NBRACER
Nature Based Solutions
for Atlantic Regional Climate Resilience

HORIZON Europe Research and Innovation actions in support of the implementation of the Adaptation to Climate Change Mission (HORIZON-MISS-2022-CLIMA-01)

Co-design of transformative systemic solutions in Marine and Coastal landscape systems

Deliverable D2.1

Version n° 3

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About NBRACER

The impacts of climate change on people, planet and prosperity are intensifying. Many regions and communities are struggling to avoid losses and need to step up the effort to increase their climate resilience. Ongoing natural capital degradation leads to growing costs, increased vulnerability, and decreased stability of key systems. Whilst there has been noticeable progress and inspiring examples of adaptation solutions in Europe, the pressure to make rapid and visible progress has often led to a focus on stand-alone, easy-to-measure projects that tackle issues through either direct or existing policy levers, or sector-by-sector mainstreaming. But the dire trends of climate change challenge Europe, and its regions, needs exploration of new routes towards more ambitious and large-scale systemic adaptation. The European Mission on Adaptation to Climate Change (MACC) recognizes the need to adopt a systemic approach to enhance climate adaptation in EU regions, cities, and local authorities by 2030 by working across sectors and disciplines, experimenting, and involving local communities.

NBRACER contributes to the MACC by addressing this challenge with an innovative and practical approach to accelerating the transformation towards climate adaptation. Transformation journeys will be based on the smart, replicable, scalable, and transferable packaging of Nature-Based Solutions (NbS) rooted in the resources supplied by biogeographic landscapes while closing the NbS implementation gap. Regions are key players of this innovative action approach aiming at developing, testing, and implementing NbS at systemic level and building adaptation pathways supported by detailed and quantitative analysis of place-specific multi-risks, governance, socio-economic contexts, and (regional) specific needs.

NBRACER works with 'Demonstrating' and 'Replicating' regions across three different Landscapes (Marine & Coastal, Urban, Rural) in the European Atlantic biogeographical area to vision and co-design place based sustainable and innovative NbS that are tailor-made within the regional landscapes and aligned with their climate resilience plans and strategies. The solutions are upscaled into coherent regional packages that support the development of time and place specific adaptation pathways combining both technological and social innovations. The project is supporting, stimulating, and mainstreaming the deployment of Nature-Based Solutions beyond the NBRACER regions and across biogeographical areas.

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Summary

Deliverable D2.1, *Co-design of Transformative Systemic Coastal Solutions*, is a key milestone within the NBRACER project, which supports the EU Mission on Adaptation to Climate Change. The deliverable focuses on the co-design processes applied to Nature-based Solutions (NbS) in coastal landscapes across two of the NBRACER Demonstrating Regions: Cantabria and West-Flanders.

The main objective of this deliverable is to document the progress and learnings from the co-design of three Coastal NbS Demonstrators. These demonstrators address a range of climate challenges, such as sea level rise, flooding, drought, water quality degradation, and soil erosion, while targeting improvements in Key Community Systems (KCSs) like Water Management, Ecosystems, and Land use & Food Systems. This is supported by mapping of the coastal landscape and ecosystem services.

The co-design process is guided by five iterative steps: issue framing, knowledge gathering, co-design of options, stakeholder validation, and decision-making. The methodology combines participatory stakeholder engagement with technical assessments, including Ecosystem Service (ES) mapping and readiness level evaluations. The deliverable presents a comparative analysis of the demonstrators, highlighting the diversity of approaches, stakeholder constellations, and maturity levels. It also identifies enabling conditions and barriers to implementation, such as governance structures, data availability, and social acceptance.

Key findings show that while the phases of the three demonstrators vary, the diversity of local to regional contexts and solution types underscores the importance of flexible and context-sensitive co-design frameworks. The insights from this deliverable will inform the development of regional NbS portfolios and adaptation pathways for the coastal landscapes in NBRACER.

This document for Deliverable 4.1 is structured as follows:

- Chapter 1 sets the scene within the scope of the NBRACER project;
- Chapter 2 introduces the objectives related to the demonstrators in Task 2.1;
- Chapter 3 presents the Coastal Demonstrators and reports the co-design process in a visual summary;
- Chapter 4 provides the mapping of landscapes and Ecosystem Services within the selected coastal regions of NBRACER;
- Chapter 5 offers an analysis of the co-design process and comparison of status among demonstrators;
- Chapter 6 provides conclusions and recommendations for the way forward within the NBRACER Regional Resilience Journey.
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Keywords

Co-design; Participatory process; Governance; Barriers; Enablers; Coastal Landscapes

Abbreviations and acronyms

Acronym	Description
CRICs	Climate Risk Impact Chains
DR	Demonstrating Regions within the context of NBRACER: Central Denmark (DK), West-Flanders (BE), Nouvelle-Aquitaine (FR), Cantabria (ES), and Porto (PT).
D2.1	Deliverable of Task 2.1, corresponding to the present document: 'Co-design of transformative systemic solutions' (due to Month 24).
Dx.2	Deliverable of Task x.2: 'Lessons learnt from monitoring in local NbS demos', transversal to WPs 2, 3 and 4 (due to Month 36).
Dx.3	Deliverable of Task x.3: 'Regional portfolios of solutions and pathways', transversal to WPs 2, 3 and 4 (due to Month 40).
Dx.4	Deliverable of Task x.4: 'Lessons learnt from validating the portfolios', transversal to WPs 2, 3 and 4 (due to Month 44).
ES	Ecosystem Service
KCS	Key Community System
MEL	Monitoring, Evaluation, and Learning
NbS	Nature-based solutions
NGO	Non-Governmental Organization
NT	Non-Tillage
P2R	Pathways2Resilience
RR	Replicating Region
TRL	Technological Readiness Level
Tx.1	Task x.1 'Co-design of transformative systemic solutions', transversal to WPs 2, 3 and 4. Task to which the present deliverable refers to.
Tx.2	Task x.2 'Monitoring and prediction of KPIs', transversal to WPs 2, 3 and 4.
Tx.3	Task x.3 'Assessing the impact of solutions portfolios and pathways', transversal to WPs 2, 3 and 4.
Tx.4	Task x.4 'Transposing and validating solutions', transversal to WPs 2, 3 and 4.
VHA	Vlaamse Hydrografische Atlas
WP	Work Package
WP1	Work Package 1 'Integrated stocktaking, visioning and prioritizing' led by Climate-KIC and mainly focused on the support to the transformational pathways towards climate resilience of the regions.
WP2	Work Package 2 'Demonstrations in Marine and Coastal Systems' led by Deltares.
WP3	Work Package 3 'Demonstrations in Urban Systems' led by Wageningen Research.

WP4	Work Package 4 'Demonstrations in Rural Systems' led by VITO.
WP5	Work Package 5 'Technical framework supporting the design and implementation of NbS' led by UCantabria.
WP6	Work Package 6 'Process framework enabling & transformative conditions for NbS implementation' led by Wageningen University.

1 Setting the Scene: the NBRACER Approach

The NBRACER Operational Climate Resilience Approach provides a flexible, co-designed framework to support regional climate adaptation using Nature-based Solutions. It responds to the growing need for transformative, system-oriented strategies that move beyond fragmented, project-level interventions. The approach views regions as complex Systems of Systems (SoS), integrating biophysical, socio-cultural, and governance domains to guide resilience-building in a way that is context-sensitive and community-driven. NbS serve as the core intervention, designed not in isolation but as part of multi-dimensional portfolios that align with local values, risks, and institutional landscapes.

The NBRACER operational framework equips decision-makers with adaptable tools and processes tailored to diverse regional contexts and scales. By employing an iterative, participatory approach and advanced spatial analysis, the framework helps regions build and sustain resilience that is adaptable to evolving risks. Emphasizing NbS and incorporating socio-ecological systems and ecosystem services dynamics, the framework supports comprehensive resilience planning, providing regions with a cohesive pathway to operationalize resilience strategies and prepare for climate uncertainties. This approach is applied across diverse regional landscapes - including Marine & Coastal, Urban, and Rural areas - within the Atlantic Biogeographical Region. NBRACER works directly with Demonstrating regions, serving as living laboratories for innovation, and Replicating regions, which test and adapt solutions for transferability. Regional pathways are rooted in participatory processes, while technical assessments, such as Climate Risk Impact Chains (CRICs), ecosystem service mapping, and multi-hazard risk profiling, help shape tailored NbS packages that respond to specific risks and local assets.

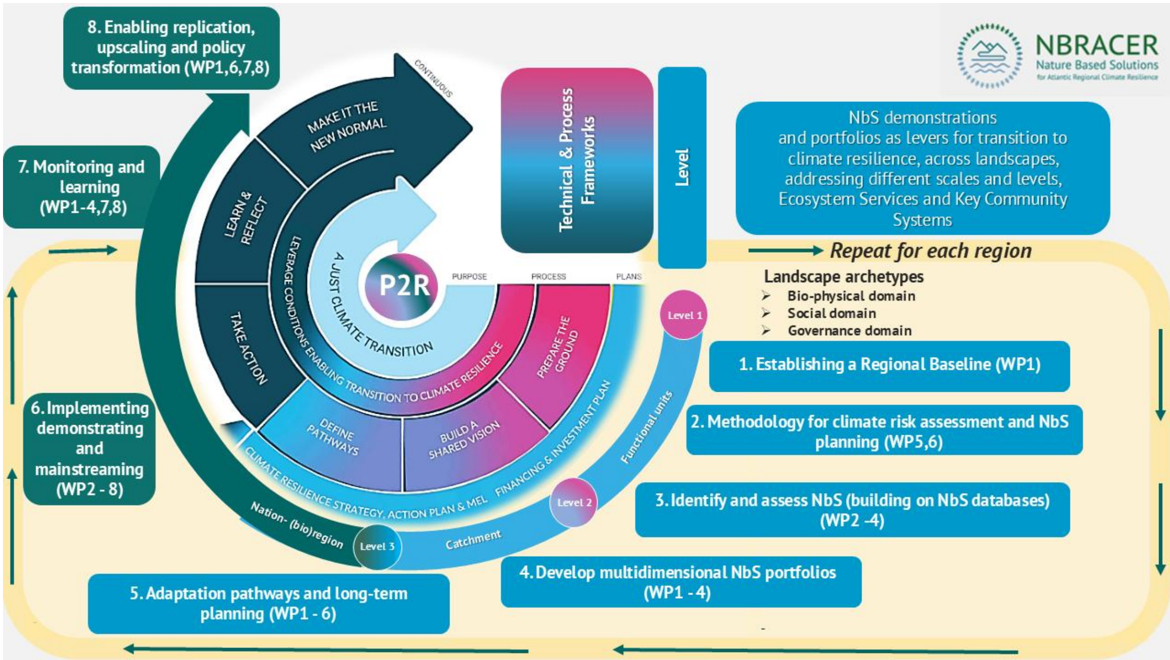

Figure 1: Overview of the NBRACER Approach with 8 steps, elaborating an iterative process for achieving a just climate transition through multi-level, multi-scale and multi-domain planning.

Structured around an eight-step operational process aligned with the Horizon Europe project Pathways2Resilience (P2R) framework, shown in Figure 1, NBRACER guides regions from system

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analysis and risk assessment to solution development, pathway design and implementation. A strong focus is placed on learning, monitoring, and iterative feedback, ensuring continuous adaptation and long-term transformation. The approach supports regions not only in deploying NbS but also in mainstreaming and scaling solutions beyond the project scope, contributing to policy transformation and enhanced resilience across Europe.

The following Figure 2 gives an overview of the WP2-3-4 tasks in relation to the P2R-framework.

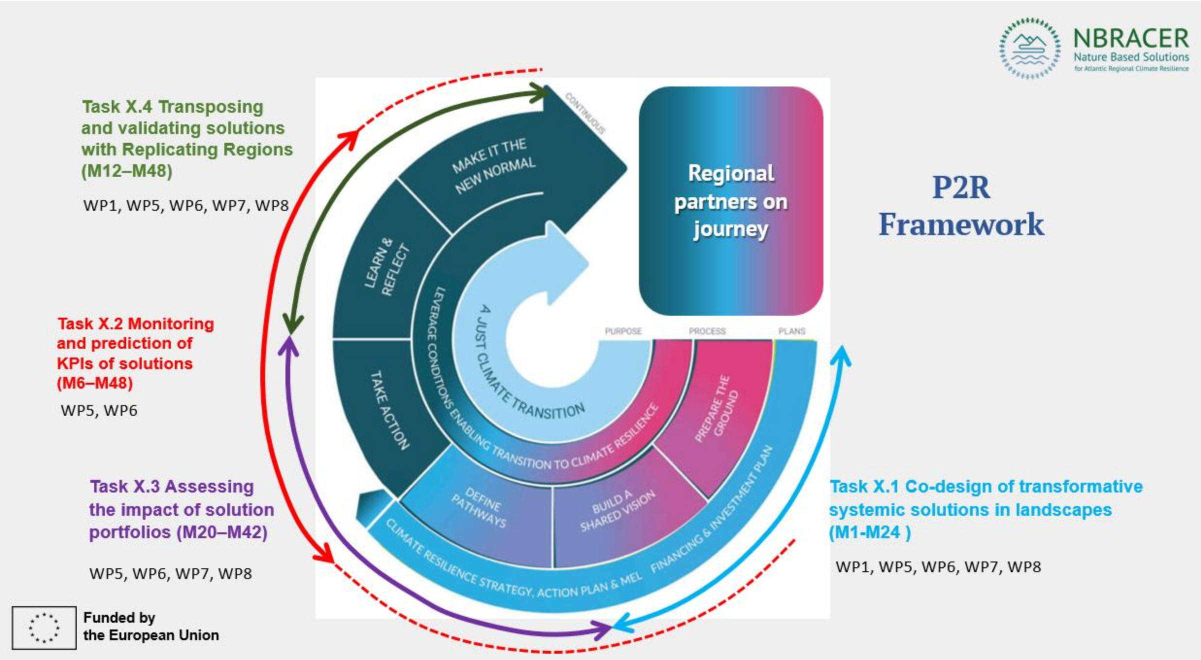

Figure 2: Overview of the WP2-3-4 tasks in relation to the P2R-framework.

Within WP2, Coastal Landscapes, the regional Demonstrators are central. In task 2.1, the focus is on the **co-design of transformative systemic solutions and further development of the NbS demos in the Coastal Landscape.** As part of the co-design, the WP lead, together with the Regional Coordinators and the project leads of the Demonstrators, will describe the Demonstrator within a Canvas, which includes the various aspects of the Baseline (D1.1) in which the systemic approach has been applied, describing the current system, the risks, the partner networks and the environmental and the socio-economic context. Together, the current state of the Demonstrators is determined, drivers and barriers are identified, and the next steps of development are defined. Moreover, mapping of the coastal landscape is performed to support the co-design process, e.g. in the selection of hotspots. The Demonstrators are aligned in the regional vision and are to be seen as exploring the first steps of further development of the portfolios and pathways as part of the Regional Resilience Journey. In the next phase (T2.3), portfolios and pathways will be built, and upscaling and mainstreaming will be explored.

2 Introduction and objectives

Characterisation of Coastal Landscapes in the Atlantic Biogeographical region

Coastal landscapes in the Atlantic Region can be characterised by a high degree of ecological diversity, dynamic geomorphological processes, and a strong interaction between natural and anthropogenic systems. This European Atlantic region features a range of coastal typologies, including sandy beaches, dune systems, estuaries, tidal flats, salt marshes, and rocky shorelines. These landscapes are shaped by high tidal ranges, strong wave action, and temperate oceanic climatic conditions, which together drive significant sediment mobility and habitat variability. The region supports critical biodiversity, including migratory bird populations and priority coastal habitats under the EU Habitats Directive. At the same time, the Atlantic coast is densely populated and intensively used for agriculture, urban development, ports, fisheries, and tourism, leading to considerable pressures on its natural systems. Consequently, the Atlantic coastal landscapes represent both high ecological value and vulnerability, making them strategic targets for the implementation of NbS.

Climate change related challenges

Coastal zones across Europe are increasingly exposed to the multifaceted impacts of climate change, posing significant challenges for environmental sustainability, economic stability, and societal well-being. Rising sea levels, intensifying storm surges, and shifting wave climates contribute to increased risks of coastal erosion, flooding, and salinisation of freshwater resources. These processes threaten critical infrastructure, degrade valuable ecosystems, and undermine the habitability of low-lying areas. Moreover, climate change exacerbates the uncertainty in long-term dynamics in the coastal zone, complicating traditional engineering approaches and necessitating adaptive, ecosystem-based strategies. In this context, the NBRACER project addresses the urgent need to develop and mainstream NbS that enhance the resilience of coastal systems. By integrating scientific knowledge with local stakeholder engagement, NBRACER aims to provide scalable, flexible responses that align climate adaptation goals with biodiversity conservation and sustainable development objectives.

Key Community Systems

In coastal zones, many interconnected KCS are particularly vulnerable to the impacts of climate change. This involves critical infrastructure, such as transportation, water supply, energy infrastructure, health services, agri- and aquaculture, ecosystems and livelihoods. Sea-level rise and extreme weather events can lead to the inundation of residential areas, disruption of transport networks, and damage to energy and communication systems. Coastal agriculture and fisheries, which support local economies and food security, are also at risk due to saline intrusion, shifting marine ecosystems, and the loss of productive land. Public health systems may be strained by climate-induced hazards, such as heatwaves and waterborne diseases, disproportionately affecting vulnerable populations. Moreover, the degradation of natural protective features such as dunes, wetlands, and barrier islands weakens the ability of communities to absorb shocks (e.g. by extreme climatic events). The interconnection of these systems means that disruptions in one domain often propagate through others, amplifying social and economic vulnerabilities.

Nature-based solutions in marine and coastal landscape

NbS offer a strategic and sustainable approach to addressing the complex challenges faced by coastal zones under climate change. Implementation involves the restoration, enhancement, and integration of natural systems, such as dunes, wetlands, salt marshes, mangroves, and seagrass beds. This serves the aim to provide protective functions for KCS against coastal hazards, while delivering co-benefits for biodiversity and local communities. For instance, restored dune systems can dissipate wave energy and reduce erosion, while tidal wetlands can buffer storm surges and sequester carbon. The successful deployment of NbS on local and regional scales requires a multidisciplinary framework that includes site-specific ecological assessments, participatory **co-design** with local stakeholders, and alignment with spatial planning and regulatory frameworks.

Coastal demonstrators

T2.1 improves the proposed solutions by co-design based on the multiple vulnerabilities and risks for KCSs (WP1), identifying the enabling conditions (supported by WP6) and facilitated by the mapping of Landscapes and ES (supported by WP5). Local partners of each DR are closely engaged in a participatory approach, supported by the MEL core connecting facility (T1.4 and supported by T6.4), to explore societal needs, benefits and trade-offs of the proposed solutions. The focus will be on increasing the TRL of NbS through testing and demonstrating, status assessment, and requirements for enabling conditions.

Objectives

Task 2.1 is focused on the **co-design of transformative systemic solutions and further development of the NbS demos in the Coastal Landscape.** This builds further on several other activities carried out within the project, such as the regional baseline reports (WP1 and WP6), the strategic regional workshops (WP1), the collection of NbS applications in NBRACER regions (WP5), and the mapping and modelling exercises that translate conceptual deliverables into regional application (WP5).

This task aims primarily to support **the regions with co-design on their coastal demonstrator cases**. To do so, WP2 provide an aligned approach to actively and closely cooperate with the regional demonstrators in the NBRACER DRs by means of setting up a **knowledge base** including inspirations and examples for the regions, as well as providing **support services** on demand, to tackle the identified needs of each region.

The main aim of this report is to report on the progress of co-creation of the demonstrators, and to report on the experiences and findings, enablers, and barriers, while also registering the process of implementation. This is supported by mapping of the coastal landscape and ecosystem services. This deliverable is centred around two main activities:

1. The **project demonstrators' MIRO board**, which includes a visual summary of all the information gathered so far regarding the demonstrators in each DR; and
2. The **mapping (and modelling) of the coastal landscape and ecosystem services**, which provides a translation of the technical framework provided by WP5 to the regional landscape context of each region.

3 Coastal demonstrators

Within its 5 DRs, NBRACER aims to demonstrate 19 NbS in total, distributed among the 3 landscapes. For the marine and coastal landscape, we focus on the following demonstrators:

1. **Restoration of tidal regime in estuary** – Oyambre, Cantabria
2. **Water level management** – Oudlandpolder, West-Flanders
3. **Sustainable farming practices** – West-Flanders

This chapter presents an overview of the coastal demonstrators, according to the structured canvas from the project demonstrators' MIRO board.

3.1 Restoration of the natural tidal regime in Oyambre estuary, Cantabria

The coastal NbS implemented in Cantabria is based on the restoration of a claimed area in the estuary of Oyambre, Ría de Capitán (see Figure 3). This area was dyked and transformed into a eucalyptus plantation in 1945. In 1995, the dyke broke, allowing the partial entrance of seawater during high tide, which led to the death of the plantation and the development of high marsh communities. Yet, the natural tidal flow remained highly restricted. The tidal restriction led to changes in the hydrodynamics, which in turn have caused erosion problems on the beach at the mouth of the estuary and flooding problems in the inner estuary. In addition, the reduction in the water salinity enhanced the spread of the invasive shrub species *Baccharis halimifolia* and the loss of low intertidal habitats, including native saltmarsh species (e.g. *S.maritima)*, seagrass meadows (e.g. *Z.noltii*) or tidal flats. This shift in vegetated communities potentially affected key ecosystem services that native and healthy estuarine habitats provide (e.g. carbon storage, benthic biodiversity support, self-adaptation to sea level rise).

