | | | | | | | | | | |
| Maintenance and post-implementation and Monitoring | | | | | | | | | | | | | | | | | | | | | |

### 10.3.3 Planning & Design

Further information on planning and design is being collected and analysed within Task 2.2 "Establishing baselines, Demand and Supply Analysis" (Demonstrators Survey) and can be found in the relevant documents elaborated within this Task.

### 10.3.4 Procurement and contracting

Local municipality and the local society SILYCAF are responsible of procurement and contracting of services and works.

#### 10.3.4.1 Finance

Financing was and will be provided by local authorities.

### 10.3.5 Construction

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.

After the reconstruction of the protection walls the next step is to see how will this affect the local oyster farmers and especially if the village of Boucholeurs will keep the authenticity that made its difference.

The construction phase for NBS that are subject of Demonstration has been completed: Multi-purpose wetlands (oyster farming risk reduction) and Engineering solutions (hybrid configuration). In the meantime the flood protection programme for the area is still under development. New developments will appear, and the relevant information will be made available to RECONECT partners.

More information will be provided at a later stage.

### 10.3.6 Monitoring

#### 10.3.6.1 Indicators

DB-6 Les Boucholeurs plans to monitor 9 Indicators all together, of which 3 in category Water, 4 in category Nature, and 2 in category People, as presented here below in Table 10-2.

*Table 10-2 Les Boucholeurs NBS Indicators and Monitoring*

| NBS | Indicators | Variables Monitoring & Measurement approach | Evaluation methods | Comments, References |
|---|---|---|---|---|
| WATER | Flood Hazard | Water Depth (m)<br>Shoreline change (m) using the data from EU monitoring network- Wind speed m/s -Wave height (m) | Flood Map | |
| | Vulnerability | - Land use map<br>- Infrastructures data<br>- Population data<br>- Building/Housing | GIS processing and statistical data | |

| | | | | |
|---|---|---|---|---|
| NATURE | Changes in riparian habitat | | -GPS<br>-Aerial images | |
| | Change in wetland habitat | | -GPS<br>-Aerial images | |
| | Increase green area | | -GPS<br>-Aerial images | |
| | Distribution of public green space | - | GPS<br>-Aerial images | |
| PEOPLE | Reduced need for management and maintenance | - Maintenance and management cost of grey infrastructures (if implemented)<br>- Maintenance and management cost of NBS | | |
| | Change in land and/or property values | - Price of land and/or properties (euro)<br>- Willingness to pay | | |

#### 10.3.6.2 *Monitoring approach*

Les Bouscheleurs project was a case study in two previous related projects:

**CRISMA** - FP7project (2012-2015) with main focus on modelling crisis management for improved action and preparedness. CRISMA Integration Project focused on large scale crisis scenarios with immediate and extended human, societal, structural and economic, often irreversible, consequences and impacts. Typically, these crisis scenarios cannot be managed alone with regular emergency and first responder resources, but require multiorganisational and multi-national cooperation including humanitarian aid.

The CRISMA project developed a simulation-based decision support system, for modelling crisis management, improved action and preparedness. The CRISMA System facilitates simulation and modelling of realistic crisis scenarios, possible response actions, and the impacts of crisis depending on both the external factors driving the crisis development and the various actions of the crisis management team.

**PEARL** - FP7 project (2014-2017) The main goal of PEARL is to develop adaptive, socio-technical risk management measures and strategies for coastal communities against extreme hydro-meteorological events minimising social, economic and environmental impacts and increasing the resilience of Coastal Regions in Europe.

Both project had this area as a case study.

#### 10.3.6.3 *Monitoring planning*

Some monitoring activities on (e.g. water level, number of tourists) have been already carried out within Meteo France and tourist organization. Data available will be used as baseline data, to support further assessment of the performance of the NBS. Selected indicators for monitoring will be re-evaluated in the coming months and then the final decision will be made, Table 10-3.

*Table 10-3 Planned monitoring activities in the Les Boucholeurs (DB6)*

| Indicator / Variable | | YEAR 1 | | | | YEAR 2 | | | | YEAR 3 | | | | YEAR 4 | | | | YEAR 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M3 | M6 | M9 | M12 | M15 | M18 | M21 | M24 | M27 | M30 | M33 | M36 | M39 | M42 | M45 | M48 | M51 | M54 | M57 | M60 |
| WATER | W1 | | | | | | | | | | | | | | | | | | | | |
| | W2 | | | | | | | | | | | | | | | | | | | | |
| NATURE | N1 | | | | | | | | | | | | | | | | | | | | |
| | N2 | | | | | | | | | | | | | | | | | | | | |
| | N3 | | | | | | | | | | | | | | | | | | | | |
| | N4 | | | | | | | | | | | | | | | | | | | | |
| PEOPLE | P1 | | | | | | | | | | | | | | | | | | | | |
| | P2 | | | | | | | | | | | | | | | | | | | | |

#### 10.3.6.4 *Data management system*

Existing hydraulic and hydrological models are available.

### 10.3.7 *Evaluation*

The main benefits of NBS area located in the Les Boucholeurs are reducing flood risk by showing potential of natural wetlands.

The existing NBS show a good example of synergies between build and natural environment and how the capacity of natural environment can be used to absorb flood risks, in this case effect of storm surge. . The actions planed are monitoring the existing NBS during the project (RECONECT).

### 10.3.8 *References*


Karavokiros, George, et al. "Providing evidence-based, intelligent support for flood resilient planning and policy: The pearl knowledge base." Water 8.9 (2016): 392.

Batica, Jelena, and Philippe Gourbesville. "Resilience in Flood Risk Management–A New Communication Tool." Procedia Engineering 154 (2016): 811-817.

http://www.biodiversite-communale.fr/commune-Ch%C3%A2telaillon-Plage-17094

Chamber of Agriculture of Poitou-Charentes, Program IGCS (Inventory, Management, Soil Conservation), 2007

# V. SYNTHESIS OF NETWORK OF DEMONSTRATORS

Based on the information provided by Demonstrators in step I (Figure II-1), the individual analysis of the Demonstrators and an overall assessment have been carried out in order to:

a) Analyse the status of NBS projects and check the compliance of specified baseline information and scope of works with the RECONECT objectives (eco-systems regeneration, demonstration of NBS for reducing hydro-meteorological risk, establishment of evidence data-base, up-scaling)- **Status of NBS Project**

b) Assess which expertise is needed by the Demonstrator (demand) and what type of expertise/lessons learnt, in regards to the NBS implementation, monitoring and evaluation the Demonstrator can share with the others- **Key 'demand' & 'supply' aspects**

The results are presented in sectons V1-V3.

In the final step (Figure II-1), the potential for knowledge sharing and twinning has been assessed by discovering common features, interests and challenges. The potential for knowledge sharing and twinning options are given in section V4.

## V.1 Demonstrators type A

### Demonstrator DA-1 Dove/Gosse Elbe Estuary

**Status of NBS Project**: Demonstrator DA-1 is in the final stage of preparation for the implementation of NBS. Their report properly specifies baseline information and defines scope of works, setting the objectives, tasks, timeline, organization, financing, monitoring and evaluation, benefits & co-benefits. Reducing Hydro-Meteorological Risks is in focus while defining all the above. Climate, hydrology, geo-morphological, environmental conditions are well systemised and prepared for sharing and use by other Demonstrators and Collaborators. Innovative Potential is well addressed, and the possibilities for sharing with other Demonstrators are shown, however more technical specifics might be required in order to serve other Demonstrators and Collaborators. Key public stakeholders have been identified. Other stakeholders that should be considered for the co-creation are suggested. There is clear vision on the governance & financing, as well as on the organisation and management of the project. Procurement and contracting procedures are adequately addressed. Project phases, planning, design & construction are well defined, timeline is clearly scheduled. There is a clear view on monitoring on NBS performance, KPIs have been selected, variables / parameters to be monitored / measured have been already previewed. More details on evaluation approach/tools might be added, to be shared with other Demonstrators and Collaborators.

**Key 'demand' and 'supply' aspects**:

Demonstrator DA-1 can provide other Demonstrators with the following type of expertise/lessons learnt, in regards to NBS implementation and evaluation:

- Development of NBS Related Flood Risk Management plans in the sense of 2007/60/EC for the areas with significant risk assessed for the ongoing and future projects;
- Harmonization between the goals and targets of the Directive 200/60/EC (Water Framework Directive) and the Directive 2007/60/EC (Flood Directive) and enhancing synergies applying NBS.