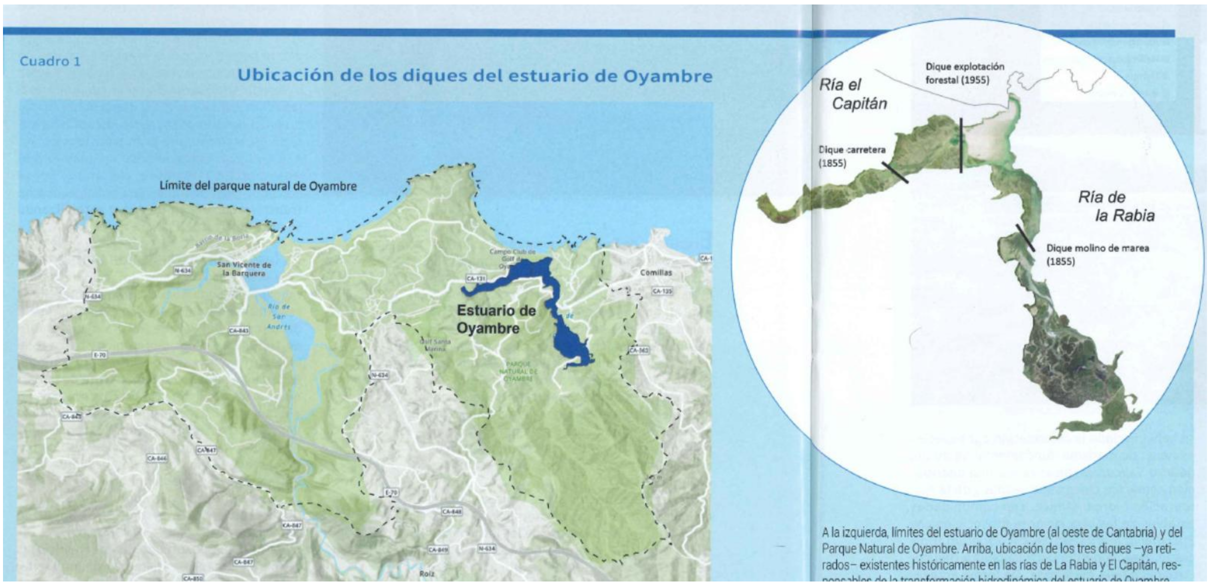

Figure 3: Location of the estuary of Oyambre, Ría de Capitán, in Cantabria.

In 2019, with support of the European project LIFE CONVIVE, the dyke was lowered to allow the full entrance of the tide, as a way to inhibit the spread of the invasive species *B.halimifolia* and restore the natural saltmarsh habitats. In addition, the removal of the dyke is expected to reduce the erosion problems in the dune system and the flooding risks in the inner sections of the estuary.

More information can be found here: [Project demonstrators' MIRO board]

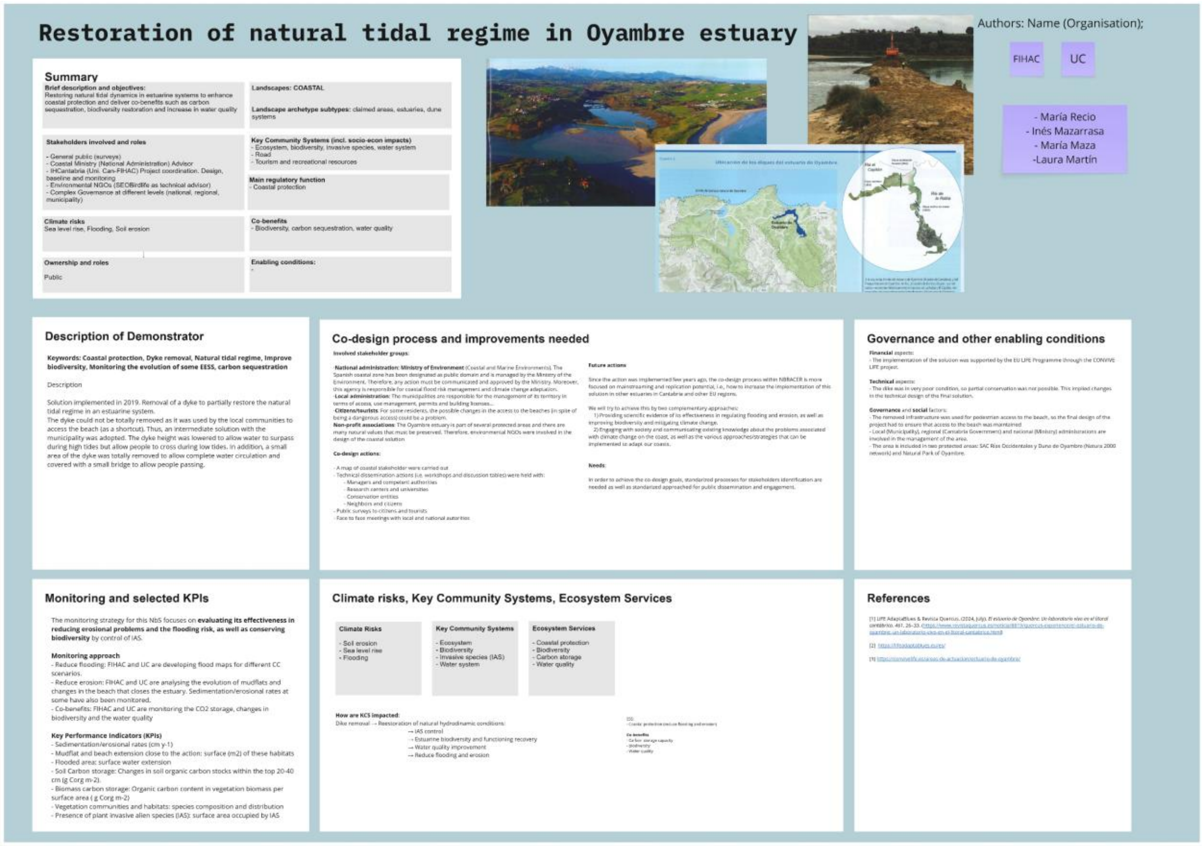

Figure 4: MIRO board for coastal demonstrator: Restoration of natural tidal regime in Oyambre estuary.

The dyke that was restricting the natural tidal flow was traditionally used by the local community and visitors to directly access the dune system at the estuary mouth. Thus, any action that compromises the use of this dyke by the local community (e.g. the complete removal of the dyke) requires a negotiation process with the local community. Thus, a co-design process with local, regional and national stakeholders was implemented before the implementation of the coastal solution in Cantabria.

The first action was the identification of these stakeholders. To achieve it, a map of stakeholders was elaborated (Table 1). Although several stakeholders were identified, the process focused on six different groups:

- **National administration: Ministry of Environment** (Coastal and Marine Environments). The Spanish coastal zone has been designated as public domain and is managed by the Ministry of the Environment. Therefore, any action must be communicated and approved by the Ministry. Moreover, this agency is responsible for coastal flood risk management and climate change adaptation.

- **Regional administration**: The regional government are responsible for the management of the Natural protected areas in Cantabria, and the Oyambre estuary is placed in a Natural Parque and inside a Natura 2000 SAC.
- **Local administration**: The municipalities are responsible for the management of their territory in terms of access, use management, permits and building licenses, etc.
- **Citizens/tourists**: For some residents, the possible changes in access to the beaches (despite being a dangerous access) could be a problem.
- **Non-profit associations**: As it has been said before, the Oyambre estuary is part of several protected areas, and many natural values must be preserved. Therefore, environmental NGOs were involved in the design of the coastal solution.
- **Companies**: Due to the estuary's tourist popularity and the need for construction work in the area, private companies with an interest in the working area were also involved in the co-design process.

Table 1: The main stakeholders identified in the coastal area of Cantabria.

Type	Entity/Organisation
National administration	Ministerio de Medio Ambiente – Dirección General de Costas
	Delegación del Gobierno
Regional administration	Dirección General de la Costa y el Mar
	Delegación del Gobierno. Área de Fomento
	Demarcación de Costas en Cantabria
	Autoridad Portuaria Santander
	Dirección General de Montes y Biodiversidad
	Dirección General de Pesca y Alimentación
	Dirección General de Aguas y Puertos
	Dirección General de Urbanismo y Ordenación del Territorio
	Dirección General del Medio Ambiente y Cambio Climático
Local administration	Capitanía Marítima de Santander
	Ayuntamiento de Santander
	Ayuntamiento de Ribamontán al Mar
	Ayuntamiento de Camargo
	Ayuntamiento de Marina de Cudeyo
	Ayuntamiento de Astillero
	Ayuntamiento de Valdáliga

Citizens / Tourist / Sports associations	Federación Cántabra de Surf
	Federación de Municipios de Cantabria
	Fundación Naturaleza y Hombre
	Federación Cántabra de Actvidades Subacuáticas
	Sociedad Deportiva de Remo de Pedreña
Non-profit associations	Navigatio
	Red Cántabra de Desarrollo Rural
	Centinelas
	Ecologistas en Acción
	Seo-BirdLife
	Asociación Ría
	Costa quebrada
Companies	COPSESA
	SENOR
	RAISAN
	ASCAN
	SIECSA
	Ecohydros
	Aves Cantábricas S.L.
	MARE
	Bahía de Santander
	Los Reginas
Academic - Research	IHCantabria
	Colegio Oficial de Biólogos (Delegación en Cantabria)
	Colegio Oficial de Geógrafos de Cantabria
	Colegio Oficial de Ingenieros de Caminos, Canales y Puertos de Cantabria

Once the stakeholders were identified, different actions were implemented:

- A technical session was held with managers and competent authorities to open a debate about their views on the administrative steps required to carry out environmental restoration activities in estuarine areas. This technical session concluded with a roundtable discussion involving seven participants from national, regional, and local authorities, as well as universities. The discussion focused on the roles of the agents and managers involved in environmental restoration activities in estuarine systems.

Figure 5: Participants in the technical session with managers (source: CONVIVE LIFE project; www.convivelife.es).

- A technical session was held in a local town hall in Valdáliga (the municipality in which the solution was implemented) to disseminate the proposal for the restoration of the hydrodynamic solution (dike removal) in Oyambre, with the participation of conservation entities, neighbours and citizens.
- In order to maximise dissemination and collect impressions from users of the Oyambre estuary, the final action was the development of surveys on the street.
- In addition, several face-to-face meetings were held with the Municipality of Valgáliga and the Ministry of Environment during the drafting of the action proposal.

Figure 6: Participants in the technical session with citizens that was held in the municipality of Valdáliga (source: CONVIVE LIFE project, www.convivelife.es).

Conclusions and recommendations

<u>Co-design process within the envisaged upscaling in the Cantabria region</u>

Since the action was implemented a few years ago, the co-design process within NBRACER is more focused on mainstreaming and replication potential, i.e., how to increase the implementation of this solution in other estuaries in Cantabria and other EU regions.

We will try to achieve this by two complementary approaches:

- Providing scientific evidence of its effectiveness in regulating flooding and erosion, as well as improving biodiversity and mitigating (carbon storing) climate change (T5.3, T5.4, WP7-8).
- Engaging with society and communicating existing knowledge about the problems associated with climate change on the coast, as well as the various approaches/strategies that can be implemented to adapt our coasts (T6.4).

To achieve these goals, different actions will be implemented. A PhD thesis is being developed to quantify the ecosystem services associated with the restoration of hydrodynamic conditions in estuaries in a standardised and replicable way. This research aims to define standards for the design of this type of NbS and for evaluating their performance as coastal protection measures.

It is also planned to develop a standardised protocol for the identification of coastal stakeholders and the design of engagement activities. This will be based on the communication process being carried out in Cantabria as part of the NBRACER project, and on the lessons learned during this process (i.e. the need to bring administrations together, rather than segmenting them by landscape).

All future engagement activities within the NBRACER project will be planned with the three project landscapes (coastal, rural and urban) in mind, to maximise stakeholders' attendance.

3.2 Water level management in Oudlandpolder (West-Flanders)

In order to establish agreed water levels, a water level agreement (“peilbesluit”) for the Oudlandpolder is being developed for 2024–2027. This agreement sets surface water levels for different compartments of the region, taking into account dominant land uses and optimal conditions in both dry and wet periods. NBRACER supports the process of moving from vision to landscape-scale agreement and design proposals. The Oudlandpolder (Figure 7) serves as a pilot region and is among the first in Flanders to apply this approach. Its polder landscape provides a suitable test case, as water levels are easier to control in flat, highly regulated systems. While outscaling poses challenges due to these specific characteristics, the overall process can act as a pioneering example with high potential for replication in other landscapes and regions.

The overarching objective is to restore more natural water levels by enabling flexible water management—both temporally and spatially. Within each compartment, water levels are adjusted according to dominant land use, prioritising either food production or ecological values. In the Uitkerkse Polder, for example, the focus is on maintaining protected natural landscape values.

To align water levels with land-use needs, land is sometimes reallocated or reorganised, clustering agricultural areas while separating them from ecologically valuable landscapes. This strategy helps address conflicting interests among land users and prevents inefficiencies. The process involves a large-scale co-design structured in multiple steps, with lessons learned providing guidance for managing similar water and climate resilience challenges in polder systems and other flat coastal landscapes. This case focuses specifically on Compartment 4 of the Oudlandpolder, the Uitkerkse Polder, where nature is the dominant land use.

LIP Oudlandpolder

VLM supports the further development of a land-inrichtingsplan, based on the raamakkoord Oudlandpolder and the peilbesluit for Compartment 4, Uitkerkse Polder. Critical points to address in the Oudlandpolder pilot are: (1) drainage of rainwater, which can result in local flooding; (2) salinisation of rivers and groundwater during dry periods; and (3) water levels for food production, which are traditionally kept low to protect crops but conflict with the need to conserve water and also threaten the area's natural values. For this pilot, we will mainly focus on the third point and examine how compartment-level agreements can support better water use and improve the climate resilience of the polder landscape.

In the co-design process, we focus on high-level (often governmental) stakeholders and how the process can be strengthened through effective collaboration and agreement among them. We investigate the experiences of these key stakeholders with this approach and seek to identify critical success factors and lessons learned.

As a first step, the instrument of 'recht van voorkoop' was implemented to obtain the land for the implementation of the measures. This is shown in Figure 7.

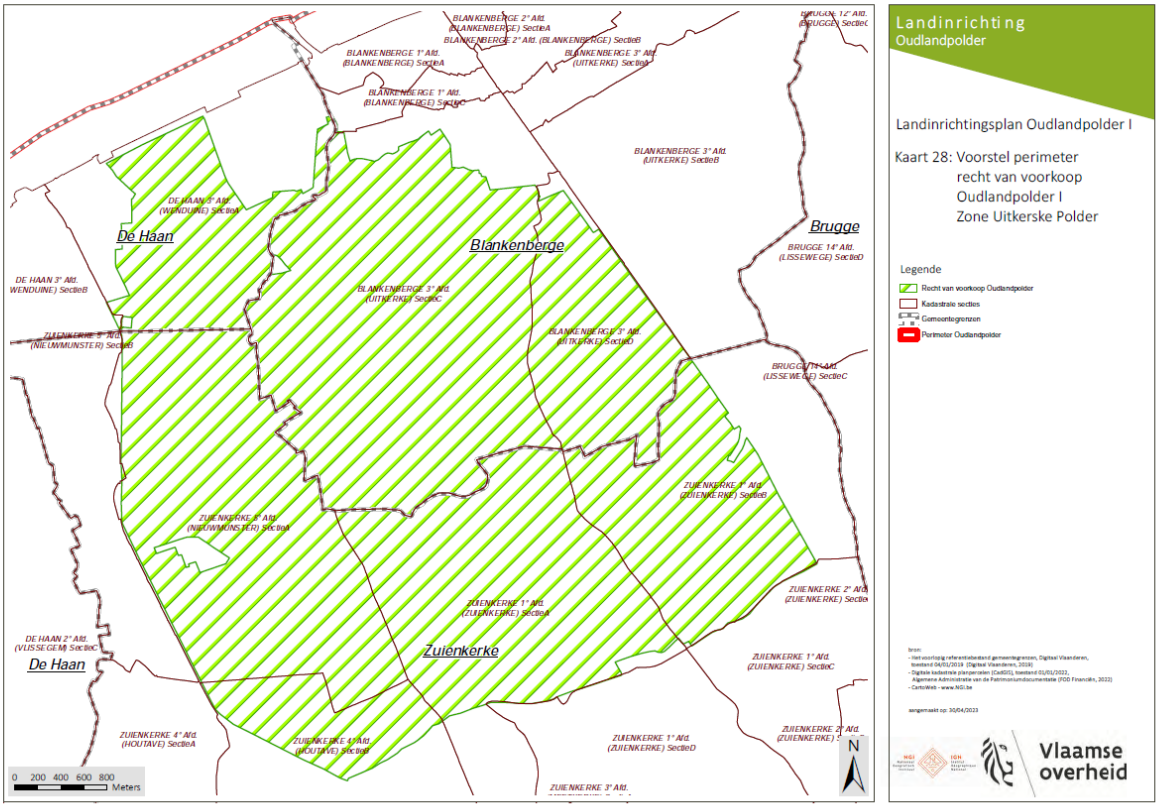

Figure 7: Recht van voorkoop Oudlandpolder.

As a second step, a detailed plan for Compartment 4 of the Uitkerkse Polder, covering the land that still needed to be obtained, was developed. The plan identifies legal requirements for land swaps and easements. This is an important aspect of the project, as land acquisition costs often represent the largest share of the total project budget in land development. The land acquisition plan for Uitkerkse Polder, Compartment 4, is shown in Figure 8.

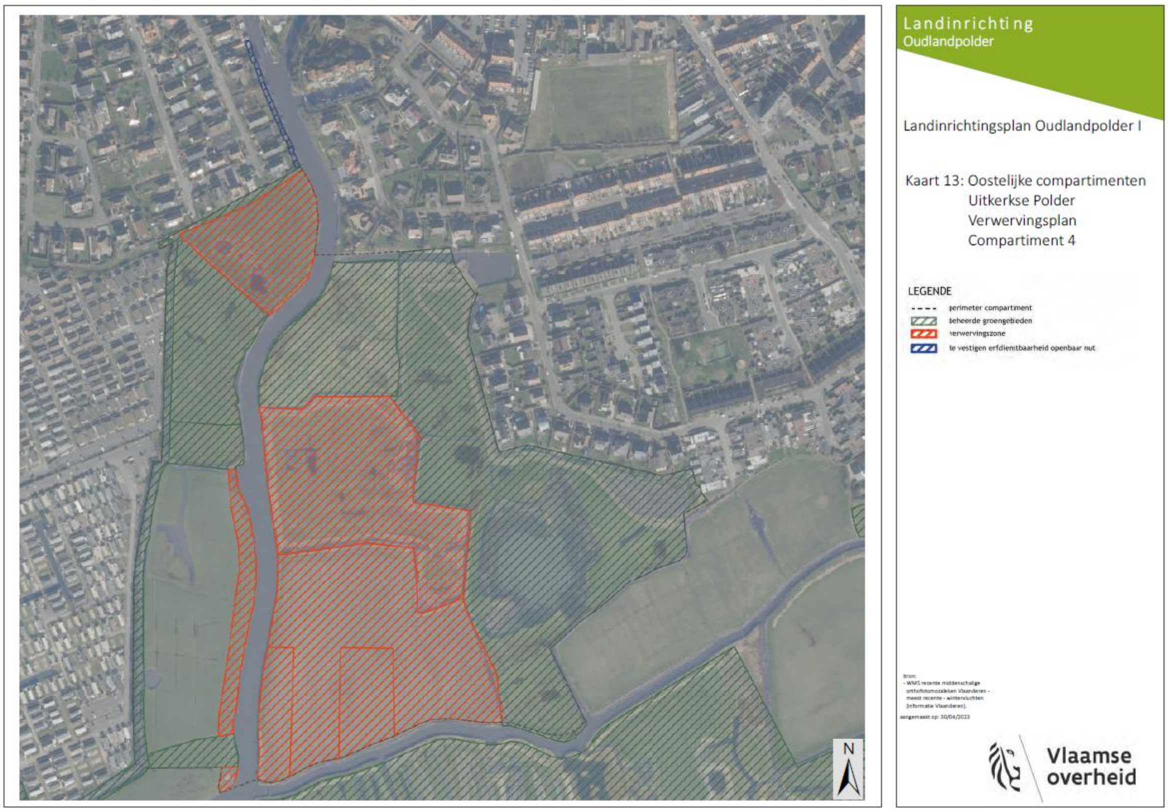

Figure 8: Legal needs for land swapping.

In order to reach the goals of the project and meet the agreements in the raamakkoord made for the region, a plan with landscape design was constructed. This plan shows the planned land use and types of vegetation and water regimes for the compartment. The implementation plan for the Uitkerkse Polder compartment 4 is shown in Figure 9. It shows the location of saline grasslands and polder grasslands, as well as locations for water and potentials for temporary water storage in the landscape for climate resilience.

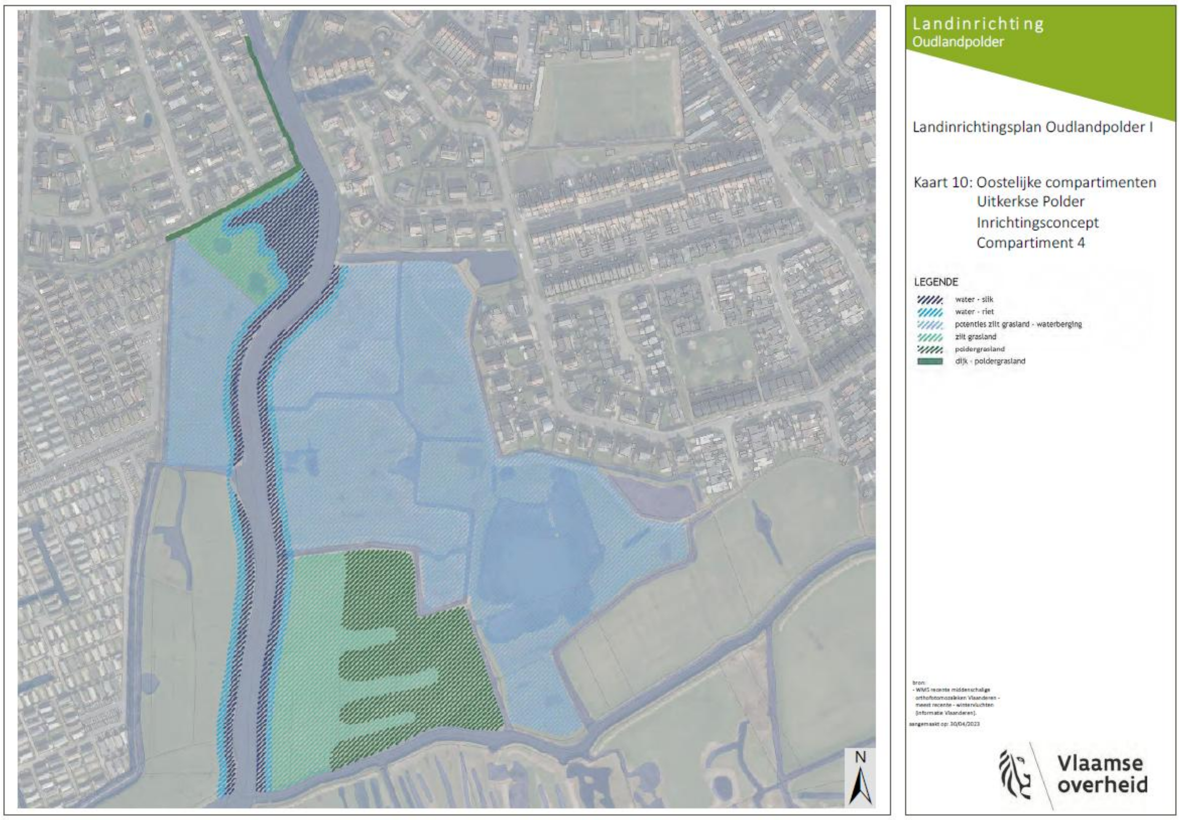

Figure 9: Plan for landscape design Uitkerkse Polder compartment 4.

<u>**Co-design actions in NBRACER**</u>

NBRACER leverages the strengths of various existing projects in the region by providing additional support through co-design and by identifying barriers and enablers. The co-design process consists of five key steps: framing issues and gathering knowledge, co-designing potential solutions, and partially validating these solutions with stakeholders, ultimately leading to informed decision-making.

Here, we focused on the enabling factors of **knowledge and data**, **governance and engagement**.

<u>Detailed process</u>:

Enabling factor: governance and engagement

1. Participate in collaborative meetings with local actors in the Uitkerkse Polder; observe, document findings, and provide advice to the project on potential improvements.
2. Conduct one-on-one interviews with key stakeholders about the process and their experiences (suggested interviewees: project manager, hydrologist, agricultural expert, polder manager, Province of WFL, ANB [nature management], ABS [agricultural representative]).
3. Examine the '*watertoets'* and its links to climate resilience.
4. Prepare a report summarising findings and compiling all interviews. *(Optional bonus: create a podcast, supported by WP8, featuring these interviews on the topic of "peilbesluiten")*.

Enabling factor: data and knowledge

1. Collect existing literature and research, and monitor new studies on the topic (with research partners: UGent, Merlin, Inagro, KU Leuven, VITO, WLS, …).
2. Attend events where knowledge and data on this NbS are shared (e.g. CIW, internal network of hydrologists, …).
3. Develop an overview of reliable sources of data and knowledge on the NbS.
4. Translate this data and knowledge to the regional context of Machuit as a replicator area: can this be outscaled to Machuit? If yes, how? If not, why?

Some questions we hope to answer:

- What are the key enablers and barriers in this process?
- Did the region succeed in involving new stakeholders and communicating with the wider public?
- Which barriers emerged during the co-design process, and which issues remain unresolved?
- What questions do key stakeholders still have about the process, and how do they evaluate their experiences in retrospect?
- How do key stakeholders view the future, and what are their hopes and concerns?
- Are there risks of maladaptation for the region resulting from this process, and how are these risks being monitored?

More information can be found here: Project demonstrators' MIRO board

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Figure 10: MIRO canvas for coastal demonstrator: Water level management in Oudlandpolder: Uitkerkse Polder.

3.3 Sustainable farming practices – non-tillage agriculture in coastal polders – West-Flanders

This demonstrator is shared with the ‘Rural landscape’ (WP4) and further detailed in D4.1 (see ‘Sustainable farming practices’ general sections and sections referring to non-tillage (NT)).

There is already considerable experience with non-tillage on sandy and loamy soils, but much less on heavy clay soils in the coastal polders. To mainstream this technique and promote its wider implementation across different soil contexts, more scientific evidence is needed on the effects of non-tillage compared to the traditional practice of ploughing before winter in the polders. This demonstration is being conducted on several fields across different locations in the polders of West Flanders. Monitoring is still ongoing, so it is too early to draw firm conclusions.

More information can be found here: [Project demonstrators’ MIRO board,]() and see also D4.1.

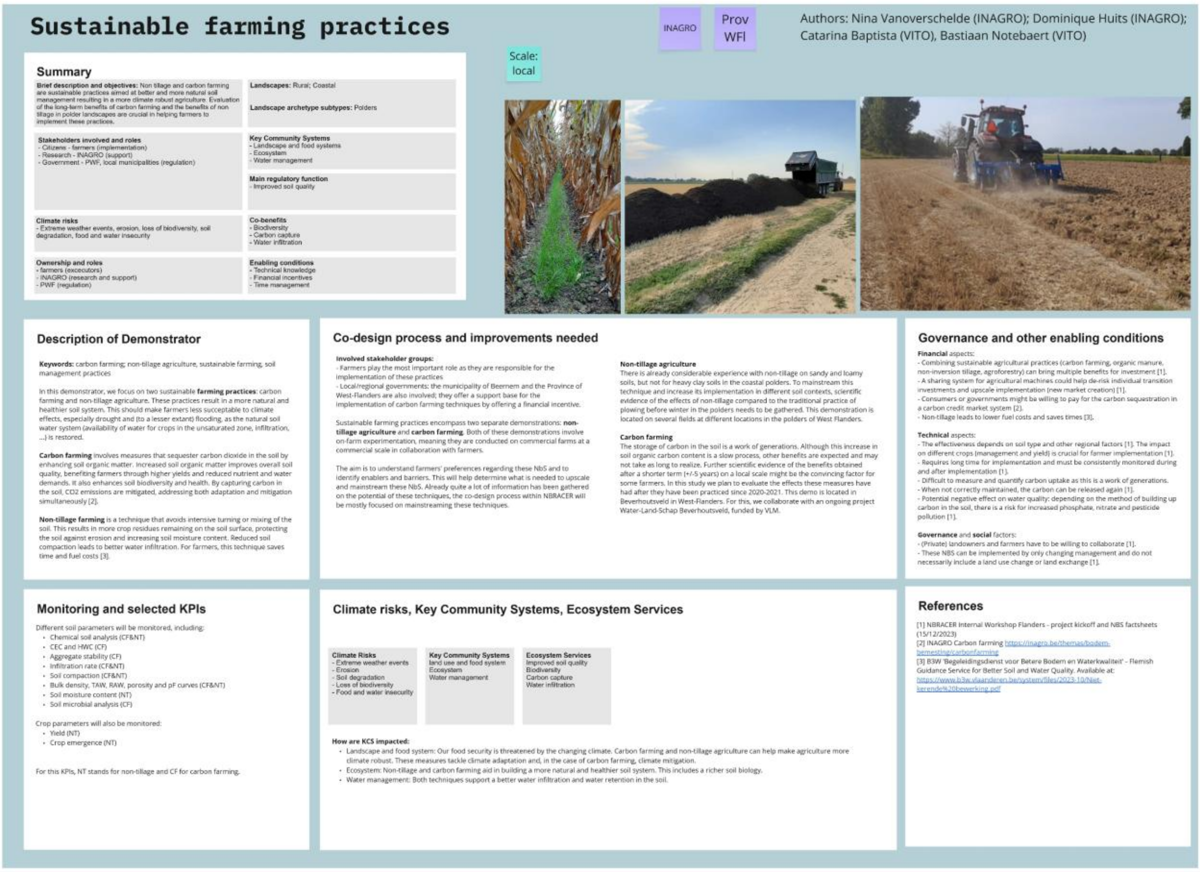

Figure 11: MIRO canvas for coastal demonstrator: Sustainable farming practices.

4 Mapping of landscapes and Ecosystem Services

This deliverable also addresses the mapping of Marine and Coastal landscapes, which will be supportive for the co-design process and further development of demos towards portfolio development at the regional level and across landscapes. At this stage, it was decided to focus on giving an overview of already available maps and data sources, as capacity in the regions was limited. Moreover, the operationalisation of the technical and process framework in the regions still has to be further discussed and developed, which will be implemented in the following T2.3 on building an integrated balanced portfolio and adaptation pathways, supported by WP5 and WP6.

The maps and sources incorporated below address (a selection of) the following:

- Location of the current demo(s)
- Hazards and risks (e.g. flood risk maps)
- Land use (incl. coastal land use types and/or coastal archetypes)
- Key community systems
- Critical infrastructure (roads, waterways, etc.)
- Ecosystems and Ecosystem Services

4.1 Oyambre estuary, Cantabria

The demo site is the Oyambre estuary, which is a small estuarine system (100 ha), located in northern Spain (Figure 12). It is formed by two branches: the eastern one, known as the Ría de la Rabia, which runs north-south, and the western one, known as the Ría del Capitán, which runs east-west. The two branches join at the estuarine mouth to form an arrow-shaped dune system, which is an important tourist attraction in the area and a highly valued leisure resource for the local people. This estuary has been subject to an intense anthropogenic transformation over the last two centuries, which included the building of several dykes and the transformation of intertidal areas to other uses (e.g. tree plantation). Figure 13 shows the functional units defined in WP5 in the area. This figure shows the altered area in one of the branches of the estuary, where the intervention was done to recover that estuarine area.

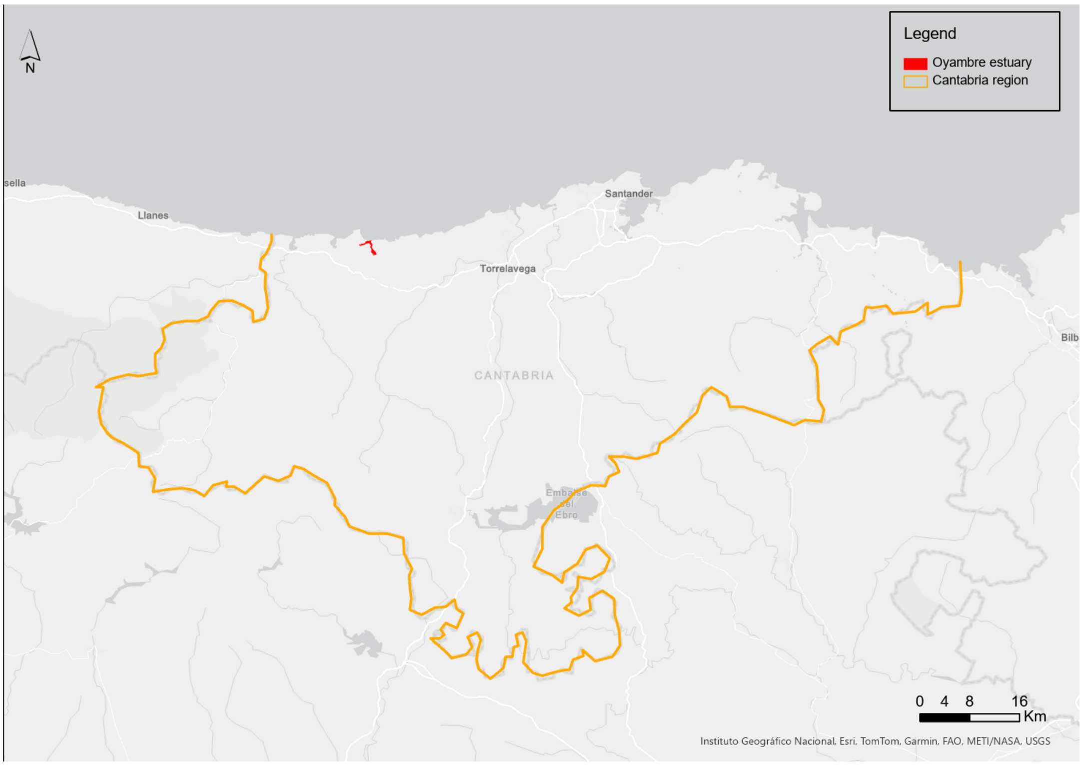

Figure 12: Location of NbS demo Oyambre within the region of Cantabria (source: IHCantabria, 2025).

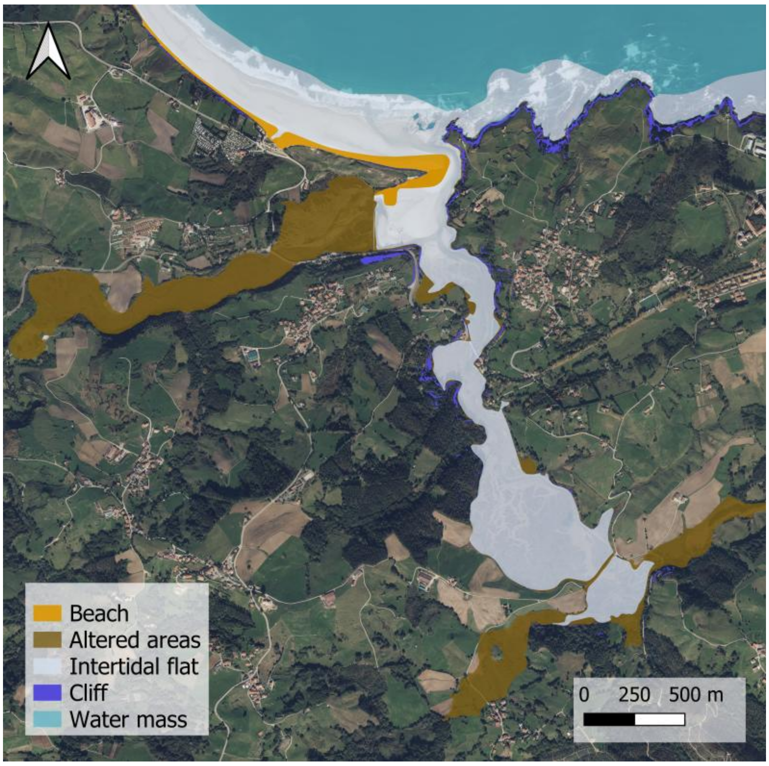

Figure 13: Functional units at the location of NbS demo Oyambre within the region of Cantabria (source: IHCantabria, 2025).

The land around the estuarine area is mainly used for pasture and various types of crop fields, although there are also significant areas of scrubland and broad-leaved forests. As it showed in the Figure 14, this is a human-altered area, primarily used for agriculture and livestock farming.

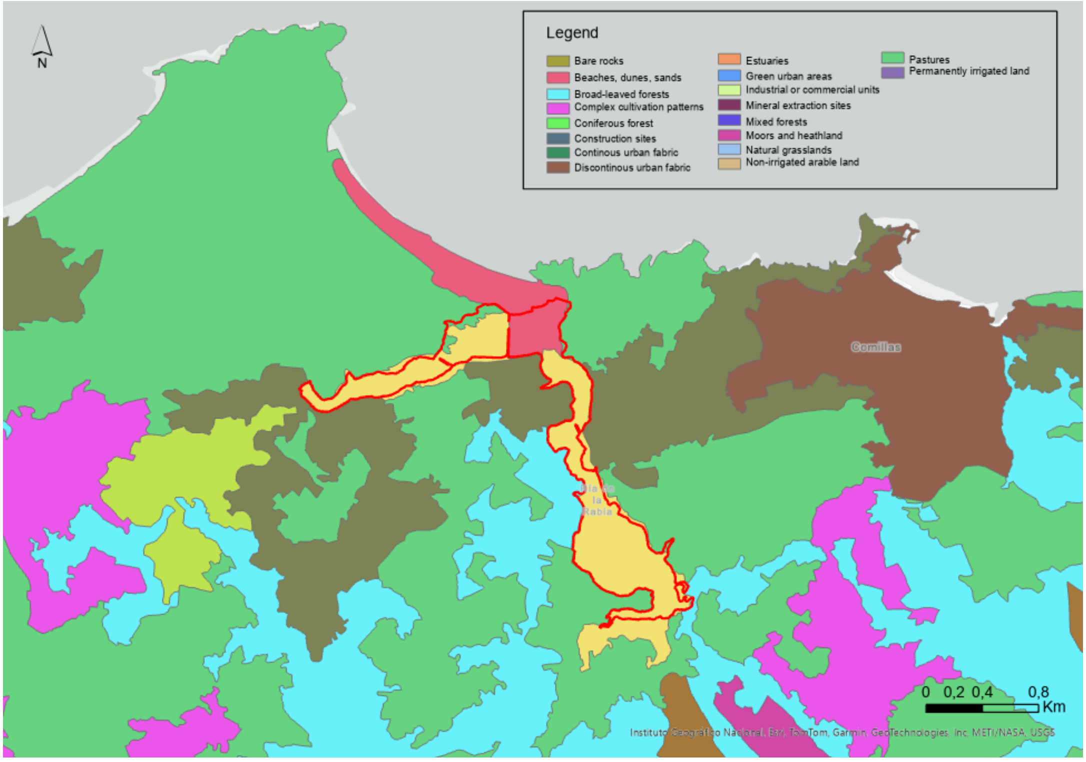

Figure 14: Land uses around the demo site (Corine Land Cover, 2018).

The NbS included in NBRACER as a demonstration case study consists of the removal of a dyke that restricted the natural tidal flow to the western branch of the estuary (Ría de Capitán) since 1945 (43°23'11.93"N / 4°19'25.64"W). The removal of this dyke in 2019 was implemented to recover the natural estuarine habitats and inhibit the spread of the invasive species (*B.halimifolia*) that was expanding to low salinity conditions. In addition, and through the increase in the tidal prism, the removal of the dyke was also expected to decrease erosional problems in the dune system at the estuary mouth (which is a valuable touristic and recreational resource) and reduce flooding problems at the most inner section of the eastern branch of the estuary, that affected one of the roads used by the local population. The landscape archetypes where this NbS is located or that are somehow affected/influenced by this NbS are claimed areas, estuaries and dune systems.

The KCS identified, and that are protected, thanks to the implementation of this NbS, are tourism and recreational resources, which would belong to the Health and Wellbeing KCSs category (Deliverable 5.1). In particular, it is expected that the restoration of the natural tidal regime to the western branch of the estuary will reduce erosional problems in the dune system located in the estuary mouth. This dune system is part of the Oyambre beach, a main tourism attraction in the area, as well as one of the main beaches used by the local population. In addition, the dune system holds a golf course, which is also a tourist attraction and was also threatened by erosion. On the other hand, this NbS is expected to reduce flooding risk in some critical infrastructures, such as roads, as well as on primary production KCS, such as agricultural land at the estuary margins. Figure 16 shows the water level reduction produced after the intervention for spring tides. This reduction in the water level is especially important for the roads located at the second branch of the estuary, Ría la Rabia. In addition, this NbS is expected to enhance the resilience of native intertidal ecosystems (e.g. saltmarshes, seagrass meadows, tidal flats) to adapt to sea level rise (i.e. through sediment accretion, if the recovery of the natural tidal flow increase sediment input at the inner section of the Ría de Capitán), which is key for the maintenance of the ecosystem services they provide.

Figure 15: KCS around the demo site (Oyambre estuary).