DA-1 expressed their definite interest on cooperation to exchange knowledge/expertise/know-how with DA-2 Odense. Cooperation is also expected with Demonstrators B-type that have already implemented similar NBS.

### Demonstrator DA-2 Odense Coastal Area

**Status of NBS Project**: The scoping of works is properly assessed and adequately assigned. Reducing Hydro-Meteorological Risks is leading when specifying baselines and scoping the works. Natural conditions are well systemised and prepared for sharing and use by other Demonstrators and Collaborators. Some basic information on stakeholders is given, while detailed information is promised to appear later within report D2.1. There is clear vision on the governance as well as on the organisation and management of the project. No information on project financing is presented. Procurement and contracting procedures are shortly addressed, focusing on construction phase that is approaching. Innovative Potential is announced as "*tools to compare the effect/added value of a NBS compared to a "traditional grey solution"*, however it needs more detailed technical specification of these tools, in order to be understand by, and be ready for sharing with, other Demonstrators and Collaborators. Project phases, planning, design & construction are well defined, timeline is clearly presented. There is a preliminary view on monitoring on NBS performance. A solid set of key indicators have been selected. It is underlined that DA-2 are in the start-up phase of their project and therefore monitoring approach will be further specified once the demonstrator's NBS projects evolve and develop.

**Key 'demand' and 'supply' aspects**:

Demonstrator DA-2 can provide Demonstrators A with expertise on the focus on biodiversity as an important parameter using NBS (i.e. protection of species and creation of natural habitats while simultaneously addressing risks like flooding and sea level rise, protecting the local community and enhancing the livability of the area).

DA-2 already expressed their interest to exchange knowledge/expertise/know-how with other all the A-demonstrators Ensuring some similarities between the projects regarding the definition of NBS, as well as also with B-type Demonstrators, and especially with the site at Les Boucholeurs, France as another coastal area.

### Demonstrator DA-3 Tordera River Basin

**Status of NBS Project**: Scope of works of Demonstrator DA-3 has been addressed in a comprehensive way, adequately assigned to the objectives of RECONECT, where reducing Hydro-Meteorological Risks is in focus. Climate, hydrology, geo-morphological, environmental conditions are well systemized. Key public stakeholders have been identified, as well as environmental NGO's, research groups, and other stakeholders are also considered for the co-creation. There is clear vision on the governance and financing, as well as on the organisation and management of the project. The importance and relevance of NBS Innovative Potential is described, however no specific information is given on innovative nature-based solution planned to be applied to Tordera River basin. Project phases, planning, design & construction are well defined, timeline is clearly presented. Procurement and contracting procedures are adequately addressed. There is a clear view on monitoring on NBS performance. NBS key performance indicators have been selected. The indicators selected include 8 indicators included in the Monitoring Programme of the Water Framework Directive, and 12 indicators among the list of RECONECT NBS Indicators.

**Key 'demand' and 'supply' aspects**:

Demonstrator DA-3 can provide other Demonstrators (type A) with expertise in:

- developing vegetation management measures to improve the hydraulic capacity of riverbeds, and
- river restoration measures.

DA-3 already expressed their interest to exchange knowledge/expertise/know-how with other Demonstrators implementing similar NBS in their pilot sites namely with DA-1 Hamburg, DB-1 the Ijssel River basin, DB-5 the Var River basin and DB-4 the Thur River basin.

**Demonstrator DA-4 Portofino National Park**

**Status of NBS Project**: Specifying baseline and scoping the works of Demonstrator DA-4 is properly presented. Reducing Hydro-Meteorological Risks is in focus when scoping works. Main hazards are landslides, and flash floods. Climate, hydrology, geo-morphological, environmental conditions are well systemized and ready to use by other Demonstrators and Collaborators. Some general information on stakeholders is given, a broad spectrum of potential stakeholders is identified, however more concrete list of stakeholders that will be involved in co-creation will be require in the next stage of the project. There is clear vision on the governance, on the organisation and management of the project, as well as on procurement and contracting procedures. Relevant information on financing is provided. Innovative Potential is well addressed, and the possibilities for sharing with other Demonstrators are available, however more technical specifics is required in order to offer innovative solutions to other Demonstrators and Collaborators. Project phases, planning, design & construction are well defined, timeline is clearly presented. There is a preliminary view on monitoring on NBS performance. NBS key performance indicators have been selected. It can be recommended that specific flood risk indicators (e.g. flood risk reduction) could be better covered in the suggested set of Key Performance Indicators for Portofino, as long as flood hazard is present, along with landslides. Some site specifics indicators are also suggested, relevant to the unique character of the Portofino NBS site. Preliminary information and preview on data management system is also available. While DA-4 are in the start-up phase of the project their monitoring approach will be further specified in parallel with the NBS project development.

**Key ‘demand’ and ‘supply’ aspects**:

Demonstrator DA-4 can provide other Demonstrators A and Collaborators with expertise on the:

- Complex governance on public-private land management;
- Management of small basins;
- Stakeholders involvement.

DA-4 already expressed their interest to exchange knowledge/expertise/know-how with other Demonstrators namely with DA-3 Tordera River Basin (ES) and DB-5 Var River Basin (FR) since they are in the Mediterranean Basin and have similar climate conditions, as well as with DB-2 Inn River Basin (A) - mountain area as Portofino, and DB-6 Les Boucholeurs (FR) - where coastal flooding is a common problem.

The potential of twinning between demonstrators A and B is presented at Figure V-1.

## V.2 Demonstrators type B

**Demonstrator DB-1 Ijssel River basin - project ‘Stroomlijn”**

**Status of NBS Project**: All aspects of scoping of works (setting the objectives, individual tasks, timeline, organization, financing, monitoring and evaluation, etc.) have been properly addressed by Demonstrator DB-1 in line of main objective of RECONECT for Regenerating Ecosystems and Reducing Hydro-Meteorological Risks. Detailed description of DB-1 project in terms of NBS type, location characteristics, governance structures, etc. is available. Innovative Potential is well presented, and ready for dissemination and sharing within RECONECT network. Main stakeholders have been already identified and involved in NBS project during planning and construction phases, and will be also contacted within NBS monitoring and performance evaluation processes. The ownership, financing of the project, as well as procurement and contracting procedures (already completed) could serve as a good example to all Demonstrators type A. Past project phases, planning, design & construction timeline are also well presented to serve as example to others. However, better specification is needed on future activities, including NBS exploitation and maintenance and relevant responsibilities.

There is a clear view on monitoring on NBS performance, key Indicators have been selected. Relevant variables to be monitored / measured on site have been already identified, and some of them have been already monitored during and after construction phase. Technical evaluation and Project evaluation has been already done, and is described in the present report, further evaluation of NBS performance will follow.

**Key 'demand' and 'supply' aspects**:

Demonstrator DB-1 can provide other Demonstrators with the following type of expertise/lessons learnt, in regards to NBS implementation and evaluation:

- Development, implementation and maintenance strategies of NBS
- High tech monitoring
- Multi disciplinary approaches
- Building with nature and NBS maintenance
- Water Framework Directive

DB-1 already expressed their interest to exchange knowledge/expertise/know-how with all Demonstrators and Collaborators, giving preference on twinning with DA-1 Hamburg and/or DA-2 Odense - the ones with most similar characteristics and geographically located at close distance.

**Demonstrator DB-2 Inn River Basin**

**Status of NBS Project**: Detailed description of DB-2 project in terms of NBS type, location characteristics, governance structures, etc. is presented. When describing the scope of works Demonstrator DB-2 is focused on demonstration, monitoring of their NBS, as well as on evaluation of their performance aiming at reducing hydro-meteorological risks, in accordance to RECONECT objectives. Innovative Potential is addressed, emphasizing on the available land-use Models, and Novel Scenarios with quantification of benefits and limitations by urban vs. torrential NBS together with technical measures. Stakeholders are listed including state forests and local municipality, however no indications is given of involvement of this and other key public stakeholders (e.g. water basin directorate/agency) in NBS project development. Procurement and contracting, financing, as well as construction issues are not reflected as long as no new constructions are planned within RECONECT. A clear view on monitoring on NBS performance is shown, appropriate key Indicators have been selected. A comprehensive monitoring approach is demonstrated, including tools/methods variables to be measured, however, when regarding Indicators and relevant variables that will be used to assess the indicators, it is seen that only precipitation and land cover use are mentioned. The correspondence between Indicators and variables needs to be addressed as this is crucial for the monitoring (the basic activity for Demonstrators B), where a detailed monitoring program will be required.

**Key 'demand' and 'supply' aspects**:

Demonstrator DB-2 can provide other Demonstrators and Collaborators with the long lasting field experience in the forestation over decades.