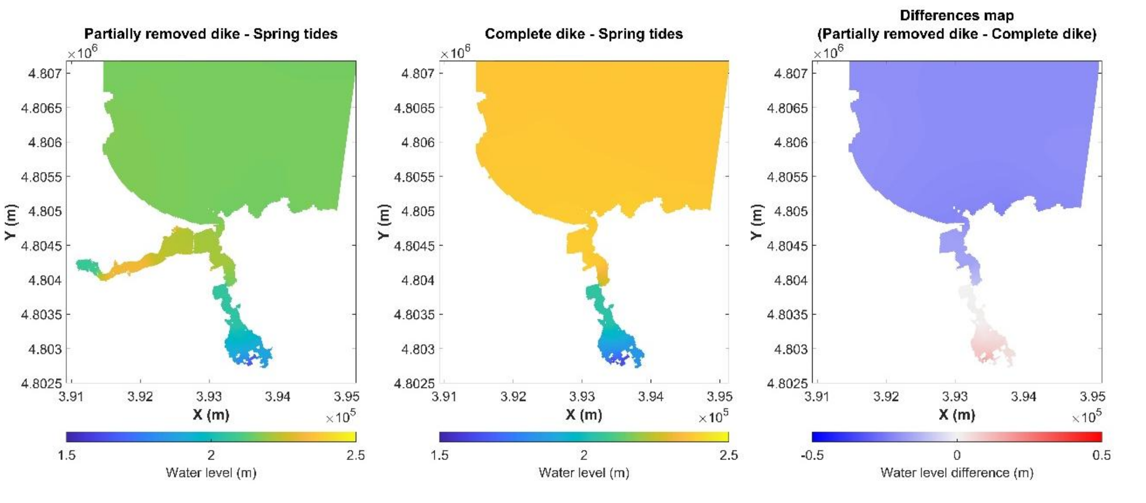

Figure 16: Water level differences under spring tide conditions after intervention (left panel, partially removed dike), previous situation (central panel, complete dike) and difference between both conditions (right panel).

The key ecosystem service on which this NbS is based is the coastal protection from erosion and flooding that is provided by estuaries and estuarine ecosystems. In addition, this NbS is expected to enhance other co-benefits related to the role estuarine vegetated ecosystems play as carbon sinks, the recovery and maintenance of native plant species (i.e. preventing Invasive Alien Species spread) and the support of biodiversity and water quality. Figure 19 shows the development of estuarine plant species in the area after the removal of the dike. Upstream of the dike and after five years of intervention, communities of Juncus maritimus and Halimione, among others, are present in the area.

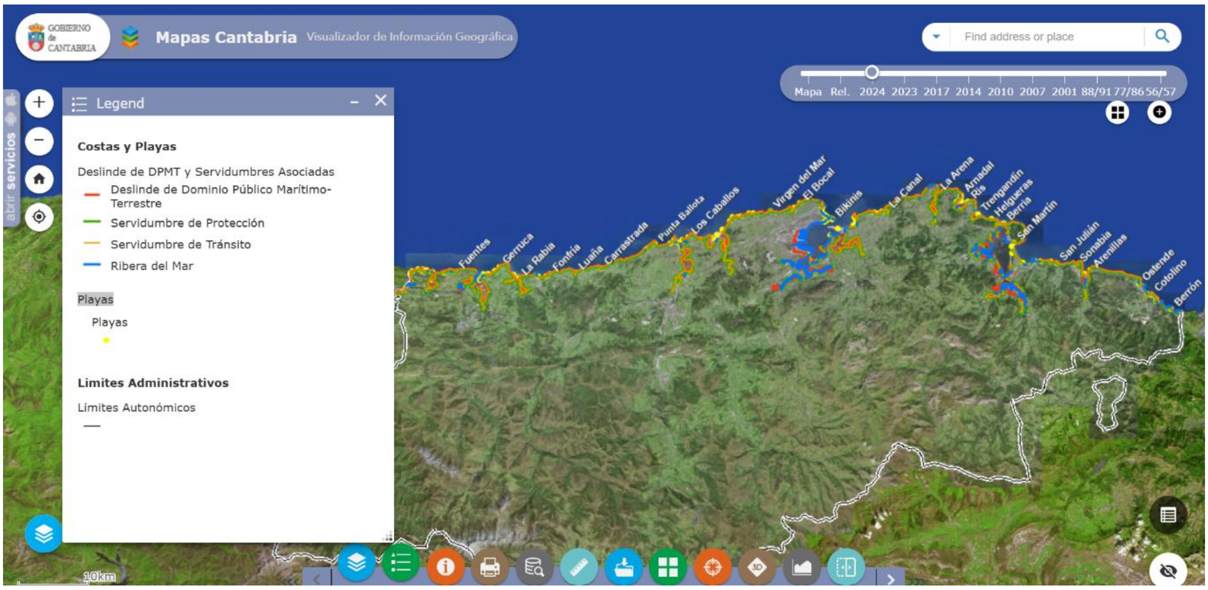

Figure 17: Beaches around the demo site.

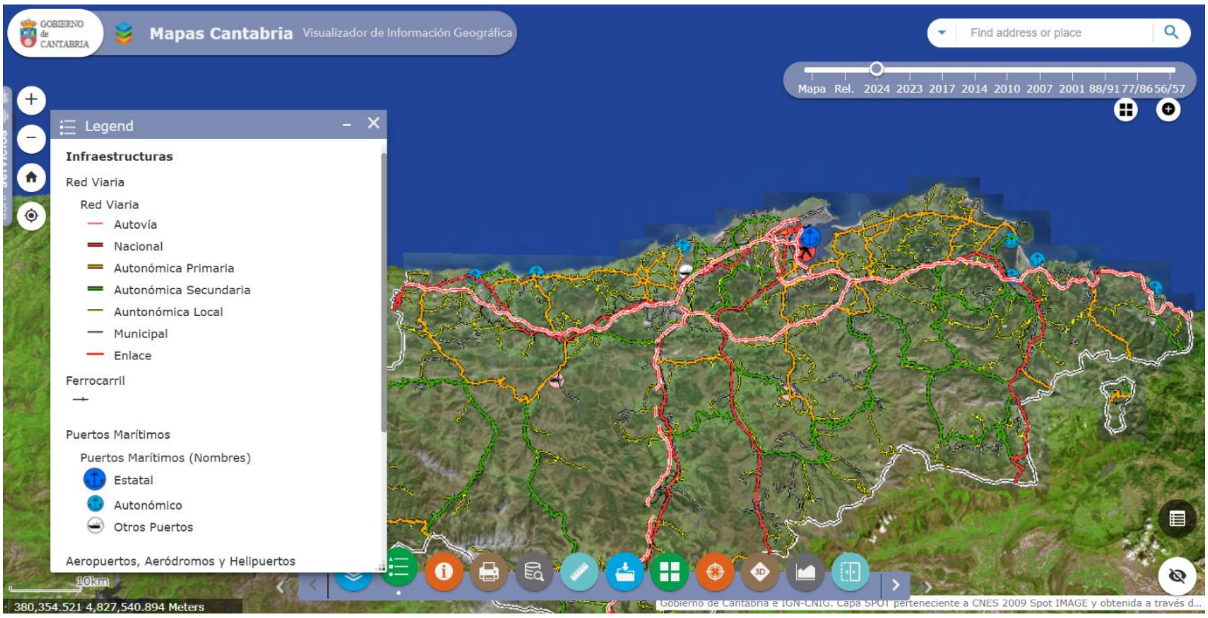

Figure 18: Road network around the demo site.

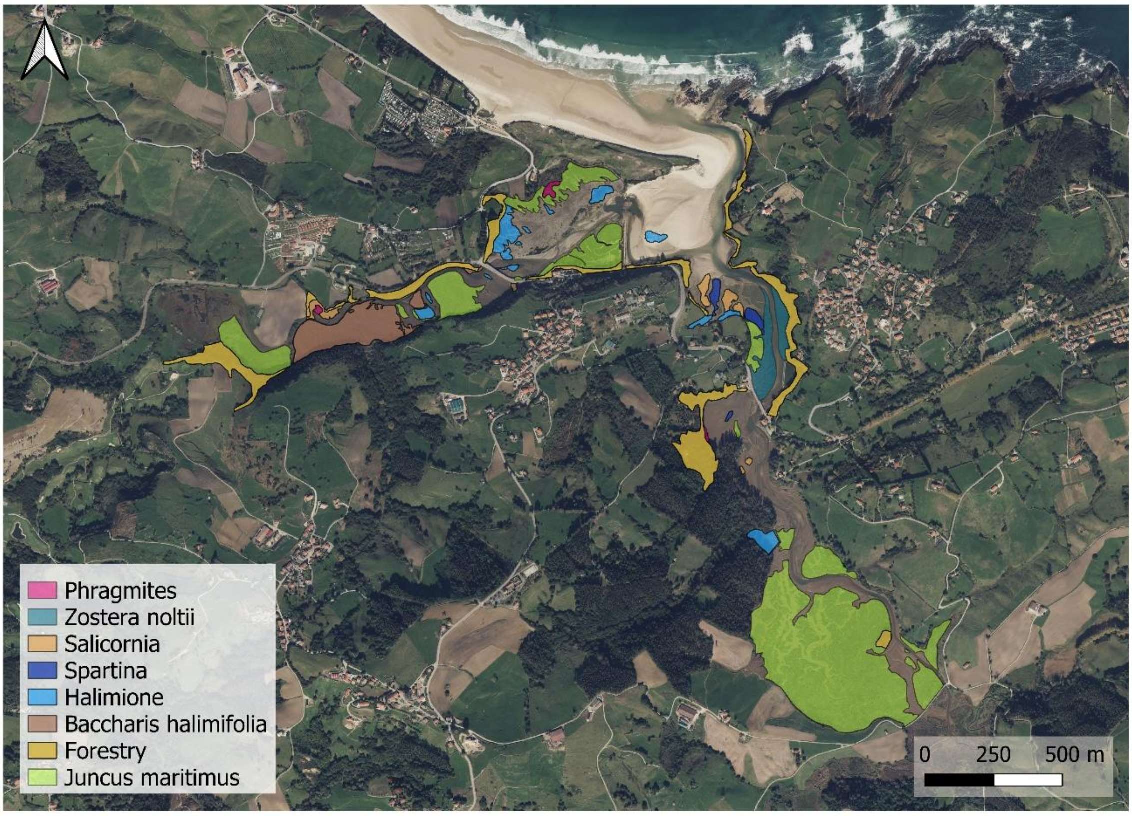

Figure 19: Vegetated communities at the demo site after intervention.

4.2 West-Flanders, Belgium

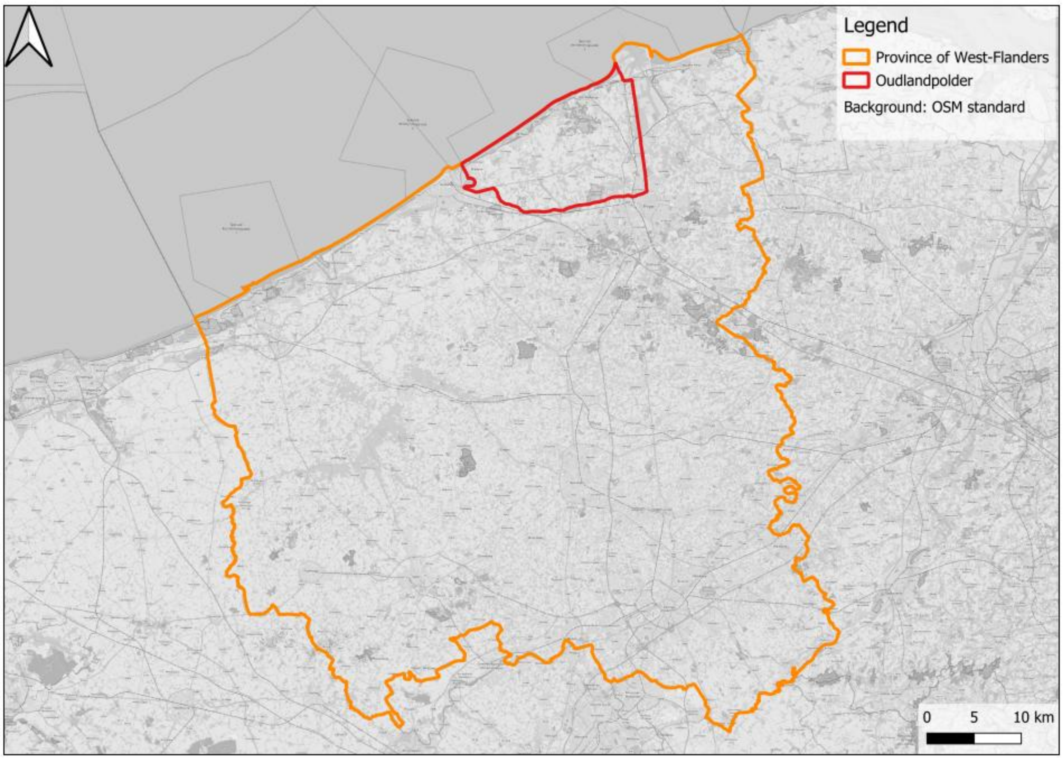

Figure 20: Location of the NbS demo Oudlandpolder within the province of West-Flanders.

4.2.1 Landscape archetypes

Land use

Figure 21 shows the actual land use at 10-meter resolution within the Flemish Region for the reference year of 2022. The concept of 'land use' refers to the actual use of the land for specific human activities such as housing, industry and services, recreation, etc., or for cultivation, such as arable farming, grassland, etc., or for natural vegetation, such as forest, shrubland, etc. Within the Oudlandpolder focus area (highlighted in yellow in Figure 21, the most prevalent land uses are arable land, followed by grassland under agricultural use, and subsequently residential areas including houses and gardens.

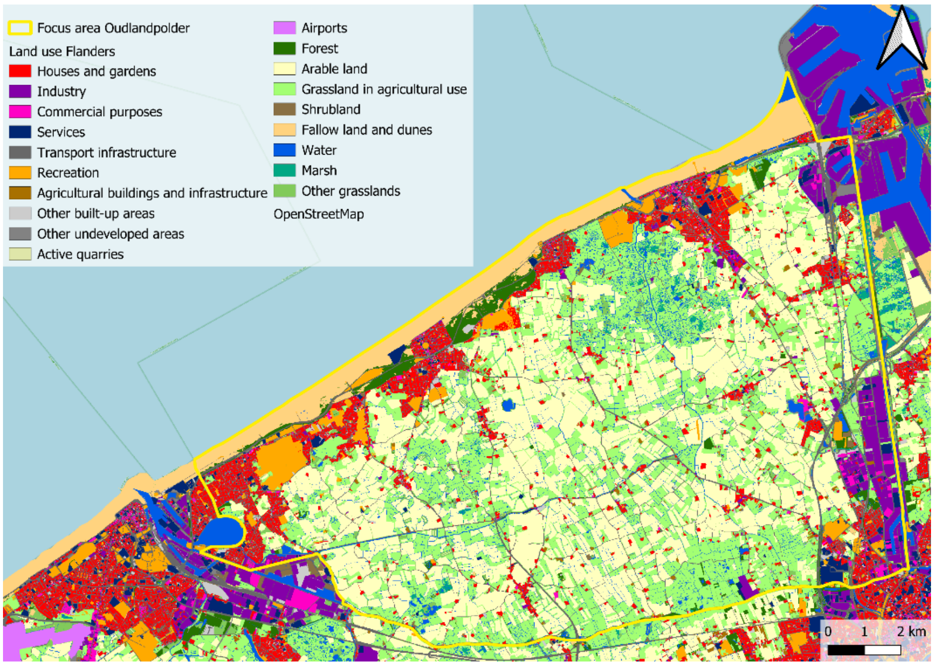

Figure 21: Land use in the focus area Oudlandpolder. The focus area is indicated in yellow.

Ecoregion

An ecoregion is an area that is relatively homogeneous in terms of its physical-geographical (soil characteristics, topography) and ecological (nature and environment) conditions. Climate, topography, and soil are particularly influential in determining the types of natural habitats that can occur within a given ecoregion.

Within the Oudlandpolder focus area, two ecoregions are present: the ecoregion of *the polders and the tidal Scheldt* and the ecoregion of the *coastal dunes* (Figure 22). The ecoregion of the *polders and the tidal Scheldt* is a low-lying, flat area with a subsurface composed of Quaternary geological formations, deposited during repeated marine inundations caused by post-glacial sea level rises. It is further characterised by a history of artificial land reclamation and clay soils lacking distinct profiles. Relevant for climate adaptation is the position below average high tide, impacting water management and flood control. The ecoregion of the *coastal dunes* is a coastal zone formed by marine and aeolian deposits, consisting of beaches, ancient dunes, subrecent inland dunes, and young dunes. It has an oceanic climate with distinctive microclimates.

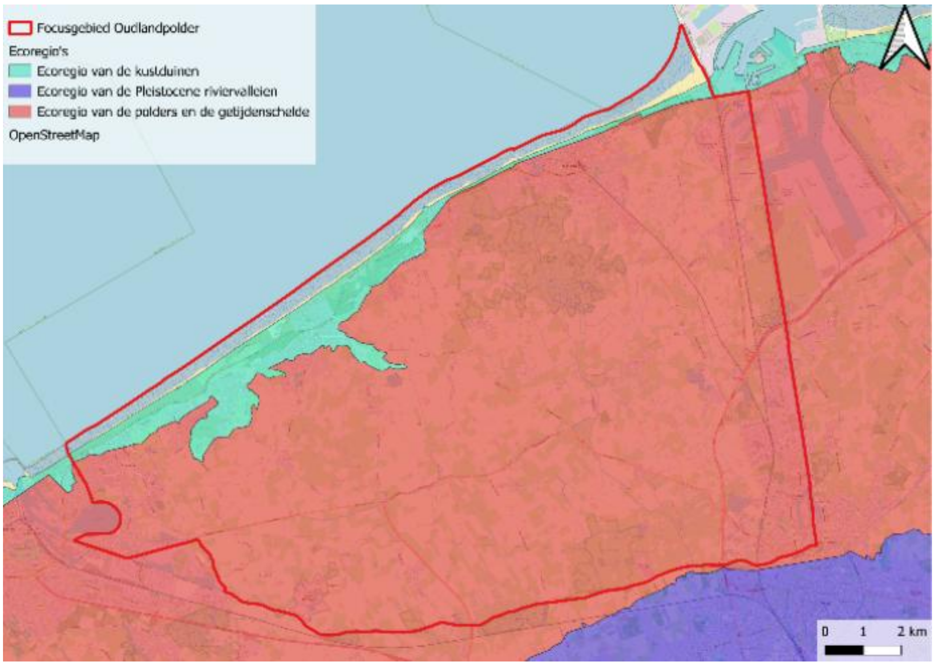

Figure 22: Ecoregions in the focus area Oudlandpolder. The ecoregion of Coastal Dunes is depicted in green, and the ecoregion of the Polders is red.

<u>Watercourses</u>

The Vlaamse Hydrografische Atlas (VHA), or Flemish Hydrographic Atlas provides detailed data on surface water systems in the Flanders region of Belgium (Vlaamse Milieumaatschappij, 2025)[1]. The VHA maps all categories of watercourses in Flanders, including navigable and non-navigable watercourses, public ditches, and some private and roadside ditches. Within the Oudlandpolder focus area (see Figure 23), a total of 678 watercourses have been identified, comprising 322 non-classified watercourses, 237 public ditches, 104 second category classified watercourses, ten navigable watercourses, and five first category classified watercourses.

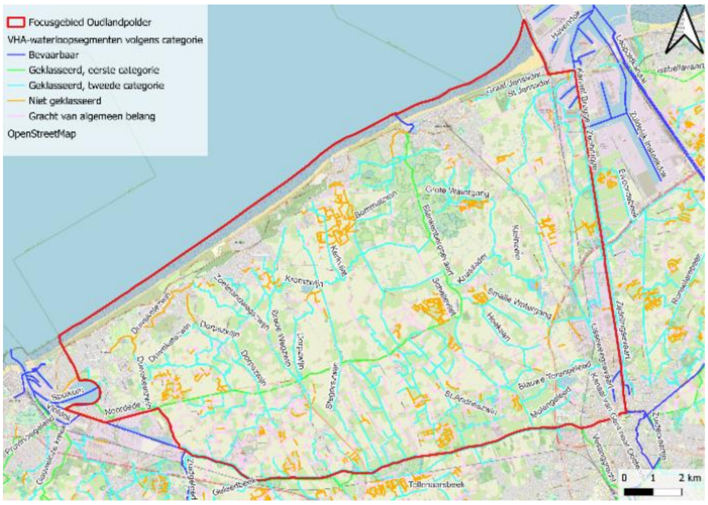

Figure 23: Watercourses in the focus area Oudlandpolder, with their official classification: navigable (blue), first category (green), second category (turquoise), not classified (orange) and ditches (pink).

[1] Vlaamse Hydrografische Atlas - Waterlopen, toestand 10/01/2025 | Vlaanderen.be

Climate hazards

Climate hazards and their impacts on KCS, such as vulnerable populations, buildings, and health infrastructure, are investigated based on information available at Klimaatportaal[2].

- Heat stress

A heat event with a return period of 20 years (T20) was used for all presented maps and figures. Spatial patterns in heat are visualised by means of the multi-year average of the **number of tropical days per year** (Figure 24). A tropical day is a day with a maximum temperature of 30°C or more. There are little to no spatial differences within the focus area, but a clear increase in the number of tropical days over time: mean of 3.3 tropical days/year (current climate) vs. 10.4 tropical days/year (future climate 2050).