DB-2 has not expressed any particular interest to exchange knowledge/expertise/know-how with some specific Demonstrators and/or Collaborators, but only gave an idea that such cooperation could build upon the long lasting field experience in the forestation over decades.

**Demonstrator DB-3 Aarhus, Egå Engsø and Lystrup**

**Status of NBS Project**: The presentation of the NBS site and the scope of works of Demonstrator DB-3 is focused on The presentation of the NBS site and the scope of works of Demonstrator DB-3 is focused on demonstration, monitoring of their NBS, as well as on evaluation of their performance in reducing hydro-meteorological risks, in accordance to RECONECT objectives. Climate, hydrology, geo-morphological, environmental conditions are well systemized and ready for sharing and use as baseline information by other Demonstrators and Collaborators. Innovative Potential is addressed, emphasizing on the available Land-use Models and Novel Scenarios with quantification of benefits and limitations by urban vs. torrential NBS together with technical measures. Stakeholders are listed including state forests and local municipality, however no indications is given of involvement of this and other key public stakeholders (e.g. water basin directorate/agency) in NBS project development. Procurement and contracting, financing, as well as construction issues are not reflected as long as no new constructions are planned within RECONECT. Better specification is needed on future activities, including NBS maintenance, coordination activities and relevant responsibilities.

Monitoring plan of DB-3 is under preparation. AAKS have not finally decided exactly which indicators and variables they are going to monitor. However, there is a clear view on monitoring on NBS performance, an appropriate monitoring approach is demonstrated, including available tools and methods, some appropriate key Indicators have been already pre-selected. Further specification on monitoring plans will be elaborated, together with the development of the NBS project. Regarding the evaluation of the NBS performance, it has been adequately addressed, and further details will follow.

**Key ‘demand’ and ‘supply’ aspects**:

Demonstrator DB-3 can provide other Demonstrators and Collaborators with the long lasting field experience in the forestation over decades.

DB-3 has not expressed any particular interest to exchange knowledge/expertise/know-how with some specific Demonstrators and/or Collaborators, but only gave an idea that such cooperation could build upon the long lasting field experience in the forestation over decades.

**Demonstrator DB-4 Thur River Basin**

**Status of NBS Project**: Demonstrator DB-4 has properly assessed and adequately assigned the scope of works, focused on demonstration, monitoring of their NBS, as well as on evaluation of their performance in reducing hydro-meteorological risks - in accordance to RECONECT objectives. Climate, hydrology, geo-morphological, environmental conditions are well systemized and ready for sharing and use as baseline information by other Demonstrators and Collaborators. Innovative Potential is very well defined, focusing on an adaptive, self-learning monitoring system that is linked to a real-time distributed hydraulic model – leading to an optimized flood protection plan with a early-warning system in place for the hydrological response units (HRU). A large potential for implementation of the measures deployed in the Thur catchment on other catchments is demonstrated, the developed methods and models can be used by the other RECONECT partners and be adapted to other catchments and basins. Appropriate approach to the involvement of administrative, technical and research stakeholders is put on place. There are additionally planned actions in the flood risk management plan of the river basin. There are no any specific construction works that will be followed within RECONECT. Nevertheless, the governance, ownership, financing of the project, as well as procurement and contracting procedures (already completed) are described here in this report, to serve as a good example to all Demonstrators type A. Past project phases, planning, design & construction timeline are also presented to be learned by others.

There is a clear view on planning on monitoring of NBS performance. A comprehensive monitoring approach is demonstrated. All together 9 indicators to monitor NBS performance have been selected, within the 3 groups Water, Nature and People.

Demonstrator DB-4 can provide other Demonstrators and Collaborators with expertise as follows

- economical evaluation of the restoration efforts
- public perception of restoration measures
- success evaluation long lasting field experience in the forestation over decades.

**Key 'demand' and 'supply' aspects**:

DB-4 has not expressed any interest of twining with some particular Demonstrators and/or Collaborators, but declared that they will work with any collaborator who would need their experience, including also from an Agency for the Environment Canton Thurgau, which led the restoration efforts at Thur river.

### Demonstrator DB-5 The Var River Éco-Vallée

**Status of NBS Project**: Detailed description of DB-5 project in terms of NBS type, location characteristics, governance structures, etc. is presented. Scoping of works is focused on demonstration, monitoring of their NBS, as well as on evaluation of their performance in reducing hydro-meteorological risks.

Flood risk, earthquakes and technological risks are considered. Climate, hydrology, geo-morphological, environmental conditions are well systemized and ready for sharing and use as baseline information. Innovative Potential is well addressed, showing some green and some hybrid technological innovations, which have the potential to meet the interest of other demonstrators, in particular those of group A. Key stakeholders are presented, as well as an appropriate approach to the involvement of key public stakeholders is demonstrated. While there are no any specific construction works that will be followed within RECONECT, there are forthcoming planned actions within the Eco Valee integrated project (running until 2035), that will influence RECONECT activities. The governance, ownership, financing of the project, as well as procurement and contracting procedures (already completed) are described. Past project phases, planning, design & construction are also mentioned. Monitoring plan and data management system are adequately addressed, key Indicators are selected, as well as basic variables are assigned. However specification of variables which will be measured on site will need further attention and more details that will be needed to elaborate a detailed monitoring program.

**Key 'demand' and 'supply' aspects**:

Demonstrator DB-5 can provide other Demonstrators and Collaborators with expertise on Post-disaster recovery.

DB-5 has not expressed so far any particular interest of twining with some particular Demonstrators and/or Collaborators, but declared that they will work with any collaborator who would need their experience.

### Demonstrator DB-6 Les Boucholeurs coastal area

**Status of NBS Project**: Demonstrator DB-6 have properly answered to questioning and surveys for scoping of works, providing detailed description of their project in terms of NBS type, location characteristics, governance structures, etc. Forthcoming works are focused on demonstration, monitoring of their NBS, as well as on evaluation of their performance in reducing hydro-meteorological risks - in accordance to RECONECT objectives. Climate, hydrology, geo-morphological, environmental conditions are well systemized and ready for sharing and use as baseline information.

Innovative Potential is addressed, representing a unique location where structural measures (e.g. flood protection seawall and detached reef breakwaters) and natural based solutions (wetland area combined with oyster farms) work together in flood hazard reduction. It can be of particular interest of other Demonstrators and Collaborators who develop NBS in coastal areas.

Information on key stakeholders presented for the purpose of this report is insufficient, and shall be improved in order to be of use by other Demonstrators and Collaborators.

Past project phases, planning, design & construction are mentioned. The governance, ownership, financing of the project, as well as procurement and contracting procedures (already completed) are also described here in this report, to serve as a good example to all Demonstrators type A.

Monitoring plan and data management system are addressed properly. Key Indicators are selected, as well as basic variables are assigned. More detail will be needed to elaborate a detailed monitoring program which will be required within WP3 of RECONECT project.

**Key 'demand' and 'supply' aspects**:

Demonstrator DB-6 can provide other Demonstrators and Collaborators with expertise on Post-disaster recovery.

DB-6 has not expressed any interest of twining with some particular Demonstrator and/or Collaborator, but declared that they will work with any Collaborator who would need their experience.

## V.3 Summary

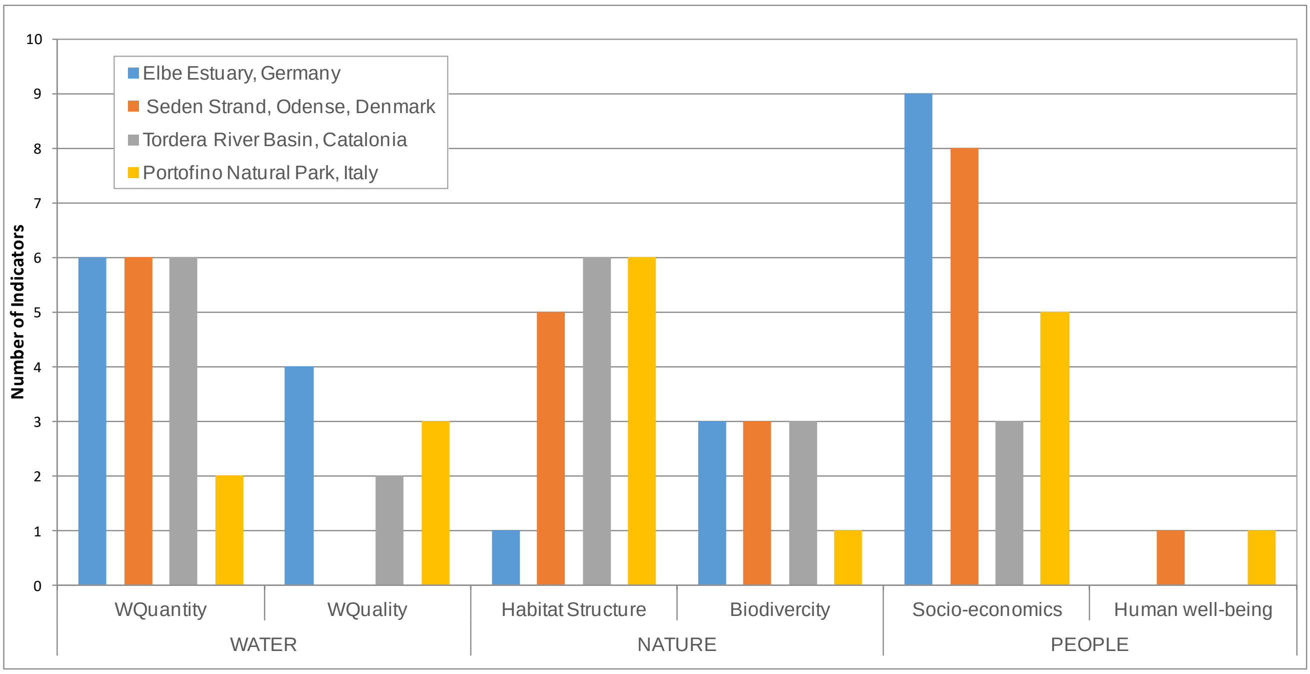
Based on the conducted assessment of the scope of works as presented in sections V1 and V2, the following findings could be derived:

- All Demonstrators A and B have defined their NBS projects and are currently at different stages of their implementation - even within each of the two groups A and B. In that sense, DA-4 Portofino is at the beginning of the construction works (recovery of stone terraces with NBS), while DA-3 Tordera River is still in the process of searching for NBS appropriate to their site - for which they rely on assistance of RECONECT through sharing of knowledge, experience and know-how between Demonstrators.
- All demonstrators identified the KPIs to be monitored and evaluated to demonstrate the co-benefits of NBS.

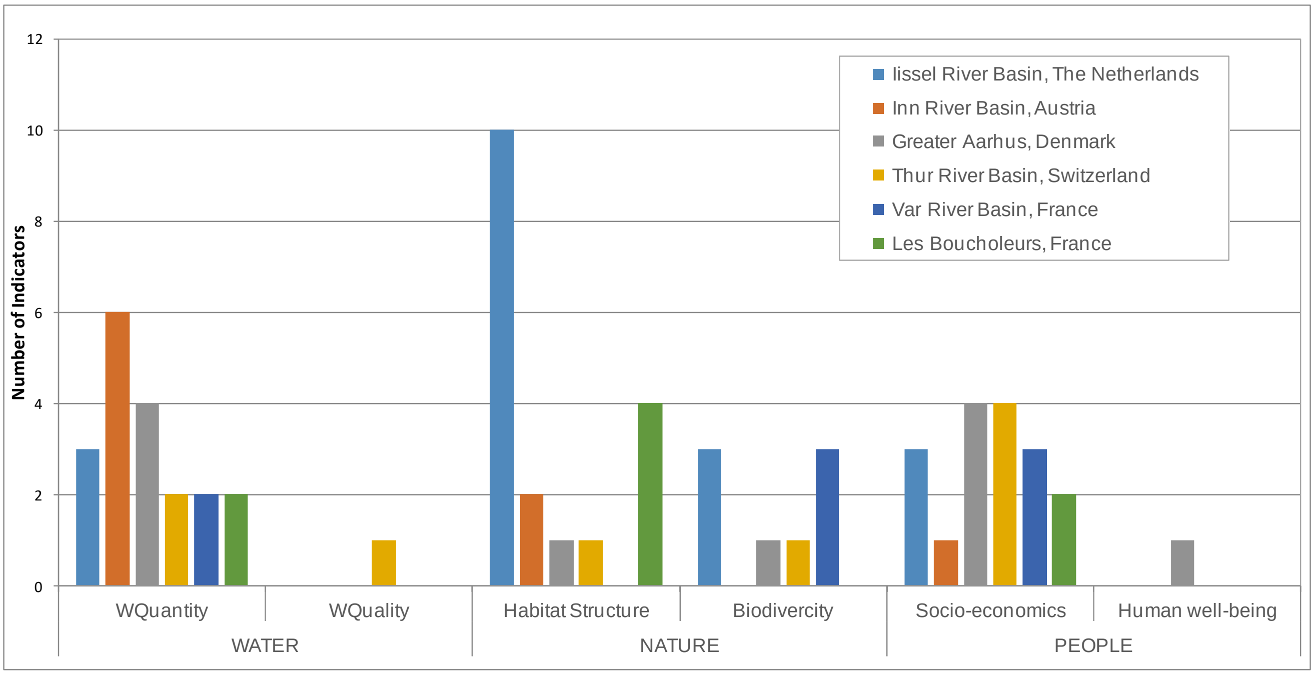
The number of KPIs that were identified by the Type A Demonstrators equals to 52 (out of the total 91), uniformly distributed by the 3 categories (WATER, 18; NATURE 17; PEOPLE, 17).

The list of KPIs identified by the Demonstrators Type B includes 45 indicators (out of the total 91), dominated by the *Flood Hazard* (WATER), *Changes in riparian habitat* (NATURE), *Reduced/avoided damage cost from hydro-meteorological risk reduction* (PEOPLE).

Distribution of Indicators for the performance of NBS selected by Demonstrators A and B is illustrated here below in figure V-1.




a)




b)

*Figure V-1 Selected Indicators by Demonstrators A (a) and Demonstrators B (b)*

- An interactive web-based map showing characteristics of all types and locations of selected NBS is available at https://www.reconect.eu/network-of-cases/. Detailed description and mapping of NBS sites and information about RECONECT activities of all Demonstrators A and B is also available at https://www.climatescan.nl/projects/2687/detail (Figure V-2).

The above mentioned internet based-information, in addition to the presentation of scope of works of Demonstrators as summarised in the present report, provide essential links to the forthcoming RECONECT activities to be carried within WP3 and Task 2.4.

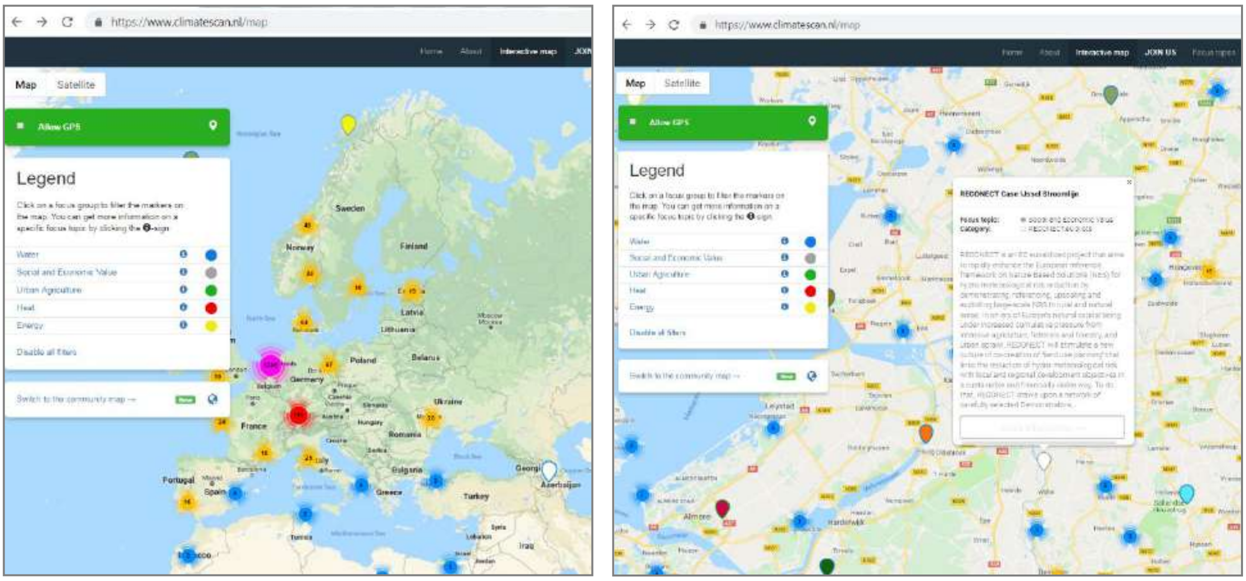



*Figure V-2 Interactive web-based map application in Climate Scan for international knowledge exchange on 'blue-green' projects*

## V.4 The potential for knowledge sharing between Demonstrators type A and B (twinning options)

**T**he potential for knowledge sharing and twinning between Demonstrators A and B has been assessed, taking into account the 6 main factors assessed for each Demonstration A and B case (see also section METHODOLOGY)

a. Type of hydro-meteorological hazard identified and type of the NBS project (flash flood, fluvial flood, landslide, coastal flood, etc.)
b. Geographical location, distance between partners
c. Similarity in natural conditions (climate, terrain, hydrology, river basin scale)
d. Similarity of NBS type - the technical solutions
e. Status of Works
f. Expressed wish by the Demonstrator for twinning and knowledge exchange

The proposed twinning between Demonstrators A and B is shown in Figure V-3 and Figure V-4.