Vulnerable individuals are defined as those aged 0 to 4 and 65 and older. More specifically, this concerns vulnerable populations for whom the daily maximum and minimum apparent temperatures during an extreme heat day (T20) are exceeded to such an extent that serious adverse health effects are anticipated. The **number of vulnerable residents exposed to heat stress** (Figure 25) increases from 0 (current climate) to 5252 (future climate 2050).

Vulnerable institutions (including childcare facilities, pre-primary, primary and special education, hospitals and nursing homes) are those where, during an extreme heat day (T20), the threshold values for maximum and minimum daily apparent temperature are exceeded beyond which severe health impacts are expected. The **number of vulnerable institutions exposed to heat stress** (Figure 26) increases from 0 (current climate) to 21 (future climate 2050). Affected vulnerable institutions are mainly located in Blankenberge.

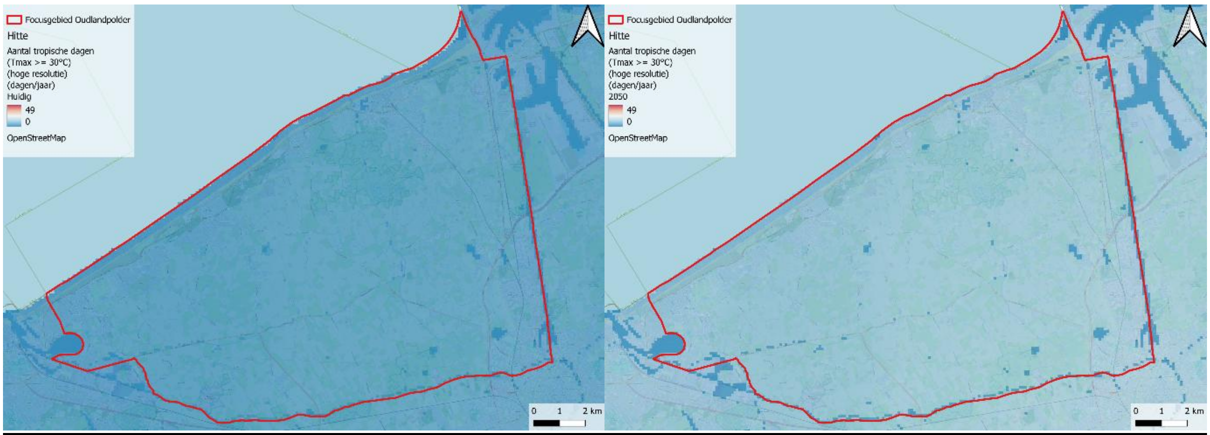

Figure 24: Number of tropical days (T_{max} ⩾ 30°C): current climate (left) & future climate (2050) (right). The colour scale ranges from blue (0) to red (49). The red polygon represents Oudlandpolder.

[2] IMPACTtool - Klimaatportaal Vlaanderen

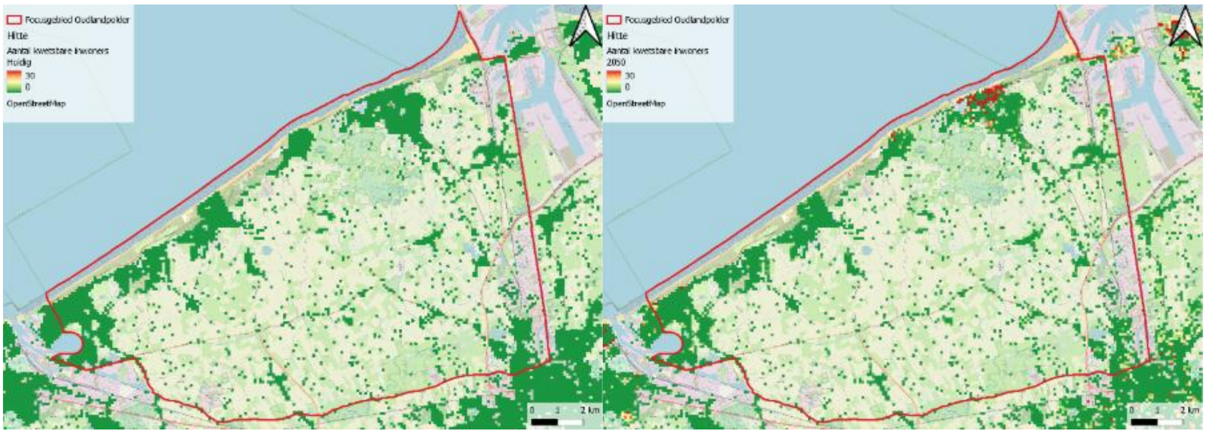

Figure 25: Number of vulnerable residents exposed to heat stress in the focus area Oudlandpolder: Current climate (left) & future climate (2050) (right). The colour scale ranges from green (0) to red (30).

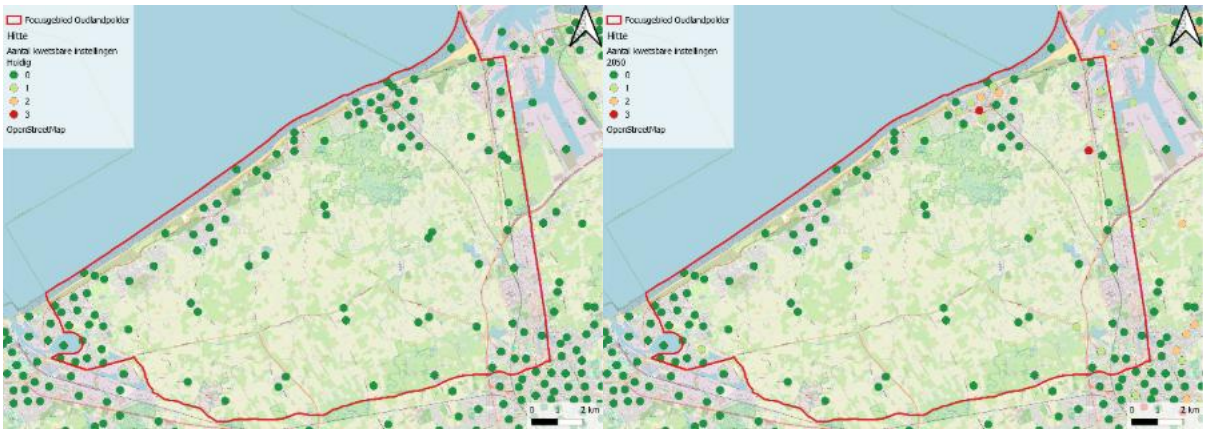

Figure 26: Vulnerable institutions with heat stress in the focus area Oudlandpolder: Current climate (left) & future climate (2050) (right). Level of heat stress: green circle (0), light green circle (1), orange (2), red (3).

- Drought

Drought-related climate risks and impacts on KCS were considered with a return period of one year (T1). For **drought duration (meteorological)** (Figure 27), the number of days per year with little or no precipitation (less than 0.1 mm/day) increased: mean of 170.7 days/year (current climate) vs. 206.0 days/year (future climate 2050). There is little to no spatial variation within the focus area. Drought duration is slightly higher in the south-western part and along the coast, compared to the more inland and southeastern part of the focus area (Figure 27).

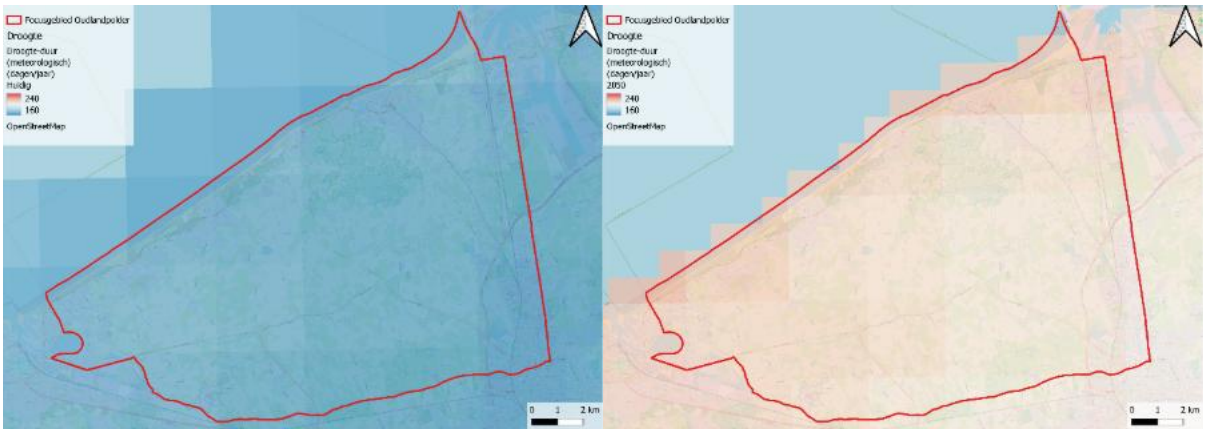

Figure 27: Drought duration (meteorological) in the focus area Oudlandpolder: Current climate (left) & future climate (2050) (right). The colour scale ranges from blue (160) to red (240).

The evaluation of **agricultural parcels with significant drought stress** (Figure 28) is based on the drought intensity. The intensity of drought is quantified as the total cumulative volume deficit of soil moisture on an annual basis, expressed in the cumulative volume of water deficit per volume of soil (cumulative m^3/m^3 year). This annual drought intensity is modelled for the current and future climate for a given return period (here T1). Agricultural crops experience significant drought stress when a given threshold is exceeded. This threshold is defined as the moment when the total water shortage exceeds the permanent wilting point and plants experience reduced plant growth and lower crop yields. This threshold was determined at a drought intensity of 1 m^3/m^3 for agricultural crops in Flanders.

In the current climate, 41 parcels (0.78% of the agricultural parcels in the region) and 106.4 ha (0.59% of the total area of the region) are identified; whereas for the future climate (2050), 237 parcels (4.2%) and 535.6 ha (2.95%) (assuming current crops). Agricultural drought stress is evaluated based on current crops and environmental factors like soil texture. The spatial patterns, therefore, reflect the effects of both factors. There are no clear spatial patterns in affected parcels apparent for the region, where all agricultural parcels are located within the clayey polder ecoregion.

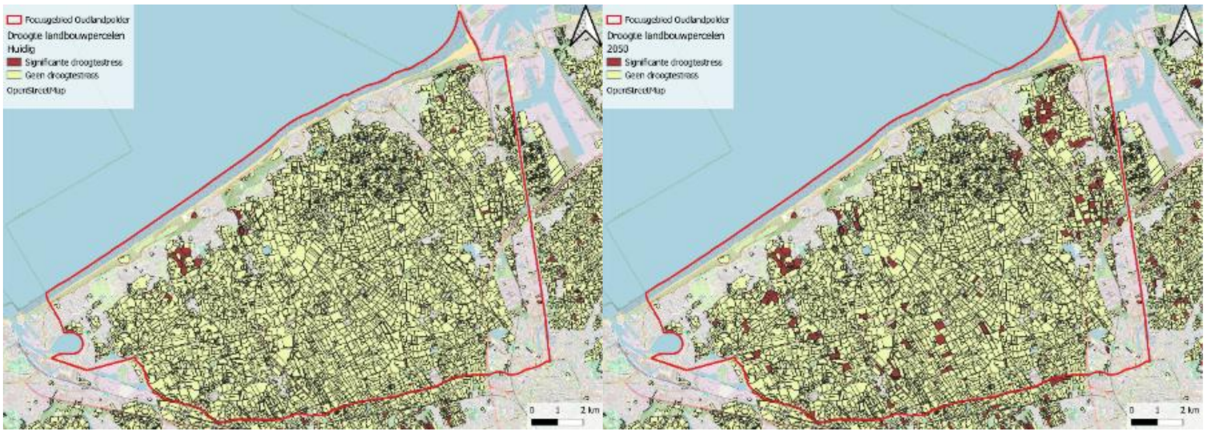

Figure 28: Agricultural parcels with significant drought stress in the focus area Male-Lieve: current climate (left) & future climate (2050) (right). Red parcels have significant drought stress.

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Vulnerable ecotopes with significant drought stress (Figure 29) correspond to natural parcels vulnerable to desiccation that are exposed to extreme drought conditions (with a drought intensity exceeding 1) (T1). For the current climate, 110 parcels and 85.47 ha (0.47% of the total area in the region) are identified; whereas for the future climate (2050), 171 parcels and 152.32 ha (0.84%).

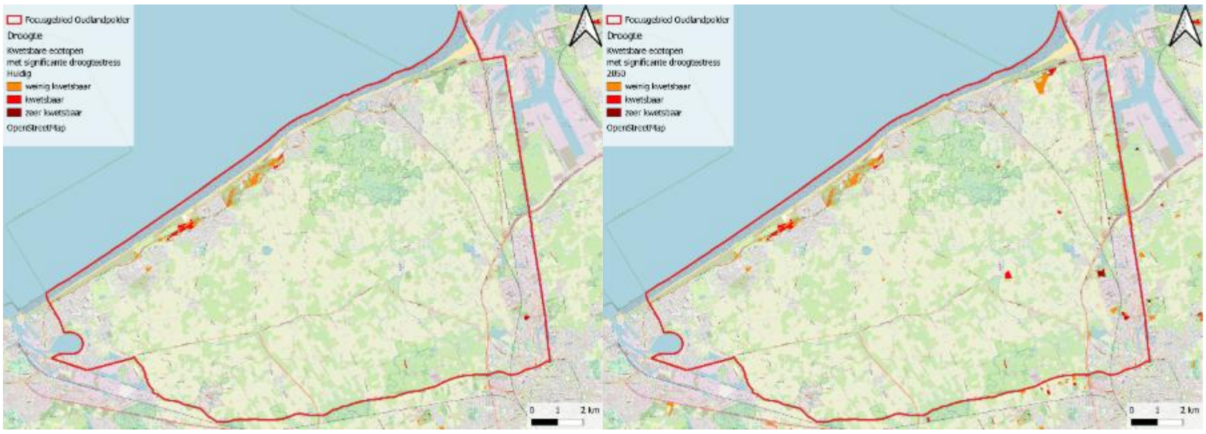

Figure 29: Vulnerable ecotopes with significant drought stress in the focus area Oudlandpolder: Current climate (left) & future climate (2050) (right).

- Flooding (fluvial)

Water depth during a flood with a probability of once every 1000 years (T1000) (Figure 30) under the current climate was identified, especially around the Uitkerkse polder in the northern part of the region, and in the southern part of the region, north of the Blankenbergsevaart. Water depth reaches up to 280 cm, with a mean of 31.24 cm. For the future climate (2050), also other areas are affected, especially the Meetkerkse Moeren, and water depth increases (up to 295 cm, with a 38.52 cm mean).

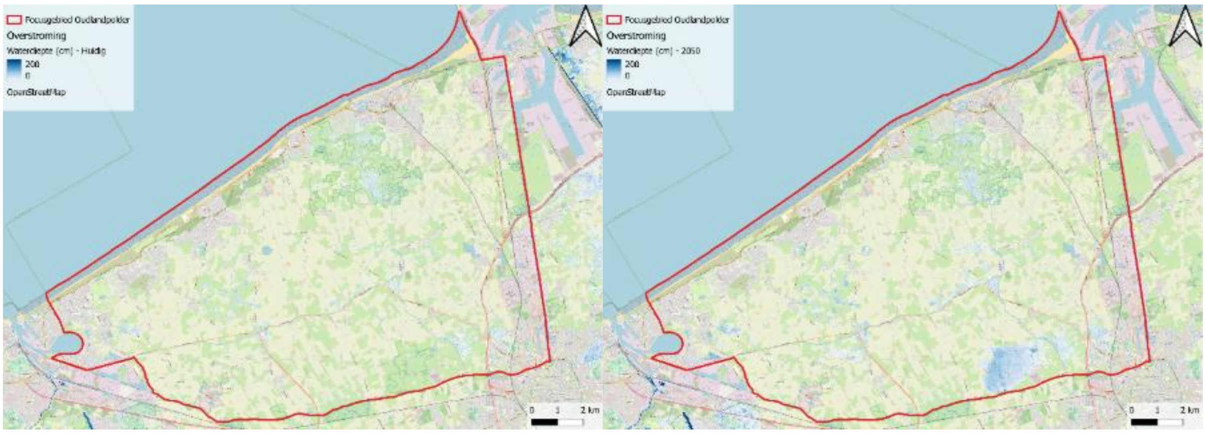

Figure 30: Water depth at flooding (fluvial) in the focus area Oudlandpolder: Current climate (left) and future climate (2050) (right). The colour scale ranges from white (0) to dark blue (200cm).

The **number of buildings by statistical sector with a probability of flooding** once every 1000 years (T1000) (Figure 31) increases from 360 (current climate) to 477 (2050 climate). The **vulnerable institutions at risk of flooding** (Figure 32) (including childcare facilities, pre-primary, primary and special education, hospitals, and nursing homes) for T1000 remains constant at 2.

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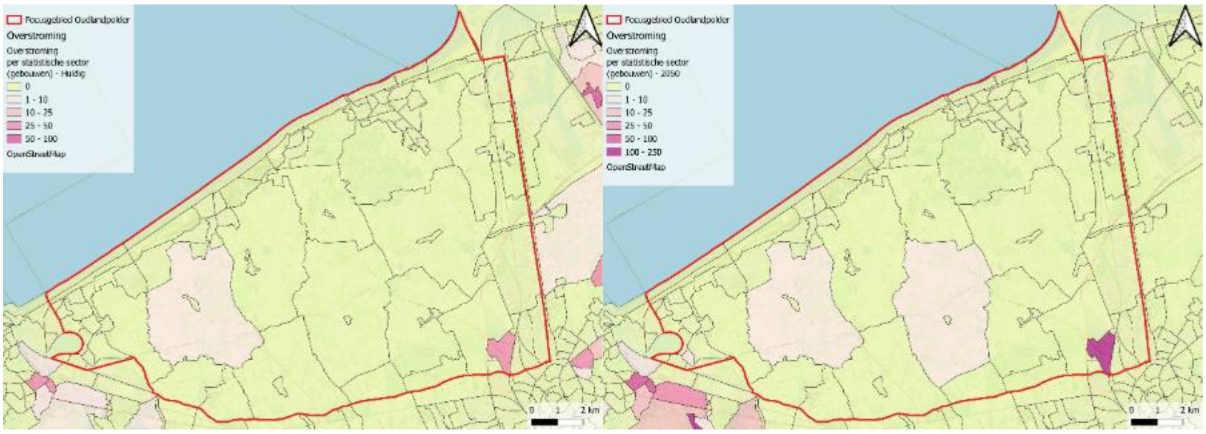

Figure 31: Fluvial flooding by statistical sector (buildings) (number) in the focus area Oudlandpolder: Current climate (left) and future climate (2050) (right). The colour scale ranges from green/yellow (0) to red (50-100 buildings).

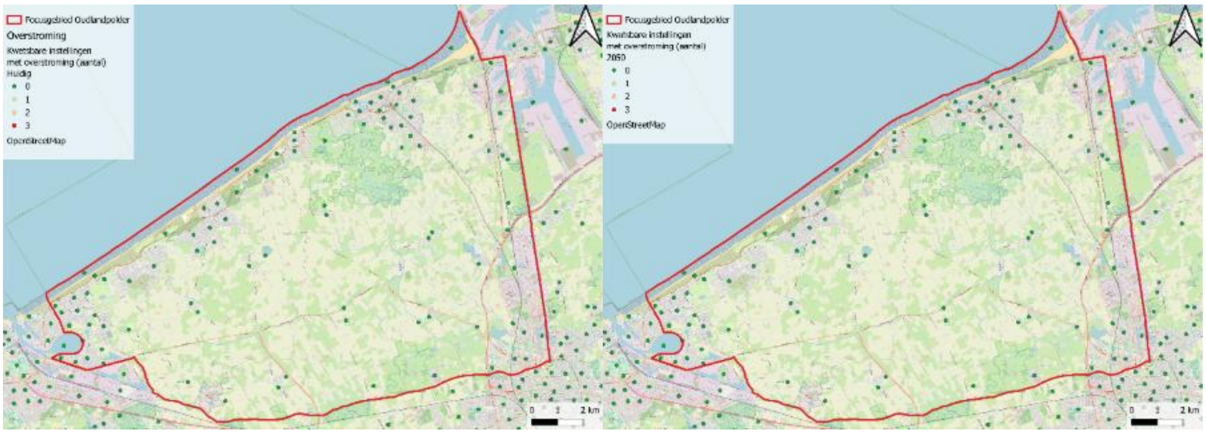

Figure 32: Vulnerable institutions at risk of fluvial flooding (number) in the focus area Oudlandpolder: Current climate (left) and future climate (2050) (right). Fluvial flooding risk levels: green circle (0), light green circle (1), orange (2), red (3).

- Pluvial flooding

The **maximum water depth resulting from pluvial flooding** due to intense precipitation associated with a T1000 event (Figure 33) present slight variations when comparing both climate scenarios. Under the current climate, water up to 348 cm deep, with an average water depth of 31.09 cm, is identified, affecting different parts of the focus region. For the future climate (2050), water up to 353 cm deep with an average water depth of 31.42 cm affects the same regions but more extensively.