The twinning between the Demonstrators A and B is a part of the RECONECT knowledge sharing and upscaling strategy that is being developed in WP4 on Overcoming barriers, upscaling and synergies with collaborators.

Following the knowledge sharing and upscaling strategy, a series of meetings, site visits and webinars will be organised in order to support the knowledge exchange and peer to peer learning between the twinning couples. The details will be available in the reports D1.2 (Social innovation approach) and D4.3 (RECONECT Upscaling strategy).

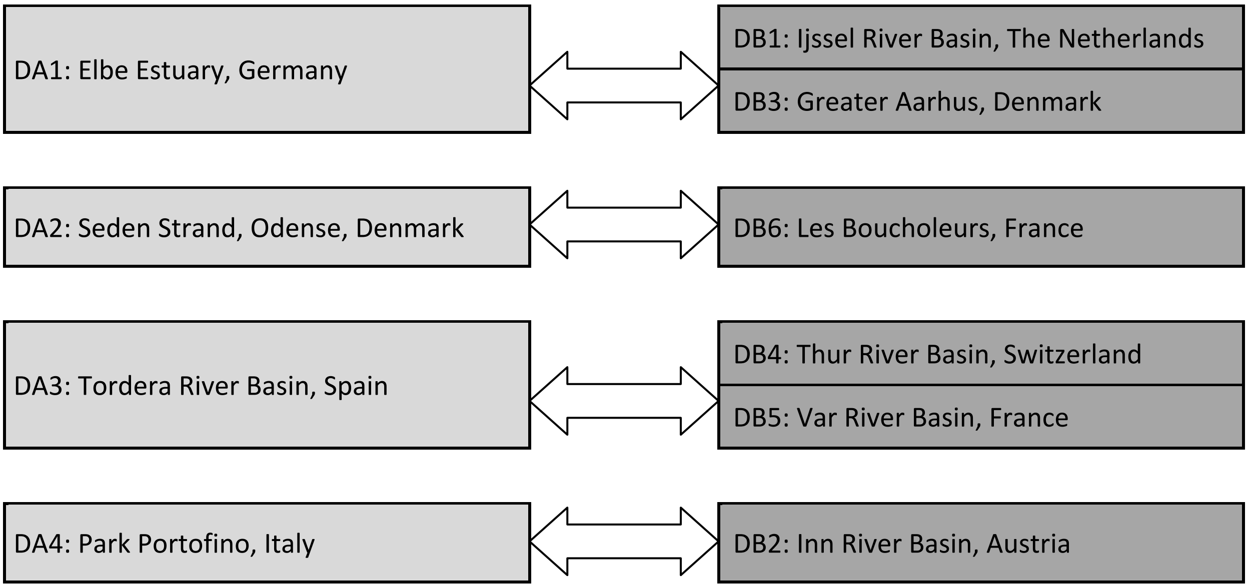



*Figure V-3 Proposed twinning between Demonstrators A and B*

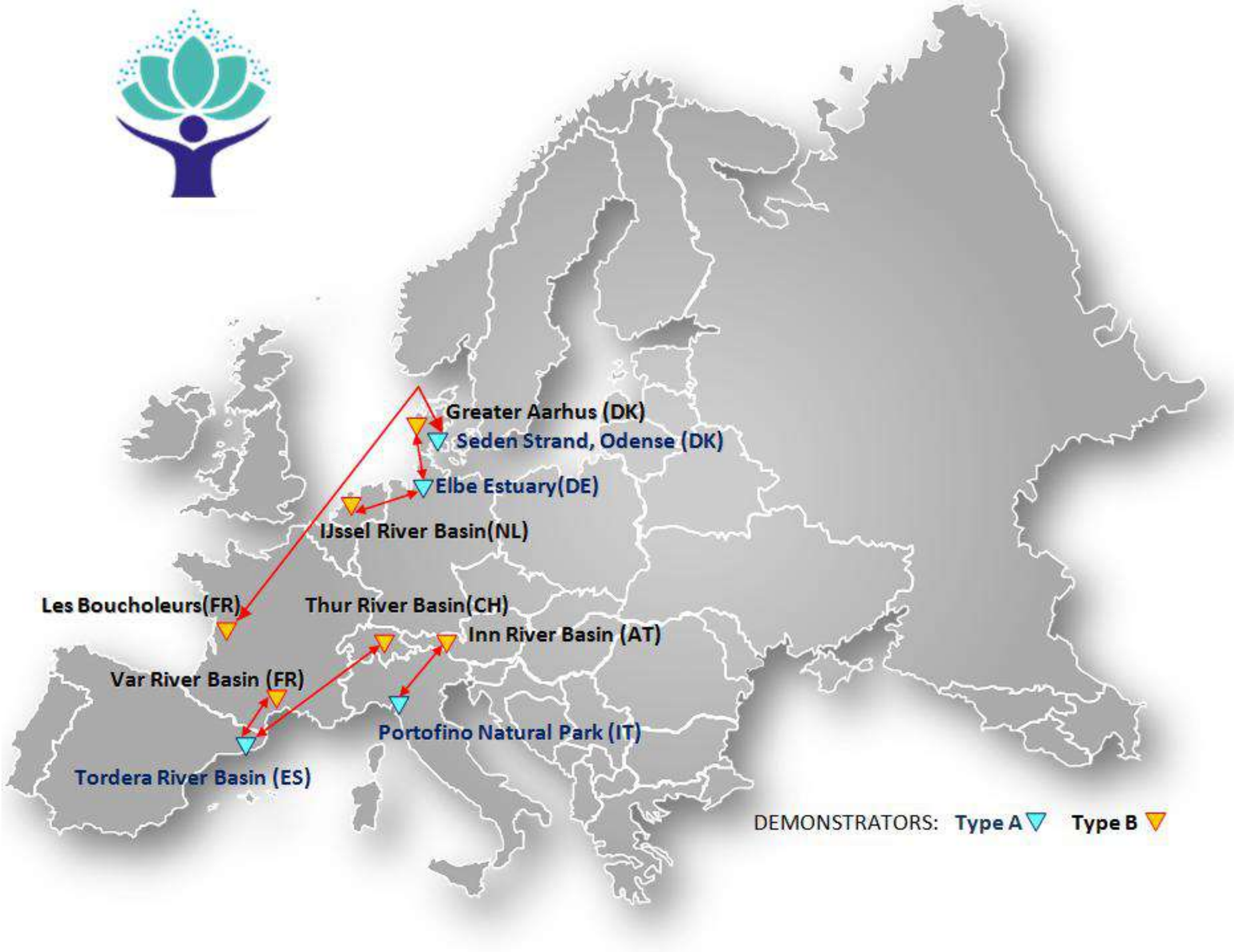



*Figure V-4 Map of proposed twinning between Demonstrators A and B*

# VI. CONCLUSIONS AND RECOMMENDATIONS

Summarising the current status of the Scope of NBS Works surveyed in the RECONECT Demonstrators A and B, the following main conclusion could be derived:

- All Demonstrators A and B have defined their NBS projects, providing relevant information upon their objectives, tasks, timeline, organisation/management/financing, monitoring, evaluation and co-benefits, as presented in their individual reports (Section IV).
- The presented scope of activities and timelines are in line with the activities and time plan set for the overall project as per RECONECT DoA.
- The Demonstrators are at different stages of their NBS implementation, creating potential for knowledge sharing and interaction between the Demonstrators, already at the early project stage. In this way, the Demonstrators, who are in the initial phases of their projects, can benefit and be inspired by RECONECT ideas by having a close exchange with the other Demonstrators and experts.
- The major challenge for the definition of the Scope of Works has been the selection of the KPIs and the corresponding monitoring strategies, which especially applies to Demonstrators A. It raised discussions within NBS Demonstration clusters and generated further needs for adjustments of the initial monitoring plans and strategies. Although this process has generated further effort, it can be assessed as beneficial for the project and to a certain extent “an eye opener” for a number of local experts and stakeholders. In most of the Demonstrators, in particular of the A type, the co- benefits of NBS are for the first time regarded in a holistic manner i.e. covering the different dimensions (WATER, NATURE, PEOPLE) within a comprehensive monitoring and evaluation strategy.