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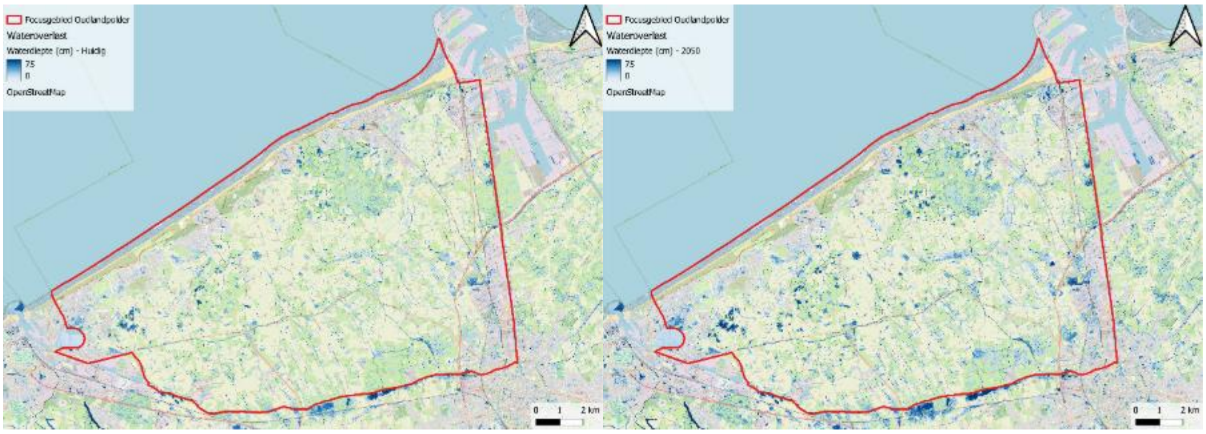

Figure 33: Water depth at water nuisance in the focus area Oudlandpolder: Current climate (left) & future climate (2050) (right). The colour scale ranges from white (0) to dark blue (75cm).

The **number of buildings by statistical sector with a probability of pluvial flooding** for a T1000 intense precipitation event (Figure 34) were analysed considering only statistical sectors fully contained within the perimeter. Under the current climate, at least 279 buildings are exposed, primarily concentrated in coastal cities and the northern region of Bruges, whereas in the future climate (2050), at least 594 buildings are exposed, with a greater number of statistical sectors affected and increased severity in already impacted areas.

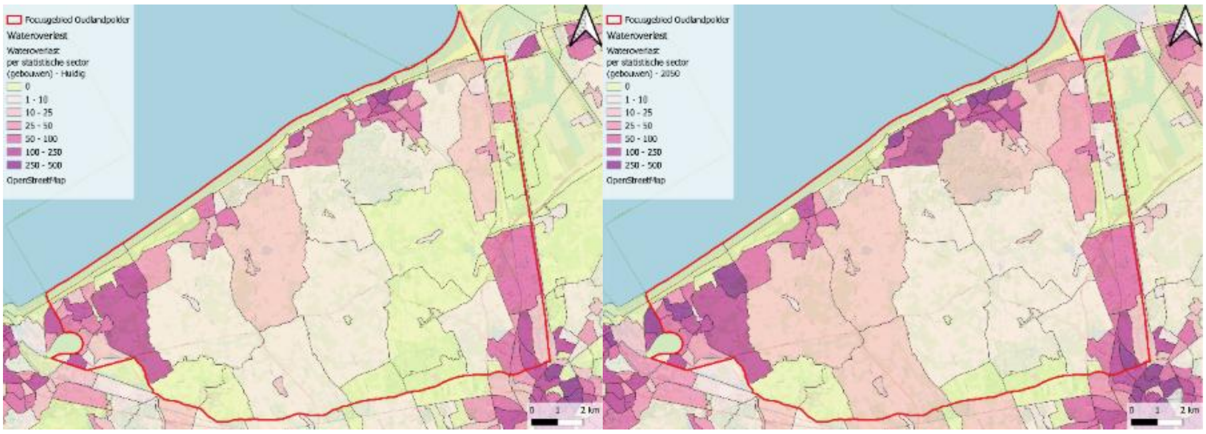

Figure 34: Water nuisance by statistical sector (buildings) (number) in the focus area Oudlandpolder: Current climate (left) & future climate (2050) (right). The colour scale ranges from green/yellow (0) to purple (250-500 buildings).

Vulnerable institutions at risk of pluvial flooding (Figure 35) (including childcare facilities, pre-primary, primary and special education, hospitals, and nursing homes) due to intense precipitation (T1000) shows an increase from 13 exposed (7 childcare institutions, one education institution, 5 hospital/nursing homes in Blankenberge, De Haan, Bredene, Sint-Pieters) to 26 exposed (11 childcare institutions, 7 education institutions, 8 hospital/ nursing homes in Blankenberge, Wenduine, De Haan, Bredene, Sint-Pieters).

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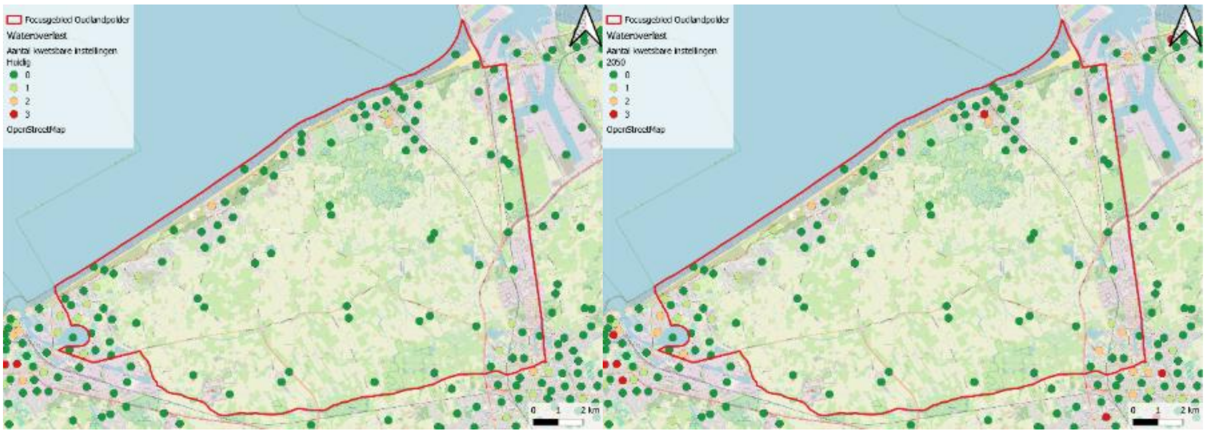

Figure 35: Vulnerable institutions with water nuisance in the focus area Oudlandpolder: Current climate (left) and future climate (2050) (right). Water nuisance levels: green (0), light green (1), orange (2) and red circles (3).

- <u>Coastal flooding</u>

The potential flood-prone area and the corresponding water depth in the event of a 1000-year storm surge (T1000) along the coast, calculated based on the sea defence as it was in the year 2015. This map doesn't consider the 2011 coastal defence plan ('Masterplan Kustveiligheid'), which protects for a T1000 in 2050, currently being implemented. In 2024, planning has also started for the longer term, with the start of the co-design of a coastal defence vision ('Kustvisie'), which will protect for a T1000 storm at 3 m sea level rise.

For the current climate, water depths are up to 1110 cm with an average of 83 cm. Main flooded areas are located near Zeebrugge, in the south-western part of the region and near the Blankenbergsevaart. For the future climate (2075), water depth increases up to 1145 cm with an average of 110 cm. The main flooding areas also stay the same.

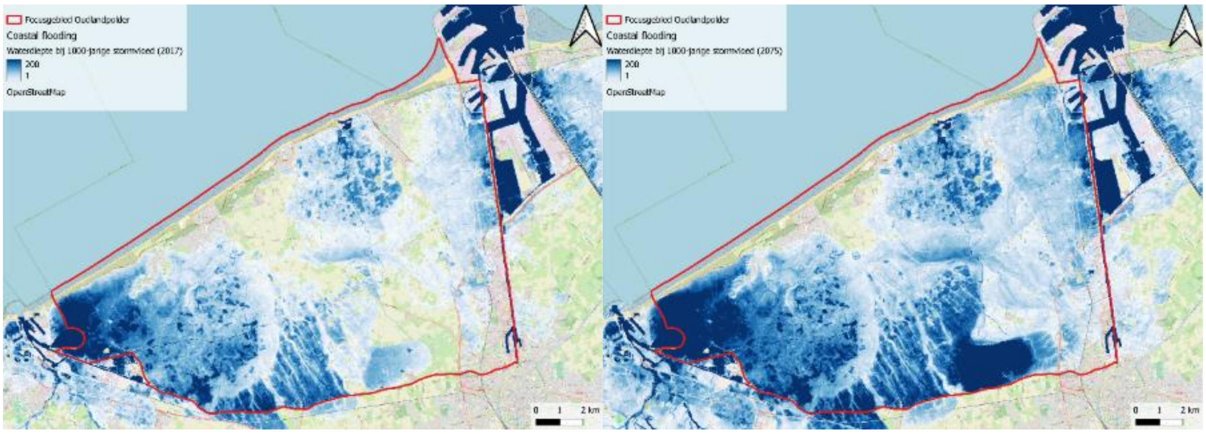

Figure 36: Water depth due to coastal flooding in the focus area Oudlandpolder: Current climate (left) and future climate (2075) (right). The colour scale ranges from white (1) to dark blue (200 cm).

4.2.2 Biodiversity and Ecosystem Services

<u>Biodiversity</u>

Biodiversity is assessed based on the biological value map as included in the Nature Value Explorer. As shown in Figure 37, most of the area is biologically less valuable, though with a high proportion of biologically valuable areas along the coast and scattered throughout the focus area, where the biggest areas are present near the Uitkerkse polder near Blankenberge/Zuienkerke and Meetkerske Moeren in the south, and some scattered remnants are spread over the polders. Biologically very valuable areas are located at the centres of these biologically valuable areas, and in the dunes along the coast.

Figure 37: Biological value map for focus area Oudlandpolder (INBO, 2019).

<u>Ecosystem services</u>

Ecosystem services were assessed using two tools: the European INCA tool and the Belgian Nature Value Explorer. We focus here on regulatory services related to climate change within the NBRACER framework.

<u>INCA</u>

Here, we assess the regulating services of flood control, global and local climate regulation for the focus areas. In a first step, this is one based on the outputs of EU-wide available data. These can be further refined in a later stage based on more detailed local data. There are no local climate regulation outputs for Belgium based on the EU-wide results, for which calculations with local data are needed.

Flood control is discussed for the entire West-Flanders under section Male-Lieve.

The service of global climate regulation considers the effect of net carbon registration (removal from the atmosphere) and carbon retention (storage in soil). These services are evaluated based on CORINE land use maps and LUCAS Soil Organic Carbon (SOC) maps.

The dune systems along the coast have the highest carbon retention and sequestration values. The grassland areas that also displayed a higher biological value also have higher carbon retention values compared to the rest of the study area.

The results of this analysis strongly depend on the land use maps. Given that this analysis is based on the CORINE dataset, where large wet nature areas that are present in the study area, which have a high carbon sequestration potential, are mapped as grassland, these areas do not show up in the maps. The actual carbon sequestration potential of the area is therefore likely underestimated. These results could be improved when working with high-resolution local land use maps and refined assignments of sequestration amounts per land use type.

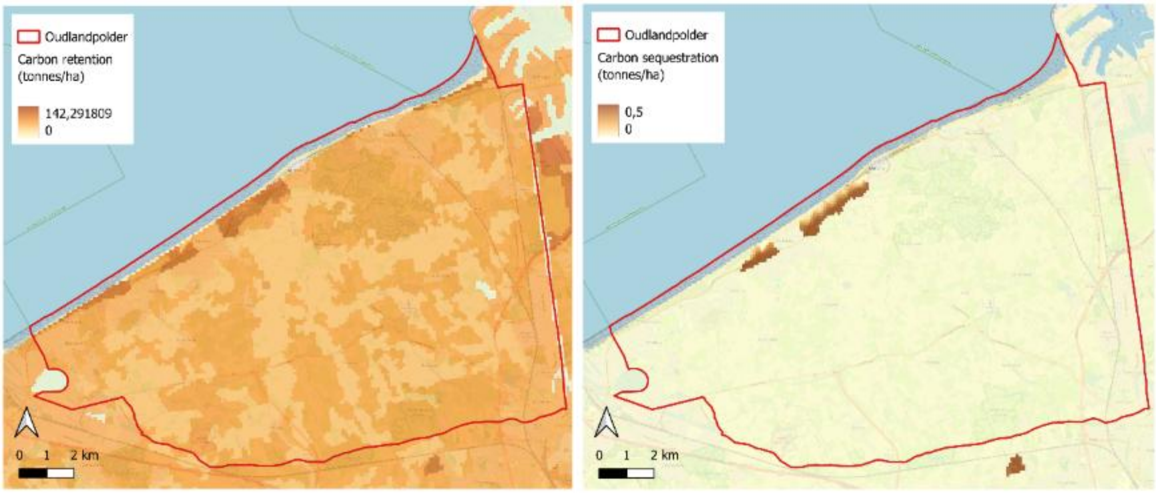

Figure 38: Global climate regulation services retention (left) and sequestration (right) for focus area Oudlandpolder.

<u>Nature Value Explorer</u>

The nature value explorer assesses a variety of ecosystem services for a given study area using qualitative scores, quantitative values and monetary value for the current situation and after implementation of a variety of measures. Here, the values for the current situation are presented. The main disadvantage is that these numbers are calculated for the entire study area, with no maps of how the ecosystem services spatially vary within the study area.

The Nature Value Explorer has a study area limit of 50.000.000 m², which is exceeded by the focus area Oudlandpolder. Ecosystem scores are therefore calculated for a subarea of the focus area, consisting of the upstream area of the IJzer river, as indicated on the figure below.

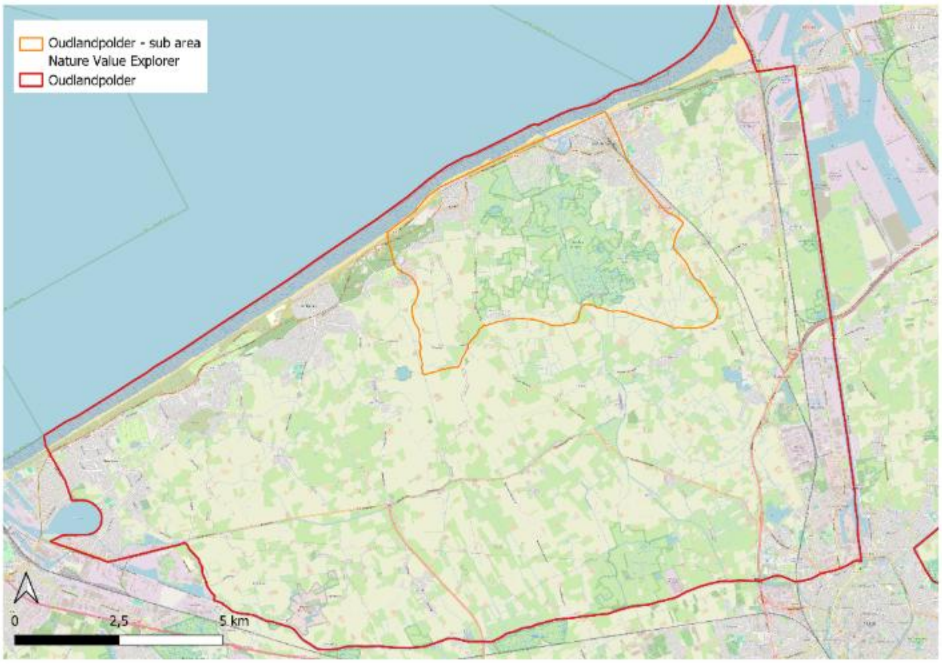

Figure 39: Sub-area for which ecosystem services were calculated using the Nature Value Explorer, corresponding to the VHA catchment of the Damse Vaart, containing the Uitkerkse polder.

The qualitative ecosystem scores for the subarea of the Oudlandpolder show the highest contribution of erosion control as a regulating service (8.5). This is likely explained by the topography of the area, which is flat, and the presence of large grassland areas. Infiltration is somewhat lower with a value of 4, likely related to the clayey soils with a low infiltration capacity. Carbon sequestration in biomass and soils is low, likely explained by the near absence of forested areas, where the score for denitrification is also low. These ecosystem services were also quantitatively assessed (Table 2).

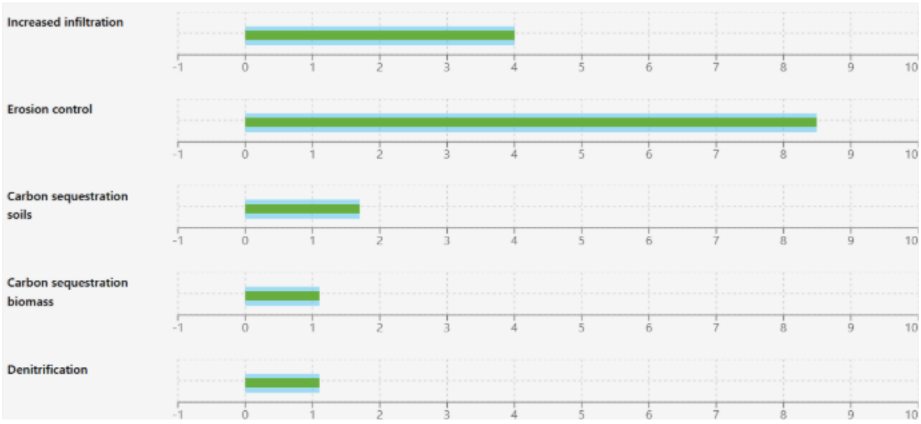

Figure 40: Qualitative scores for selected ecosystem services from Nature Value Explorer for the sub-area of Oudlandpolder

Table 2: Quantitative ecosystem service evaluation for sub-area Oudlandpolder.

Ecosystem Service	Total Oudlandpolder – sub area
Infiltration (m^3 / year)	4,070.863

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Erosion control (tons/year)	339,345.3
Carbon sequestration soils (tonnes C/year)	5,507.2
Carbon sequestration biomass (tonnes C/year)	30.3
Denitrification	1,358.9

5 Discussion of results

5.1 Co-design steps

There are different definitions of co-design, also in relation to the design of NbS for climate adaptation. In its core, co-design is based on **a collaborative approach to design and implement a solution** (Basnou et al., 2020; Lupp et al., 2021). All regions are applying the Mission driven innovation and the concept of the Regional Resilience Journey. Some generic concepts on quadruple helix interplay, multi-actor and multi-level governance, and inter- and transdisciplinary approaches will be applied in all the regions. The different NBRACER regions will vary in applying these approaches, as this will require the introduction of new ways of working. Further, the regions are all at different stages of the Regional Resilience Journey to climate resilience, but also, their demonstrated solutions are diverse and at different readiness levels. As such, the **co-design processes will and should be tailor-made for the specific solutions, within the different contexts**.

NBRACER has defined the following five steps for the co-design process:

1. **Issue framing** – Involvement of stakeholders to debate and raise awareness on the regional climate risks and the role of NbS for climate adaptation. Stakeholder consultations are often focused on the identification of the problem and building a trust basis for further collaboration.
2. **Knowledge gathering and diagnosis** – Establishing a knowledge basis and evidence support is crucial to enable stakeholders to make informed decisions. This stage can involve capacity building, monitoring and gathering of data to assess the baseline and allow for debate on potential solutions to address the identified issues.
3. **Co-design of options** – Stakeholders are involved in and actively contribute to the design of different solutions, including NbS. The design stage is once again informed by the gathered data and knowledge and builds further capacity.
4. **Stakeholder validation** – The co-designed NbS are implemented and validated with and by stakeholders. Stakeholders are actively involved in the monitoring of the solutions and perceive directly the benefits brought by their implementation.
5. **Decision-making and agreement** – The gathered knowledge allows for comparing and validating different solutions, upon which an agreement or consensus can be reached among stakeholders, pending their different opinions and perspectives.

Table 3: Overview of the co-design steps in the Coastal Demonstrators (X = applied).

Coastal Demonstrators	**Co-design steps**				
	1. Issue framing	**2. Knowledge gathering and diagnosis**	**3. Co-design of options**	**4. Stakeholder validation**	**5. Decision making and agreement**
1. Restoration tidal regime		X		X	
2. Water level management		X		X	X
3. Sustainable farming (non-tillage agriculture)		X		X	

Table 3 summarises which phases of co-design are applied in the Coastal Demonstrators. Although the phases of the demonstrators vary in all three demos, efforts go to data and knowledge gathering, engagement and validation with and by stakeholders. For example, in Cantabria, the coastal demonstrator was implemented in 2019, and the focus now is on mainstreaming and replication potential, i.e. how to increase the implementation of this solution in other estuaries in Cantabria and other EU regions. Similarly, this counts for W-Flanders regarding the non-tillage agriculture.