  Demonstrators B are in a more advanced phase of their monitoring programs, some of them already benefiting from the previous projects, in which the monitoring has already been initiated (DB-1 Ijssel River, D-4 Thur River, DB-3 Aarhus). Still, Demonstrators B will adapt their existing monitoring plans, following the RECONECT monitoring and evaluation strategy and the corresponding KPIs.
- Taking into consideration the type of NBS and the potential for knowledge/lessons-learnt sharing, and based on the information provided by the Demonstrators within the present report, the twinning potential between demonstrators A and B has been assessed, and the structure of RECONECT Demonstrators’ twining process was established;

Based on the presented Scope of Works which have been further analysed and assessed (see Chapter V), the following future actions in Demonstration sites are envisaged and recommendations derived:

➔ As the Demonstrators are at different implementation stages, the twinning process should start in this project phase, following the scheme as given in section V.4. Face-to- face meetings, webinars or bilateral site visits should be organised to support the twinning process following the knowledge sharing and upscaling strategy being developed in WP4 (also summarised in the report D1.2 due Month 9).

➔ Identification of the innovative potential and the relevant activities for demonstration and replication of innovations of the NBS need further attention. Describing the innovations with enough practical/technical details, ready for sharing within RECONECT network, is the key step for its further replication by other Demonstrators and Collaborators

➔ The outcomes of the stakeholder analysis that is still ongoing (in Task 2.1) should be further integrated in this report, once all results are available.

➔ This report reflects the baselines and envisaged activities in Demonstrators A and B and as such can be considered a reference document for further planning and works (e.g. D2.5 on the preparatory actions). Moreover, it will serve as a basis for development of guidelines for design, implementation, and evaluation of NBS envisaged in within WPs 3, 4 and 5.

➔ Rather diverse implementation stages and patterns of the Demonstrators require considerable coordination effort. Regular conference calls and meetings are planned in order to ensure timely delivery and accomplishment of tasks, but also in order to provide support and advice upon need.

➔ Finally, in parallel to the coordination of the individual actions, the twinning process should be planned and executed as per scheme given in section V4. The outcomes of the twinning sessions might have an (positive) influence on the time line and type of activities in the individual Demonstration NBS projects, which should be considered for the future planning of the overall NBS activities in Demonstrators.

# ANNEX A

*To Deliverable D2.3*

# Scope of Works for Demonstrators A and B



*Acknowledgement*
This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 776866

*Disclaimer*

# Annex A: Overview on NBS Key Performance Indicators for Demonstrators A and B

RECONECT co-assessment aims at assessment of hazards, vulnerabilities and risk of demonstrators (and collaborators) to hydro-meteorological events, their experiences, expectations, needs and capacities to implement NBS and other risk mitigation options. Appraisal of different types of NBS will be carried out in relation Key Performance Indicators (KPI). Therefore, substantial efforts in Task 2.3 were put on establishing the base of co-assessment through selection of relevant KPI applicable for NBS cases for Demonstrators type A and B.

By requesting information on the Indicators they are using or planning to use, Demonstrators may be further encouraged to think about wider possibilities of benefits and co-benefits that may be relevant to their cases.

A List of applicable KPI has been developed by IHE based on analysis of main objectives and sub-goals of performance of NBS, and addressing definition of expected benefits and co-benefits with each demonstrator A and B. Indicators have been selected in way to follow the SMART criteria list, that means they will be Specific, Measurable, Achievable, Relevant and Time-bound. The list includes 91 KPI in total, for each of the indicators the most important parameters/variables have been identified.

Further, an interactive Indicators Selection tool has been developed by IHE (*Table A-1*), and has been offered to Demonstrators, to facilitate their preparation works, to assist specifying baselines and scope of works (including monitoring and evaluation), by selection of most relevant KPI for their NBS sites, as well as of relevant Variables, which be followed/monitored. In the next step of RECONECT some target values may be established for selected Variables which will be monitored, this way providing the basis for quantification of the KPI, and the relevant assessment of performance of the NBS.

All together 91 indicators have been suggested, grouped into three categories WATER (31), NATURE (23) and PEOPLE (37), *Tables A-2 to A-4*. The indicators will be assessed in relation to spatial and temporal dimensions. Spatial dimension will concern evaluation in relation to the space required for ecosystem regeneration and hydro-meteorological risk reduction. The temporal dimension will concern evaluation in relation to time required for ecosystem regeneration and hydro-meteorological risk reduction.

The number of indicators that were identified by the Type A Demonstrators includes 52 different indicators (out of the total 91 proposed by the Indicator selection Tool), plus another 3 identified at Portofino NBS case, DA-4, where site-specific indicators/variables, e.g. floating wood, or debris, have been suggested. The above indicators are uniformly distributed by the 3 categories (WATER, 20; NATURE 17; PEOPLE, 18).

The most chosen indicators are being Vulnerability/Flood risk reduction (WATER), Change in vegetation along watercourses (NATURE), Increasing recreational opportunities of NBS area (PEOPLE). Demonstrators Type A will follow between 18 and 23 indicators each, *Table A-5*.

The list of indicators identified by the Demonstrators Type B includes 35 indicators in total, the most chosen being Flood Hazard (WATER), Changes in riparian habitat (NATURE), Change in land and/or property values (PEOPLE). Within this list, Demonstrators B have shown a wide variety in selecting Indicators which they will follow, ranging from 8 indicators (Var River Eco Valee) to 19 indicators (Ijssel river basin).

Predominance in group B Demonstrators is given to NATURE category (16 indicators selected), while WATER category includes 9 indicators, and indicators selected within PEOPLE category are 10.

A Summary of all identified Indicators is presented in *Table A7.*

The Indicator list will be continuously reviewed during different project steps and will be adapted accordingly, in particular regarding Demonstrators type A.

Table A-1 Illustration on Indicators Selection Tool (IHE)

RECONECT

**Demonstrator:** xxxx

****Note:** if the indicator is applicable to your case please type Y otherwise if it is not applicabe type NA or simply leave a blank cell.

Yellow button is to filter the applicable indicators while Brown/Orange button is to clear the filter. Green button is to save/export your final indicator list into a new separate file. You can also save the existing file.

Filter applicable indicators | Remove | Save/export your final indicators

| | NBS | Goals | Sub-Goals | Recommended indicators | Description of indicator | Variables | Example of methods | References | Applicable |
|---|---|---|---|---|---|---|---|---|---|
| 26 | WATER | Water Quantity | Landslide risk reduction | Landslide hazard | Landslide refers to a variety of processes that result in the downward and outward movement of slope-forming materials, including rock, soil, artificial fill, or a combination of these. | - Slope angle<br>- Geology<br>- Land use<br>- Earthquakes<br>- Precipitation | | Abella, E. A. C., & Van Westen, C. J. (2007). Generation of a landslide risk index map for Cuba using spatial multi-criteria evaluation. Landslides, 4(4), 311–325. https://doi.org/10.1007/s10346-007-0087-y | Y |
| 27 | | | | Vulnerability | Vulnerability is the state of being prone to or susceptible to harm. In this respect, we can distinguish different forms of vulnerability (e.g., social, economic, environmental and so on). | - Land use<br>- Infrastructure data<br>- Population<br>- Building/Housing | | Abella, E. A. C., & Van Westen, C. J. (2007). Generation of a landslide risk index map for Cuba using spatial multi-criteria evaluation. Landslides, 4(4), 311–325. https://doi.org/10.1007/s10346-007-0087-y | Y |
| 31 | | Water Quality | | Sediment deposition | Sediment (e.g., silt) resulting from soil erosion can be carried into water bodies by surface runoff. Sediment interferes with the penetration of sunlight and upsets the ecological balance of a body of water. Also, it can disrupt the reproductive cycles of fish and other forms of life, and when it settles out of suspension it can smother bottom-dwelling organisms. | - Suspended Solids(TSS)<br>- Total dissolved solid (TDS)<br>- Turbidity (NTU)<br>- Sediment Composition<br>- Sediment characteristics | Collect samples and test in laboratory | | Y |
| 37 | NATURE | Habitat structure | Increase habitat area (quantity) | Changes in riparian habitat | A riparian habitat is the habitat that are associated with bodies of water. It is found along the bank of a river, stream, or other actively moving source of water such as a spring | - Riparian habitat area (km2) | - GPS<br>- Aerial images | | Y |
| 40 | | | | Changes in terrestrial habitat | Terrestrial habitat can only find on land such as forests, grasslands, deserts, shorelines and wetlands. Terrestrial habitat also includes man mad habitats such as farms, towns, cities. | - terrestrial habitat area (km2) | - GPS<br>- Aerial images | | Y |
| 45 | | | To reflects ecological status and physical structure of habitats | Change in vegetation along watercourses | Changes in riparian vegetation can have significant effects on aquatic biodiversity through direct (change in water temperature and light availability) and indirect ( increased run-off, situation, etc.) impacts. | - Vegetation along watercourses using remote sensing or transect, quadrat survey | - Remote sensing or transect, quadrat survey | | Y |

Sheet1

*Table A-2 NBS Key Performance Indicators - WATER*

| | | INDICATORS |
|---|---|---|
| **WATER** | **W-1** | Surface run-off reduction |
| | **W-2** | Slowing and storing runoff |
| | **W-3** | Flood hazard |
| | **W-4** | Vulnerability (Flood risk reduction in urban areas and around rivers, lakes, watercourses, etc.) |
| | **W-5** | Delay time to peak |
| | **W-6** | Flood peak reduction |
| | **W-7** | Storm surge |
| | **W-8** | Coastal Hazard index |
| | **W-9** | Exposed value index (EVI) |
| | **W-10** | Coastal vulnerability index (CVI) |
| | **W-11** | Waves exposure |
| | **W-12** | Soil infiltration capacities |
| | **W-13** | Groundwater recharge |
| | **W-14** | Change in Groundwater level/water table |
| | **W-15** | Standardized Precipitation Index |
| | **W-16** | Palmer Drought Severity Index |
| | **W-17** | Surface water supply Index |
| | **W-18** | Increased water storage capacity |
| | **W-19** | Available water supply |
| | **W-20** | Water Consumption |
| | **W-21** | Landslide hazard |
| | **W-22** | Vulnerability (Landslide risk reduction) |
| | **W-23** | Change in water pollution caused by wastewater (point sources) |
| | **W-24** | Reduced pollutants coming from land to water (non-point sources) |
| | **W-25** | Attenuation of heavy metals and nutrients contamination in surface water |
| | **W-26** | Sediment deposition |
| | **W-27** | Reduction of pollution in coastal waters |
| | **W-28** | Coastal water pollutants in shellfish |
| | **W-29** | Attenuation of pollution in groundwater |
| | **W-30** | Change in soil quality |
| | **W-31** | Seawater intrusion |

*Table A-3 NBS Key Performance Indicators – NATURE*

| INDICATORS | | |
|---|---|---|
| NATURE | N-1 | Changes in riparian habitat |
| | N-2 | Changes in aquatic habitat/(Mesohabitats) |
| | N-3 | Change in wetland habitat |
| | N-4 | Changes in terrestrial habitat |
| | N-5 | Increase green area |
| | N-6 | Distribution of public green space |
| | N-7 | Connectivity/fragmentation of habitat structural |
| | N-8 | Change in location of habitat boundaries |
| | N-9 | Change in vegetation along watercourses |
| | N-10 | Conservation status of habitats |
| | N-11 | Shoreline characteristics and erosion protection |
| | N-12 | Low impact space |
| | N-13 | Diversity of land use in the agricultural area |
| | N-14 | Change in land cover |
| | N-15 | Change in land use |
| | N-16 | Restricted-range species |
| | N-17 | Species richness and composition in respect to indigenous vegetation and local/national biodiversity targets |
| | N-18 | Number and type of protected species |
| | N-19 | Density of Species |
| | N-20 | Diversity of species |
| | N-21 | Type, density of native species |
| | N-22 | Number, area, location, of non-native/mitigated animal and planted species |
| | N-23 | Number, area, location, of invasive non-native animal and planted species that are threatening to ecosystem, habitats or species |

*Table A-4 NBS Key Performance Indicators - PEOPLE*

| INDICATORS | | |
|---|---|---|
| PEOPLE | P-1 | Increasing recreational opportunities of NBS area |
| | P-2 | Number and value of people visit or spend free time in NBS area |
| | P-3 | Number of people engaging in alternative livelihood activities in the NBS area |
| | P-4 | Number of tourists |
| | P-5 | Provision of NBS sites for education and research |
| | P-6 | Loss of cultural heritage due to hydro-metrological events/ due to land take |
| | P-7 | Food production |
| | P-8 | Number of cultural events in NBS area |
| | P-9 | Accessible NBS area per capita |
| | P-10 | Average journey time for people by foot to NBS area or average distance from home/public transportation to NBS area |
| | P-11 | The number of people communicate with neighbourhood in the NBS area |
| | P-12 | Cognitive and social development in children and young people |
| | P-13 | Community development and cohesion |
| | P-14 | Number of subsidies or tax reductions applied for (private) NBS |
| | P-15 | Number of new businesses attracted from NBS |
| | P-16 | Number of green jobs created |
| | P-17 | Enhancing attractiveness of places for living and working, and to visit |
| | P-18 | Gross value added per employees based on full time equivalent jobs in the green sector. |
| | P-19 | Increased competitive advantage for cities applying NBS |
| | P-20 | Reduced/avoided damage cost from hydro-meteorological risk reduction |
| | P-21 | Economic benefit from the reduction of stormwater that typicaly needs to be treated in a public sewerage system |
| | P-22 | Energy and carbon savings from reduced building energy consumption (heating and cooling) |
| | P-23 | Reduce cost of health impacts of air and noise pollution |
| | P-24 | Value of reduced CO2 emission and carbon sequestration |
| | P-25 | Reduced need for management and maintenance |
| | P-26 | Change in land and/or property values |
| | P-27 | Mental well-being |
| | P-28 | Mitigating heat stress |
| | P-29 | Urban heat island effect mitigation |
| | P-30 | Reduction in chronic stress and stress related diseases |
| | P-31 | Noise pollution attenuation |
| | P-32 | Reduction in number of cardiovascular morbidity and mortality events |
| | P-33 | Improved physical health |
| | P-34 | Change in heavy metal emission |
| | P-35 | Avoided greenhouse gas emissions |
| | P-36 | Annual amount of pollutants captured and removed by vegetation |
| | P-37 | Air pollution improvement |