5.2 Types of stakeholders involved

Various types of stakeholders have been involved in each of the Coastal Demonstrators. The proposed categories are:

- **Farmers**, as a key stakeholder group with special relevance in the coastal landscape in West-Flanders;
- **Local administrations**, since water management affects various local municipalities in the coastal landscape;
- **Regional and National governments**, as stakeholders in charge of decision-making with ownership over the co-design process and implementation of the NbS;
- **Citizens**, often as stakeholders affected by the implementation of the NbS;
- **Nature**, often through NGOs, as a representation of the natural environment;
- **Researchers**, or academia, such as knowledge partners, can providing scientific evidence to inform decision-making for the implementation of NbS.

Table 4: Overview of the stakeholder groups involved in the Coastal Demonstrators (X = involved).

Coastal Demonstrators	Stakeholder groups involved					
	Farmers	Local administration	Regional and National governments	Citizens	Nature	Researchers
1. Restoration tidal regime		X	X	X	X	X
2. Water level management		X	X		X	
3. Sustainable farming – non-tillage agriculture	X		X			X

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Table 4 describes the stakeholder groups involved in each of the Coastal Demonstrators. The main observation is that **regional governments are involved in all three NbS demonstrators**. Another finding is that **combinations of involved stakeholders seem to be site-dependent**, although the sample size is limited.

5.3 Key Community Systems

The KCSs correspond to the key areas and underlying systems where innovation can happen within the regions. The EU Mission on Adaptation to Climate Change refers to 6 KCSs in the middle of the chart:

Critical infrastructure, Health and Well-being, Land use and Food systems and Water Management, these are all linked to Ecosystems and Nature-based Solutions, together with the Local economic systems.

Table 5: Overview of the most relevant Key Community Systems (KCSs) in the Coastal Demonstrators (X = impacted; (X) = partially impacted).

Coastal Demonstrators	Key Community Systems					
	Critical Infrastructure	**Water Management**	**Land use & Food systems**	**Health & Wellbeing**	**Ecosystems & NbS**	**Local Economic Systems**
1. Restoration tidal regime		X			X	
2. Water level management	(X)	X	X	(X)		
3. Sustainable farming – non-tillage agriculture		X	X		(X)	(X)

5.4 Climate risks

The climate risks that impact the KCSs in each of the Coastal Demonstrators are identified in Table 6. The following climate hazards are listed: sea level rise, flooding (marine, pluvial and fluvial), drought, water quality (and salinisation), and soil erosion.

Table 6: Overview of the identified climate risks for the Coastal Demonstrators (X = relevant; (X) = partially relevant).

Coastal Demonstrators	Climate risks						
	Sea level rise	**Marine flooding**	**Pluvial flooding**	**Fluvial flooding**	**Drought**	**Water quality**	**Soil erosion**

1. Restoration tidal regime	X	X				X	X
2. Water level management	X	X	X		X	X	
3. Sustainable farming – non-tillage agriculture			(X)	(X)	X	(X)	(X)

Although each region focuses on solutions to tackle their locally identified coastal climate risks, shared risks relate to sea level rise, flooding and drought.

- **Cantabria** NbS demonstrator is dealing with present-day **flooding,** which may increase due to **sea level rise**. Restoring natural tidal dynamics in estuarine systems to reduce **soil erosion**, and hence enhance coastal protection and deliver co-benefits such as biodiversity restoration and an increase in **water quality**.
- **West-Flanders** has identified **flooding** and **drought** as the main climate risks for their coastal landscape. Therefore, the region works on NbS that not only allow effective management of excess water in case of heavy rainfall events but also store this water locally for it to be available during the dry season (e.g., re-naturalisation of streams). **Water quality and salinisation** are also main concerns, especially in the case of agricultural land use.

5.5 Readiness level of solutions

The readiness level of a solution refers to its maturity for full-scale implementation: in the context of NBRACER, the maturity level of an NbS demonstrator and its potential for mainstreaming. It can cover both Technology Readiness Level (TRL), to estimate the technical maturity of NbS, and the Societal Readiness Level (SRL), to assess the level of societal adaptation of the demonstrator, including ethical, legal, social, and economic factors. Table 7 summarises the readiness level of the NBRACER Rural Demonstrators, including potential improvements by co-design in the project.

Table 7: Overview of the readiness level of the Coastal Demonstrators and its expected increase in the project, including the improvements by co-design.

Coastal Demonstrators	Expected increase of the solution's readiness level	Improvements by co-design
1. Restoration tidal regime	Solution already implemented in 2019.	Co-design will support the replication in the region.
2. Water level management	TRL 4 (medium) to 7-8	Gathering lessons learned, identifying enabling conditions and barriers, key stakeholder engagement.

3. Sustainable farming – non-tillage agriculture	TRL 5 to 7-8: demonstration of carbon farming and non-tillage practices in dedicated plots.	Social acceptance: support transition practices with farmers by collecting evidence on the benefits of NbS.

6 Conclusion and recommendations

The co-design processes documented in Deliverable D2.1 have demonstrated the value of participatory approaches in shaping NbS tailored to coastal climate resilience. Across the 3 Coastal Demonstrators, the integration of stakeholders has been instrumental in aligning technical feasibility with local needs and values. The diversity of regional contexts and solution types underscores the importance of flexible and context-sensitive co-design frameworks.

Key learnings from the discussion include:

- **Early-stage engagement is critical** – Most demonstrators are still in the initial phases of issue framing and knowledge gathering. These stages are essential for building trust, raising awareness of climate risks, and establishing a shared understanding of the challenges and opportunities.
- **Stakeholder diversity enhances solution robustness** – Demonstrators that actively involve a broader range of stakeholders, including also civil society and nature, tend to show stronger alignment with community priorities and greater potential for long-term adoption.
- **Readiness levels vary widely** – While some demonstrators are close to full-scale implementation, others require further technical validation, governance support, and societal buy-in. Co-design has allowed us to identify barriers and enabling conditions that influence readiness.
- **Climate risks are region-specific** – The demonstrators reflect a strong alignment between local climate hazards (e.g., flooding, drought, water quality) and the design of NbS. This reinforces the importance of place-based approaches in adaptation planning.

To enhance the effectiveness and scalability of co-design processes in future phases of NBRACER and similar initiatives, the following recommendations are proposed by the knowledge partners:

- **Enhance knowledge exchange** – Providing scientific evidence of its effectiveness in regulating flooding and erosion, as well as improving biodiversity and mitigating climate change. For this, findings from present demos can be used to inform discussions on NbS at other locations/regions.
- **Enhance engagement with stakeholders** – Engaging with society and communicating existing knowledge about the problems associated with climate change on the coast, as well as the various approaches/strategies that can be implemented to adapt our coasts.'
- **Support stakeholder engagement** – Develop a standardised protocol for the identification of coastal stakeholders and the design of engagement activities.

Overall, the co-design exercise has laid a solid foundation for mainstreaming of coastal NbS and has highlighted the importance of adaptive, inclusive, and integrative approaches. The lessons learned will inform the next phases of NBRACER, particularly in **developing robust regional portfolios** and **upscaling successful solutions across biogeographical contexts**. By implementing these recommendations, NBRACER can further strengthen its role as a catalyst for systemic climate adaptation through NbS, ensuring that solutions are not only technically sound but also socially accepted and institutionally supported.

7 References

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8 Appendix A: Glossary

Reported below is a glossary with a collection of definitions, abbreviations, and descriptions of important elements to take into consideration when filling in the template.

8.1 Climate risks

The European Climate Risk Assessment (EUCRA) enables a comprehensive assessment of the major climate risks Europe is facing today and in the future. It identifies **36 climate risks** that threaten energy and food security, ecosystems, infrastructure, water resources, financial systems, and people's health (**Table 8**).

Table 8: An extensive list of 36 major climate risks was identified in the comprehensive assessment of the European Climate Risk Assessment (EUCRA, European Environment Agency). Source: European Climate Risk Assessment (adapted).

Ecosystems	**1.** Coastal erosion and inundation in coastal ecosystems **2.** Anthropogenic pressure in marine ecosystems **3.** Risks to biodiversity and carbon sinks from increased frequency and intensity of wildfires **4.** Risks to biodiversity and carbon sinks from more frequent and severe drought and related insect pest outbreaks **5.** Species distribution shifts in food web dynamics and associated ecosystems **6.** Climate-induced species invasion **7.** Reduction of low flow in aquatic and wetland ecosystems **8.** Decreasing soil health **9.** Cascading impacts from forest disturbances
Food	**10.** Adverse weather conditions for crop production **11.** Risks to food security, agricultural production, and supply chains **12.** Risks to food and nutrition security from increasing prices **13.** Changed environmental conditions for fisheries and aquaculture **14.** Increased spread of pests and diseases for livestock production
Health	**15.** Heat stress in human health **16.** Risks to population and built environment from wildfire, heat and drought **17.** Risk to wellbeing due to non-adapted buildings **18.** Health stress for outdoor workers from increased heat **19.** Emergence of harmful pathogens in waters **20.** Stress to health systems and health infrastructure **21.** Geographic expansion and spread of infectious diseases

Infrastructure	**22.** Risks to population, infrastructure, and economic activities from pluvial, and fluvial flooding **23.** Risks to population, infrastructure, and economic activities from coastal flooding **24.** Damage to infrastructure and buildings **25.** Energy disruption due to heat and drought **26.** Energy disruption due to flooding **27.** Widespread disruption of marine transport **28.** Widespread disruption of land-based transport
Economy	**29.** Compromise of European solidarity mechanisms **30.** Public finances leading to a financial crisis **31.** Stability of European property and insurance markets **32.** Risks to population and economic sectors due to water scarcity **33.** Interruption of pharmaceutical supply chains **34.** Disruption in key industrial sectors of supply chains for raw materials and components **35.** Disruption of financial markets **36.** Inviabilization of winter tourism in regions that highly depend on it

8.2 Enabling conditions & Key Community Systems

The **Enabling Conditions** refer to the means for enabling innovation that are intrinsic to the regions. The EU Mission on Adaptation to Climate Change mentions 4 Enabling Conditions on the edges of the chart (**Figure 41**): (1) **knowledge and data** to reveal what is happening and how the solutions help; (2) **governance** and political structure, as well as **engagement** from citizens and stakeholders; (3) **finance and resources** of the local economic systems; (4) **behavioural change**.

The **Key Community Systems (KCSs)** correspond to the key areas and underlying systems where innovation can happen within the regions. The EU Mission on Adaptation to Climate Change refers to 6 KCSs in the middle of the chart (**Figure 41**): (1) **critical infrastructure**; (2) **health and well-being**; (3) **land use and food systems**; (4) **water management**; these are all linked to (5) **ecosystems and nature-based solutions**, together with the (6) **local economic systems**. A detailed list of KCSs as defined within NBRACER can also be found in T5.1 Annexe (KCS).

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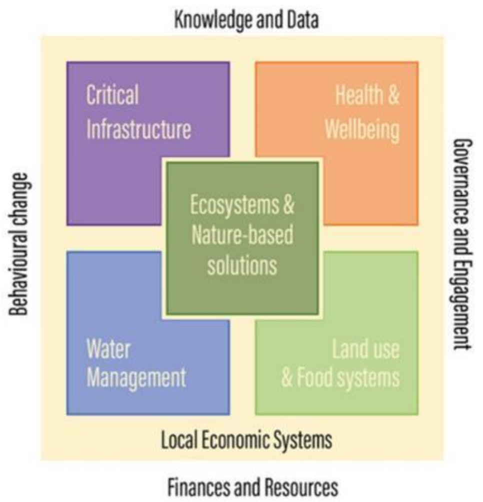

Figure 41: Key innovation areas mentioned in the EU Mission for adaptation to climate change. Source: [A solutions-focused approach to adapting Europe to the climate crisis | Research and Innovation]

8.3 Ecosystem Services

The World Bank has provided a framework to support the identification of suitable investments on NbS based on the processes taking place, which functions can be extracted from those (i.e., Ecosystem Services), and which benefits they give for people (i.e., co-benefits) (**Figure 42**).

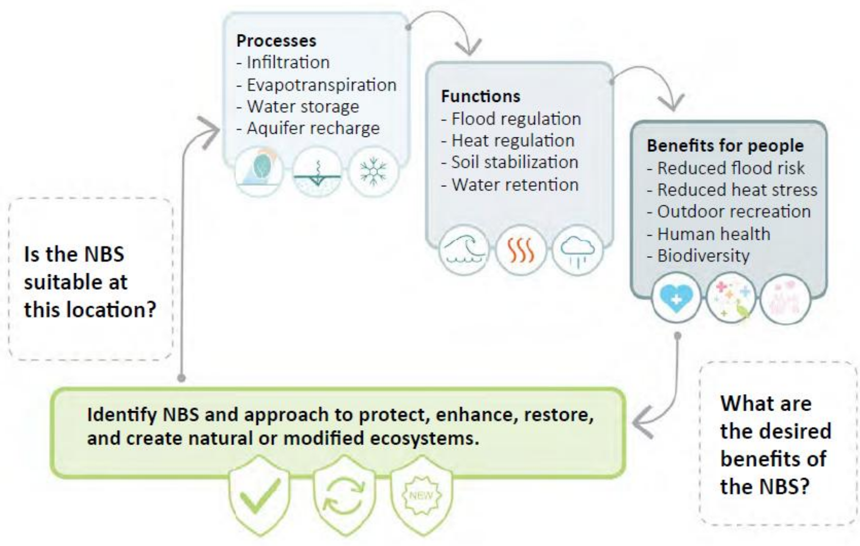

Figure 42: Framework to support the identification of suitable implementation of NbS at a given location based on the processes taking place, providing functions and benefits for people. Source: World Bank, 2021 (adapted).

Ecosystem Services (ES) are the services that an ecosystem supplies and from which humans can take benefit. The European Environment Agency (EEA) proposes the following thematic, class and group structure for a Common International Classification of Ecosystem Services (CICES) (**Figure 43**):

- **Provisioning:** which covers material or energetic outputs from ecosystems, including food, water and other resources;
- **Regulation and maintenance:** which covers factors that affect the ambient biotic and abiotic environment, such as flood and disease control, nutrient cycling and primary productivity, that maintain the conditions for life on Earth;
- **Cultural:** which covers non-material (intellectual, cognitive, symbolic) uses, such as spiritual and recreational benefits.

Theme	Class	Group
Provisioning	Nutrition	Terrestrial plant and animal foodstuffs
		Freshwater plant and animal foodstuffs
		Marine plant and animal foodstuffs
		Potable water
	Materials	Biotic materials
		Abiotic materials
	Energy	Renewable biofuels
		Renewable abiotic energy sources
Regulation and Maintenance	Regulation of wastes	Bioremediation
		Dilution and sequestration
	Flow regulation	Air flow regulation
		Water flow regulation
		Mass flow regulation
	Regulation of physical environment	Atmospheric regulation
		Water quality regulation
		Pedogenesis and soil quality regulation
	Regulation of biotic environment	Lifecycle maintenance & habitat protection
		Pest and disease control
		Gene pool protection
Cultural	Symbolic	Aesthetic, Heritage
		Religious and spiritual
	Intellectual and Experiential	Recreation and community activities
		Information & knowledge

Figure 43: Classification of Ecosystem Services: thematic, class and group structure proposed by Common International Classification of Ecosystem Services (CICES, European Environment Agency). Source: [Classification of ecosystem services (EEA) (UNCEEA/5/7) Introduction to the CICES proposal.]

A detailed list of ES, as defined within NBRACER, can also be found in D5.1 Annexe (Ecosystem Services). The **ES provided by NbS** can be subdivided into the **main regulatory function and co-benefits**. The main regulatory function corresponds to the main purpose of their design, referring to the specific (climate) challenge to which the solutions aim to respond. Nonetheless, NbS often provide other ES beyond their design purpose – these are referred to as **co-benefits**. See the example below (**Figure 44**) for a better understanding of the two concepts (in this case, the main regulatory function is urban flood management, and several direct and indirect co-benefits have been identified).

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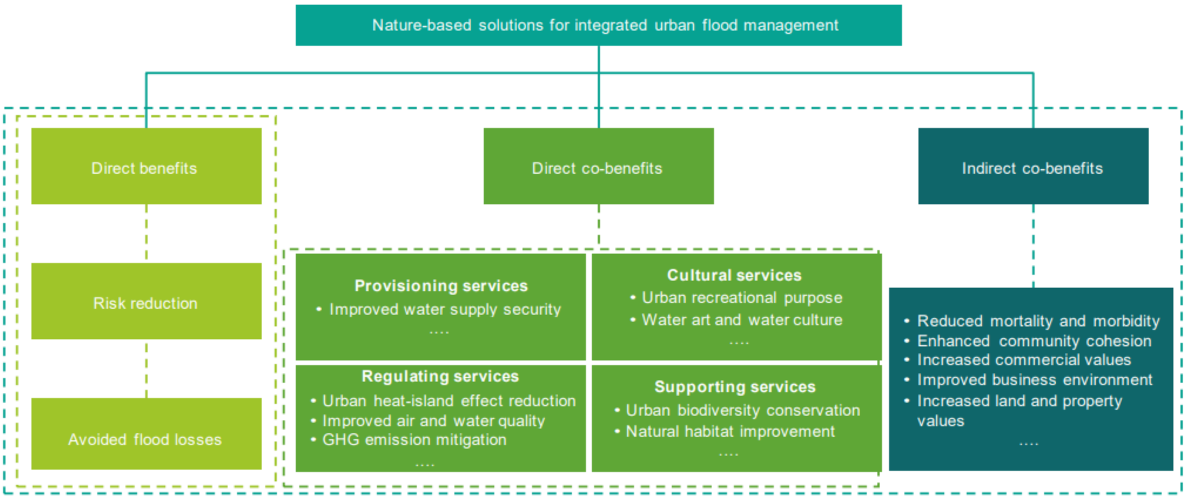


Figure 44: Example of benefits and Ecosystem Services provided by NbS for integrated urban flood management. Source: Wishart et al., 2021.

8.4 Readiness level

The readiness level refers to the maturity of a solution for full-scale implementation, i.e., the maturity level of an NbS demonstrator and its potential for mainstreaming. It can cover both **Technology Readiness Level (TRL)**, to estimate the technical maturity of NbS, and **Societal Readiness Level (SRL)**, to assess the level of societal adaptation of the demonstrator, including ethical, legal, social, and economic factors. The schemes below illustrate what each readiness level corresponds to in terms of TRL (**Figure 45**) and SRL (**Figure 46**).

TRL	Description	Example
1	Basic principles observed	Scientific observations made and reported. Examples could include paper-based studies of a technology's basic properties.
2	Technology concept formulated	Envisioned applications are speculative at this stage. Examples are often limited to analytical studies.
3	Experimental proof of concept	Effective research and development initiated. Examples include studies and laboratory measurements to validate analytical predictions.
4	Technology validated in lab	Technology validated through designed investigation. Examples might include analysis of the technology parameter operating range. The results provide evidence that envisioned application performance requirements might be attainable.
5	Technology validated in relevant environment	Reliability of technology significantly increases. Examples could involve validation of a semi-integrated system/model of technological and supporting elements in a simulated environment.
6	Technology demonstrated in relevant environment	Prototype system verified. Examples might include a prototype system/model being produced and demonstrated in a simulated environment.
7	System model or prototype demonstration in operational environment	A major step increase in technological maturity. Examples could include a prototype model/system being verified in an operational environment.
8	System complete and qualified	System/model produced and qualified. An example might include the knowledge generated from TRL 7 being used to manufacture an actual system/model, which is subsequently qualified in an operational environment. In most cases, this TRL represents the end of development.
9	Actual system proven in operational environment	System/model proven and ready for full commercial deployment. An example includes the actual system/model being successfully deployed for multiple missions by end users.

Figure 45: Technology Readiness Level (TRL) scale diagram. Source: What are Technology Readiness Levels (TRL)? - TWI (adapted).

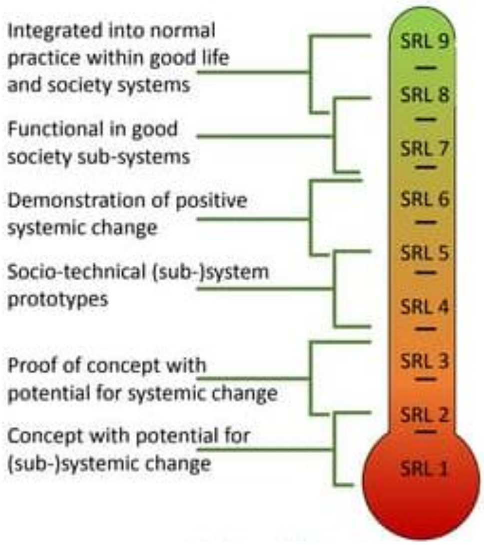


Figure 46: Societal Readiness Level (SRL) scale diagram. Source (adapted): Cut Carbon Symposium: Societal Readiness Levels | PPT (adapted).

8.5 Landscape (sub)archetypes

NBRACER considers 3 landscape types: **marine & coastal**, **urban**, and **rural**. Nonetheless, it is relevant to further characterise landscape (sub)archetypes in order to better define each region and draw conclusions based on replicability and suitability of solutions across contexts. The framework for the landscape (sub)archetypes refers to three different types of datasets: (i) the **European CORINE Land Cover classes** (as initially addressed in the NbS questionnaire) in combination with others, such as Copernicus Urban Atlas and Coastal Zones (**Table 9**); (ii) the landscape archetypes are translatable and relate to all the **functional units of the conceptual model formulated in Task 5.1** (**Table 10**); and (iii) whenever data is available, **base layers are also considered** for specific landscape characterisation relating to **geomorphology, soil type, groundwater levels, elevation**, etc.