*Table A-5 Selected Indicators – DEMONSTRATORS A*

| | | INDICATORS | DA-1 | DA-2 | DA-3 | DA-4 | TOTAL by RECONECT Demonstrators |
|---|---|---|---|---|---|---|---|
| WATER | W-1 | Surface run-off reduction | ■ | | | | 1 |
| | W-2 | Slowing and storing runoff | ■ | | ■ | | 2 |
| | W-3 | Flood hazard | ■ | | ■ | | 2 |
| | W-4 | Vulnerability (Flood risk reduction in urban areas and around rivers, lakes, watercourses, etc.) | ■ | ■ | ■ | | 3 |
| | W-5 | Delay time to peak | ■ | | ■ | | 2 |
| | W-6 | Flood peak reduction | ■ | | ■ | | 2 |
| | W-7 | Storm surge | | ■ | | | 1 |
| | W-8 | Coastal Hazard index | | ■ | | | 1 |
| | W-9 | Exposed value index (EVI) | | ■ | | | 1 |
| | W-10 | Coastal vulnerability index (CVI) | | ■ | | | 1 |
| | W-14 | Change in Groundwater level/water table | | ■ | ■ | | 2 |
| | W-21 | Landslide hazard | | | | ■ | 1 |
| | W-22 | Vulnerability (Landslide risk reduction) | | | | ■ | 1 |
| | W-23 | Change in water pollution caused by wastewater (point sources) | ■ | | | | 1 |
| | W-24 | Reduced pollutants coming from land to water (non-point sources) | ■ | | | | 1 |
| | W-25 | Attenuation of heavy metals and nutrients contamination in surface water | ■ | | ■ | | 2 |
| | W-26 | Sediment deposition | ■ | | | ■ | 2 |
| | W-31 | Seawater intrusion | | | ■ | | 1 |
| | * | Possible source of debris/ hyper-concentrated flow | | | | ■ | 1 |
| | * | Floating transport in hydrographical network | | | | ■ | 1 |
| NATURE | N-1 | Changes in riparian habitat | | ■ | ■ | ■ | 3 |
| | N-2 | Changes in aquatic habitat/(Mesohabitats) | | ■ | ■ | | 2 |
| | N-4 | Changes in terrestrial habitat | | | | ■ | 1 |
| | N-6 | Distribution of public green space | ■ | | | | 1 |
| | N-7 | Connectivity/fragmentation of habitat structural | | | ■ | | 1 |
| | N-8 | Change in location of habitat boundaries | | ■ | | | 1 |
| | N-9 | Change in vegetation along watercourses | | ■ | ■ | ■ | 3 |
| | N-10 | Conservation status of habitats | | ■ | ■ | ■ | 3 |
| | N-14 | Change in land cover | | | ■ | ■ | 2 |
| | N-15 | Change in land use | | | | ■ | 1 |
| | N-16 | Restricted-range species | ■ | | | | 1 |
| | N-17 | Species richness and composition in respect to indigenous vegetation and local/national biodiversity targets | | ■ | | | 1 |
| | N-18 | Number and type of protected species | | ■ | ■ | ■ | 3 |
| | N-19 | Density of Species | | ■ | | | 1 |
| | N-20 | Diversity of species | ■ | | ■ | | 2 |
| | N-21 | Type, density of native species | ■ | | | | 1 |
| | N-23 | Number, area, location, of invasive non-native animal and planted species that are threatening to ecosystem, habitats or species | | | ■ | | 1 |
| PEOPLE | P-1 | Increasing recreational opportunities of NBS area | ■ | ■ | ■ | ■ | 4 |
| | P-2 | Number and value of people visit or spend free time in NBS area | ■ | ■ | | | 2 |
| | P-4 | Number of tourists | ■ | ■ | | ■ | 3 |
| | P-5 | Provision of NBS sites for education and research | | | ■ | ■ | 2 |
| | P-6 | Loss of cultural heritage due to hydro-metrological events/ due to land take | | | | ■ | 1 |
| | P-8 | Number of cultural events in NBS area | ■ | | | | 1 |
| | P-9 | Accessible NBS area per capita | | ■ | | | 1 |
| | P-10 | Average journey time for people by foot to NBS area or average distance from home/public transportation to NBS area | | ■ | | | 1 |
| | P-11 | The number of people communicate with neighbourhood in the NBS area | ■ | | | | 1 |
| | P-16 | Number of green jobs created | ■ | | | | 1 |
| | P-17 | Enhancing attractiveness of places for living and working, and to visit | | ■ | | | 1 |
| | P-19 | Increased competitive advantage for cities applying NBS | | ■ | | | 1 |
| | P-21 | Economic benefit from the reduction of stormwater that typicaly needs to be treated in a public sewerage system | ■ | | | | 1 |
| | P-20 | Reduced/avoided damage cost from hydro-meteorological risk reduction | ■ | | ■ | | 2 |
| | P-25 | Reduced need for management and maintenance | | | | ■ | 1 |
| | P-26 | Change in land and/or property values | ■ | ■ | | | 2 |
| | P-27 | Mental well-being | | ■ | | | 1 |
| | * | Footpath network recover through erosion reduction & improvement of path smoothness | | | | ■ | 1 |
| | | TOTAL | 23 | 23 | 20 | 18 | 84 |

** Additional Indicators for DA-3 Portofino*

*Table A-6 Selected Indicators – DEMONSTRATORS B*

| RECONECT | | INDICATORS | DB-1 | DB-2 | DB-3 | DB-4 | DB-5 | DB-6 | TOTAL by RECONECT Demonstrators |
|---|---|---|---|---|---|---|---|---|---|
| WATER | W-1 | Surface run-off reduction | ■ | ■ | ■ | | | | 3 |
| | W-2 | Slowing and storing runoff | ■ | ■ | | | | | 2 |
| | W-3 | Flood hazard | ■ | ■ | ■ | | ■ | ■ | 5 |
| | W-4 | Vulnerability (Flood risk reduction in urban areas and around rivers, lakes, watercourses, etc.) | | | ■ | | ■ | ■ | 3 |
| | W-5 | Delay time to peak | | ■ | ■ | | | | 2 |
| | W-6 | Flood peak reduction | | ■ | | ■ | | | 2 |
| | W-14 | Change in Groundwater level/water table | | | | ■ | | | 1 |
| | W-21 | Landslide hazard | | ■ | | | | | 1 |
| | W-29 | Attenuation of pollution in groundwater | | | | ■ | | | 1 |
| NATURE | N-1 | Changes in riparian habitat | ■ | | ■ | | | ■ | 3 |
| | N-2 | Changes in aquatic habitat/(Mesohabitats) | ■ | | | | | | 1 |
| | N-3 | Change in wetland habitat | ■ | | | | | ■ | 2 |
| | N-4 | Changes in terrestrial habitat | ■ | | | | | | 1 |
| | N-5 | Increase green area | | | | | | ■ | 1 |
| | N-6 | Distribution of public green space | | | | | | ■ | 1 |
| | N-8 | Change in location of habitat boundaries | ■ | | | | | | 1 |
| | N-9 | Change in vegetation along watercourses | ■ | | | | | | 1 |
| | N-10 | Conservation status of habitats | ■ | | | | | | 1 |
| | N-11 | Shoreline characteristics and erosion protection | ■ | | | ■ | | | 2 |
| | N-14 | Change in land cover | ■ | ■ | | | | | 2 |
| | N-15 | Change in land use | ■ | ■ | | | | | 2 |
| | N-16 | Restricted-range species | ■ | | | | ■ | | 2 |
| | N-18 | Number and type of protected species | ■ | | ■ | ■ | ■ | | 4 |
| | N-21 | Type, density of native species | | | | | ■ | | 1 |
| | N-23 | Number, area, location, of invasive non-native animal and planted species that are threatening to ecosystem, habitats or species | ■ | | | | | | 1 |
| PEOPLE | P-1 | Increasing recreational opportunities of NBS area | | | ■ | ■ | ■ | | 3 |
| | P-2 | Number and value of people visit or spend free time in NBS area | | | ■ | ■ | | | 2 |
| | P-5 | Provision of NBS sites for education and research | | | | ■ | | | 1 |
| | P-6 | Loss of cultural heritage due to hydro-metrological events/ due to land take | ■ | | | | | | 1 |
| | P-8 | Number of cultural events in NBS area | | | | | ■ | | 1 |
| | P-20 | Reduced/avoided damage cost from hydro-meteorological risk reduction | ■ | ■ | | | ■ | | 3 |
| | P-25 | Reduced need for management and maintenance | | | | | | ■ | 1 |
| | P-24 | Value of reduced CO2 emission and carbon sequestration | | | ■ | | | | 1 |
| | P-26 | Change in land and/or property values | ■ | | ■ | ■ | | ■ | 4 |
| | P-33 | Improved physical health | | | ■ | | | | 1 |
| | | TOTAL | 19 | 9 | 11 | 9 | 8 | 8 | 64 |

*Table A-7 Selected Indicators – SUMMARY*

| DEMONSTRATORS: | | | INDICATORS | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | | | WATER | | NATURE | | PEOPLE | | |
| | | | WQuantity | WQuality | Habitat Structure | Biodivercity | Socio-economics | Human well-being | |
| TYPE A | Elbe Estuary, Germany | DA-1 | 6 | 4 | 1 | 3 | 9 | 0 | **23** |
| | Seden Strand, Odense, Denmark | DA-2 | 6 | 0 | 5 | 3 | 8 | 1 | **23** |
| | Tordera River Basin, Catalonia | DA-3 | 6 | 2 | 6 | 3 | 3 | 0 | **20** |
| | Portofino Natural Park, Italy | DA-4 | 2 | 3 | 6 | 1 | 5 | 1 | **18** |
| TYPE B | IJssel River Basin, The Netherlands | DB-1 | 3 | 0 | 10 | 3 | 3 | 0 | **19** |
| | Inn River Basin, Austria | DB-2 | 6 | 0 | 2 | 0 | 1 | 0 | **9** |
| | Greater Aarhus, Denmark | DB-3 | 4 | 0 | 1 | 1 | 4 | 1 | **11** |
| | Thur River Basin, Switzerland | DB-4 | 2 | 1 | 1 | 1 | 4 | 0 | **9** |
| | Var River Basin, France | DB-5 | 2 | 0 | 0 | 3 | 3 | 0 | **8** |
| | Les Boucholeurs, France | DB-6 | 2 | 0 | 4 | 0 | 2 | 0 | **8** |
| **TOTAL** | | | **39** | **10** | **36** | **18** | **42** | **3** | **148** |