Table 9: European CORINE Land Cover classification.

Artificial surfaces	Agricultural areas	Forest and semi-natural areas	Wetlands	Water bodies
• Continuous urban areas • Discontinuous urban areas • Industrial or commercial units • Road and rail networks and associated land • Port areas • Airports • Mineral extraction sites • Dump sites • Construction sites • Green urban areas • Sport and leisure facilities	• Non-irrigated arable land • Irrigated land arable land • Rice fields • Vineyards • Fruit trees and berry plantations • Olive groves • Pastures • Annual crops associated with permanent crops • Complex cultivation patterns • Land principally occupied by agriculture, with significant areas of natural vegetation • Agroforestry areas	• Broad-leaved forest • Coniferous forest • Mixed forest • Natural grasslands • Moors and heathland • Sclerophyllous vegetation • Transitional woodland-shrub • Beaches, dunes, sands	• Inland marshes • Peat bogs • Salt marshes • Salines • Intertidal flats	• Water courses • Water bodies • Coastal lagoons • Estuaries • Sea and ocean

Table 10: Detailed list of functional units identified for the conceptual model (Deliverable 5.1).

Functional units	Dominant geomorphic processes	Definition	Geomorphic Classification System
Interfluve	Pedogenetic processes associated with vertical subsurface soil water movement	The area between rivers; esp. the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. (Bates and Jackson, 1995)	(Haskins, et al. 1998) [Common landform] **Interfluve**
Hillslope (Montgomery, 1999)	Slope processes	A positive relief generated by an unspecified tectonic/structural process. A positive relief generated by bedrock bedding (modified after Huggett, 2017).	(Nanson, et al., 2022) Solid Earth BGU: **Tectonic high** BGU-T: Compressional ridge; tectonic dome BGU: **Bedding ridge** BGU-T: Cuesta; homoclinal ridge; hogback

		A natural elevation of the land surface, rising rather prominently above the surrounding land, usually of limited extent and having a well-defined outline (rounded rather than peaked or rugged), and generally considered to be less than 300 m from base to summit; the distinction between a hill and a mountain is arbitrary and dependent on local usage. (Bates and Jackson, 1995). Any part of the Earth's crust higher than a hill, sufficiently elevated above the surrounding land surface of which it forms a part to be considered worthy of a distinctive name, characterized by a restricted summit area (as distinguished from a plateau), and generally having comparatively steep sides and considerable bare rock surface; it can occur as a single, isolated eminence, or in a group forming a long chain or range, and it may form by earth movements, erosion, or volcanic action. Generally, a mountain is considered to project at least 300 m above the surrounding land.	(Haskins, et al. 1998) [Landscape Term] **Hill** [Landscape Term] **Mountain**
Hollow/Torrent (Montgomery, 1999)	Processes of water flow concentration (runoff) only after precipitation events. The rest of the time, slope processes dominate	Though diverse in form, GULLIES tend to be relatively small (though larger than RILLS), steep, narrow, deeply incised SUBAERIAL CHANNELS that are carved into unconsolidated regolith (modified from Goudie, 2006).	(Nanson, et al., 2022) Coastal or fluvial BGU: Subaerial channel BGU-T: **Gully**
		A very small valley, such as a small ravine in a cliff face, or a long, narrow hollow or channel worn in earth or unconsolidated material (as on a hillslope) by running water and through which water runs only after a rain or the melting of ice or snow; it is smaller than a gulch. (b) Any erosion channel so deep that it cannot be crossed by a wheeled vehicle or eliminated by plowing, esp. one excavated in soil on a bare slope. (c) A small, steep-sided wooded hollow. (Bates and Jackson, 1995).	(Haskins, et al. 1998) [Common Landform] **Gully**

River channel and banks (Montgomery, 1999)	Stream processes, driven by water flow	Formed of alluvium, usually have mobile boundaries and are self-adjusting in response to changing conditions. Commonly parabolic or trapezoid in cross section with adjacent, roughly horizontal FLOODPLAINS are inundated when the channel exceeds bankfull capacity (modified from Goudie, 2006).	*(Nanson, et al., 2022)* Coastal or fluvial BGU: **Subaerial channel** BGU-T: River; Creek
		The bed where a natural body of surface water flows or may flow; a natural passageway or depression of perceptible extent containing continuously or periodically flowing water, or forming a connecting link between two bodies of water; a watercourse. (Bates and Jackson, 1995). The sloping margin of, or the ground bordering, a stream, and serving to confine the water to the natural channel during the normal course of flow. It is best marked where a distinct channel has been eroded in the valley floor, or where there is a cessation of land vegetation. A bank is designated as right or left as it would appear to an observer facing downstream. (Bates and Jackson, 1995).	*(Haskins, et al. 1998)* [Fluvial Landform and Microfeature] Stream Processes (Subprocess Modifiers: Undifferentiated, Eroding, Transporting or Depositional) - **Channel** - **Bank**
Riparian zone	Riparian processes, driven by a high lateral-vertical connectivity between the river and the terrestrial area	Transitional semiterrestrial areas regularly influenced by freshwater, normally extending from the edges of water bodies to the edges of upland communities. These are 'three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems' (Gregory et al. 1991). In this sense, flood recurrence interval may be an objective approach to delineate the outward boundary of the riparian zone. In this regard, the 50-yr flood has been indicated as an appropriate hydrological descriptor for riparian zones as it usually coincides with the first terrace or other upward sloping surface (Ilhardt et al., 2000).	

Floodplain (Montgomery, 1999)	Recurrent river flooding processes	The relatively flat area of land between the banks of the parent stream and the confining valley walls, over which water from the parent stream flows at times of high discharge. The sediment that comprises a FLOODPLAIN is mainly alluvium derived from the parent stream (modified from Goudie, 2006) and can be comprised of CONFINED / CUT-AND-FILL, BRAIDED, LATERAL MIGRATION or ANABRANCHING FLOODPLAIN deposits (Nanson and Croke, 1992).	(Nanson, et al., 2022) Coastal or fluvial BGU: **Floodplain** BGU-T: High-energy confined floodplain; Medium-energy unconfined floodplain; Low-energy cohesive floodplain
		A small alluvial plain bordering a river, on which alluvium is deposited during floods. (Bates and Jackson, 1995).	(Haskins, et al. 1998) [Fluvial Element Landform] Stream Processes (Subprocess Modifiers: Undifferentiated, Eroding, Transporting or Depositional) - tplain o **Alluvial flat** o Meander scar o Meander scroll o Oxbow o Levee

Estuary	Marine-river mixing processes determined by the tidal cycle	A near-horizontal depositional surface formed above the mean high water spring tide level. Typically located on the landward margins of saltmarshes and along **estuary** and lagoon shorelines.	(Nanson, et al., 2022) Coastal BGU: tidal flat BGU-T: supratidal flat
		The seaward end or the widened funnel-shaped tidal mouth of a river valley where freshwater comes into contact with seawater and where tidal effects are evident; e.g., a tidal river, or a partially enclosed coastal body of water where the tide meets the current of a stream (Bates and Jackson, 1995).	(Haskins, et al. 1998) [Coastal Marine Landform] Shoreline Processes - **Estuary**
Delta	Sedimentation processes are subject to tidal, waves and currents dynamics	A discrete shoreline sedimentary protuberance formed where a river enters a body of water and supplies sediment more rapidly than it can be redistributed by basinal processes (modified from: Elliott, 1986).	(Nanson, et al., 2022) Coastal and fluvial BGU: **delta** BGU-T: front; pro-; upper; lower; bayhead; shelf edge; tidal delta

		The low, nearly flat, alluvial tract of land at or near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area, crossed by many distributaries of the main river, perhaps extending beyond the general trend of the coast, and resulting from the accumulation of sediment supplied by the river in such quantities that it is not removed by tides, waves, and currents. Most deltas are partly subaerial and partly below water. (Bates and Jackson, 1995) The level or nearly level surface composing the landward part of a large delta; strictly, an alluvial plain characterised by repeated channel bifurcation and divergence, multiple distributary channels, and interdistributary flood basins. (Bates and Jackson, 1995)	(Haskins, et al. 1998) [Landscape term] **Delta** [FLuvial Landform] Stream Processes (Subprocess Modifiers: terminal deposition) - **Delta** ○ **Delta plain**
Coastal cliff	Wave erosion	A steep slope, or ESCARPMENT formed in rock, ranging in height from tens to hundreds of metres.	(Nanson, et al., 2022) Coastal BGU: rocky coast BGU-T: **cliff**
		A cliff or slope produced by wave erosion, situated at the seaward edge of the coast or the landward side of the wave-cut platform, and marking the inner limit of beach erosion. It may vary from an inconspicuous slope to a high, steep escarpment. (Bates and Jackson, 1995)	(Haskins, et al. 1998) [Coastal Marine Landform] Shoreline Processes - **Cliff**

Intertidal reef		A general term for an occurrence of rock, biogenic, or other stable material that lies at or near the sea surface and is elevated at least partially above the surrounding seabed (in the intertidal case: the area above water level at low tide and underwater at high tide). In-situ, positive relief, persistent build-ups of primarily skeleton-supported framework (+ internal binding), that influence the local sedimentary environment (Klement, 1967), and support (or supported) living communities during active accretion. Definition modified from a range of sources: (Cumings, 1932; Goudie, 2006; Harris and Baker, 2020; Klement, 1967; Lo Iacono et al., 2018). Cf. REEF (Marine Setting)	(Nanson, et al., 2022) Biogenic - Marine BGU: **reef** BGU-T:
		A bioherm of sufficient size to develop associated facies. It is erected by, and composed mostly of the remains of, sedentary or colonial and sediment-binding organisms, generally marine: chiefly corals and algae, less commonly crinoids, bryozoans, sponges, molluscs, and other forms that live their mature lives near but below the surface of the water (although they may have some exposure at low tide; in fact, in the intertidal case: the area above water level at low tide and underwater at high tide). Their exoskeletal hard parts remain in place after death, and the deposit is firm enough to resist wave erosion. An organic reef may also contain still-living organisms. (Bates and Jackson, 1995)	(Haskins, et al. 1998) [Coastal Marine Landform] Shoreline Processes - **Organic reef**
Subtidal coast		A low gradient surface formed below the mean low tide level. Typically located at the seaward of saltmarsh and mangrove communities.	(Nanson, et al., 2022) Coastal BGU: tidal flat BGU-T: **subtidal flat**

		(a) A strip of land of indefinite width (may be many kilometres) that extends from the low tide line inland to the first major change in landform features (remains submerged except during particularly low tides). (Bates and Jackson, 1995) An extensive, nearly horizontal, marshy or barren tract of land that remains submerged except during particularly low tides and consisting of unconsolidated sediment (mostly mud and sand). It may form the top surface of a deltaic deposit. (Bates and Jackson, 1995)	(Haskins, et al. 1998) [Landscape term] **Coast** [Coastal Marine Landform] Shoreline Processes - **Subtidal flat**
Coastal land-reclamation area or polder?		Land reclamation is the process of creating new land from the sea. The simplest method of land reclamation involves simply filling the area with large amounts of heavy rock and/or cement, then filling with clay and soil until the desired height is reached. Draining of submerged wetlands is often used to reclaim land for agricultural use. (Stauber et al., 2016)	
Polder or coastal land-reclamation area		Originally meaning silted-up land or earthen wall, and generally used to designate a piece of land reclaimed from the sea or from inland water. It is used for a drained marsh, a reclaimed coastal zone, or a lake dried out by pumping. (Eisma, 2014)	

9 Appendix B: Structure of the demonstrator canvas on MIRO

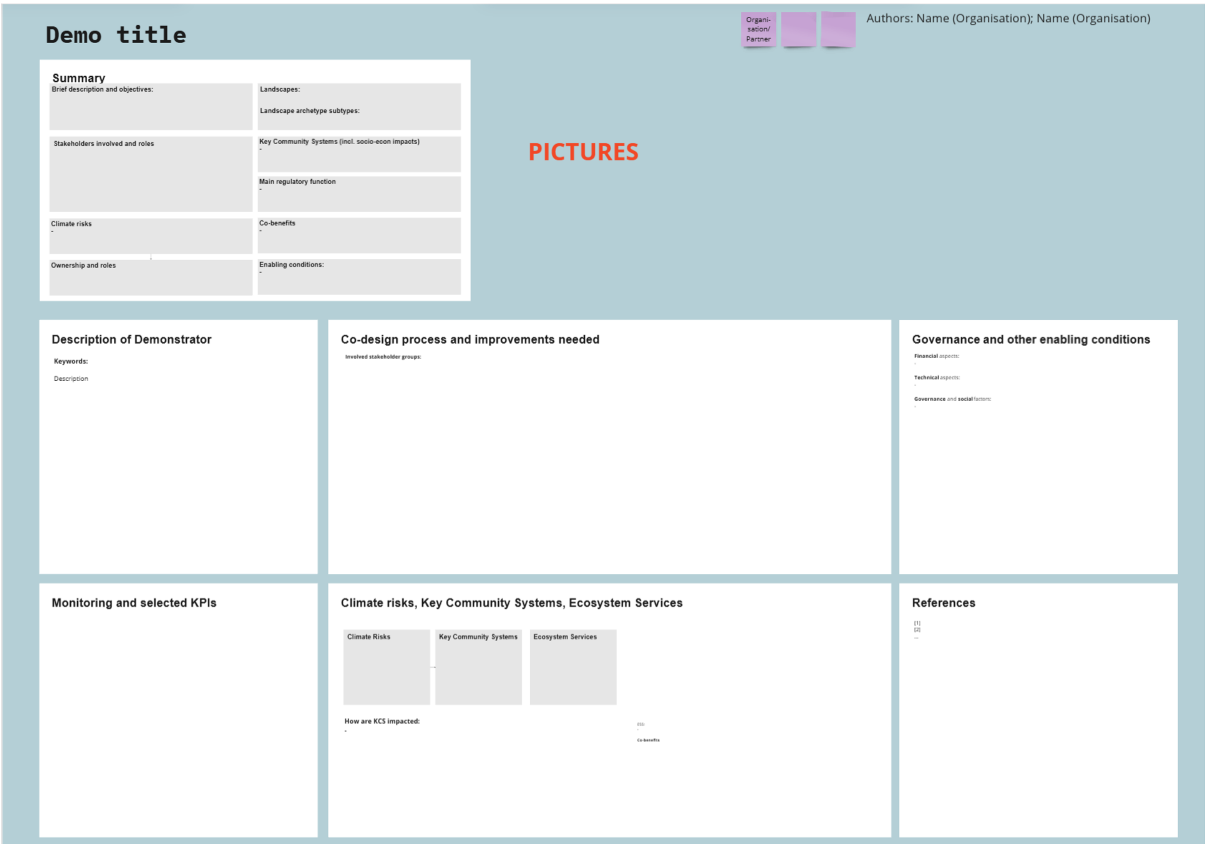


Figure 47: Structure of the MIRO canvas for co-design (illustrative blank).

9.1 Summary

Write a summary about your NbS case that allows readers to quickly grasp what it is about (max 5 sentences). Please include pictures (max 5) to better illustrate the system to the readers.

Brief description and objectives *Briefly describe your case and its research objectives. Make sure to use terms for a non-expert reader.*	**Landscape types and (sub)archetypes** *Select the landscape types of the project and the (sub)archetypes (see the Appendix* A: Glossary *section for more information). If the case addresses more than one landscape, make sure to mention it here.*
Stakeholders involved and roles *Mention which stakeholders have been involved in your demonstrator and which role they have (e.g., involved, informed, decision maker).*	**Key Community Systems** *Refer to the 6 Key Community Systems (KCSs) as mentioned in the EU Mission on Adaptation to Climate Change (see the Appendix* A: Glossary *section for more information).* **Main regulatory function** *Describe which regulatory function that your demonstrator is addressing, i.e., which is the propose of design of your NbS (see the Appendix* A: Glossary *section for more information on the concept of Ecosystem Services).*
Climate risks *Refer to the climate risks as mentioned in the European Climate Risk Assessment (see the Appendix* A: Glossary *section for more information).*	**Co-benefits** *NbS often provide extra Ecosystem Services besides its main regulatory function or purpose for design. Reflect which extra benefits your solution can contribute to in terms of climate mitigation, adaptation, and resilience (see the Appendix* A: Glossary *section for more information on the concept of Ecosystem Services).*
Ownership and roles *Describe the ownership structure of your case, i.e., who the owner is, who is responsible for maintenance and operation of the systems, and how is the setup facilitated in terms of financing.*	**Enabling conditions** *Refer to the 4 Enabling Conditions as mentioned in the EU Mission on Adaptation to Climate Change (see the Appendix* A: Glossary *section for more information).*

9.2 Description of the demonstrator

Link to the sections 'brief description and objectives' and 'landscape types and (sub)archetypes' in the summary. Provide a short description of the demonstrator case, including keywords (max. 4) and the following information:

- Technical description of the demonstrator (include technical plans, if applicable);
- Location of the demonstrator (and contextual background, if relevant);
- Description of the processes involved, including which NbS have been tested and demonstrated;
- Why this case has been selected for the project;
- How the demonstrator relates to existing adaptation plans, as well as the regional adaptation journey and the vision drafted for the region;
- Use references to reports and literature.
- Max 15 lines.

9.3 Co-design process and improvements needed

Link to the sections 'stakeholders involved and roles' and 'co-design process' in the summary. Describe the co-design process tailored according to the demonstrator, and how this co-design is contributing to improving the solution and increasing its readiness level. Consider the following key aspects:

- Which are the involved stakeholder groups and how have they been involved?
- Which role does each stakeholder play in the process?
- How is the bridge between scientific knowledge and practice of the demonstrator?
- Does the region succeed in the interplay between stakeholders?
- Does the region succeed in involving new stakeholders and in communicating to the wider public?
- Which are the barriers along the co-design process and issues to be solved?
- What is the focus of the co-design in NBRACER project?
- How is NBRACER project, partnership and approach supporting the demonstrator?
- What are the benefits of NBRACER support?
- Lessons learned by co-design in other (NbS) projects
- Which aspects are needed to upscale the solution and can be addressed by co-design?
- What is the current readiness level of the demonstrator and how is the co-design process contributing to mainstreaming the solution?
- To what extend has the demonstrator shown progress (technological, organizational, social/societal)?
- How are the co-design barriers being addressed?
- What are the plans for long-term engagement of the stakeholders?
- What is the timeline foreseen for the process of the demonstrator?
- Use references to reports and literature.
- Max 40 lines.

9.4 Governance and other enabling conditions

Link to the sections 'ownership and roles' and 'enabling conditions' in the summary. Please describe the contribution of each enabling condition for mainstreaming NbS in the demonstrator, with particular relevance on **governance aspects**, and including the following:

- What are the main barriers for implementation?
- Are there any gaps on knowledge and data to increase the readiness level of the solution?
- What is the governance structure behind the demonstrator (incl. funders and decision makers)?
- If relevant, what is the perception of stakeholders and citizens over the solution? Is there willingness for the behavioural and systemic changes needed to mainstream this solution?
- Are there any needs for extra financing resources to mainstream the solution?
- Use references to reports and literature.
- Max 15 lines.

9.5 Monitoring and selected KPIs

Please describe the monitoring framework and which Key Performance Indicators (KPIs) are under consideration for the demonstrator case. If there is no monitoring strategy already in place, please include this information in this section. A more detailed report regarding monitoring will be elaborated in the upcoming phase of the project (related to Dx.2 on lessons learnt from monitoring).

- Use references to reports and literature.
- Max 10 lines.

9.6 Climate risks, Key Community Systems, Ecosystem Services

Link to the 'climate risks', 'Key Community Systems', 'main regulatory function' and 'co-benefits' sections in the summary. Please provide additional information on (see the Appendix A: Glossary section for more information):

- Describe further the climate risks tailored to the demonstrator
- Describe how the identified KCSs relate to the demonstrator
- How are the identified KCSs impacted by the climate risks in the context of the demonstrator?
- Does the demonstrator address risks for maladaptation?
- How does the demonstrator address the **main regulatory function and purpose for its design**?
- Describe the **co-benefits** provided by the demonstrator and its contribution (e.g., qualitative score, such as negative – low – medium – high).
- If the demonstrator has negative impacts, please refer them here as **disservices** (e.g., converting arable land into a wetland for water treatment will lower the crop production yield per area of available land).

- If applicable, describe which tools/methodologies are available for quantifying the Ecosystem Services delivered by the demonstrator.
- Use references to reports and literature.
- Max 20 lines.

9.7 References

Please add any references to scientifically back up what you have described in the remaining sections of the canvas. You can number them and refer with '[x]' in the text (cfr. "engineering is described in [1]").

10 Appendix C: High-quality versions of the MIRO canvas per demonstrator

Restoration of natural tidal regime in Oyambre estuary

Authors: Name (Organisation);

FIHAC

UC

- María Recio
- Inés Mazarrasa
- María Maza
-Laura Martín

Summary

Brief description and objectives:
Restoring natural tidal dynamics in estuarine systems to enhance coastal protection and deliver co-benefits such as carbon sequestration, biodiversity restoration and increase in water quality

Landscapes: COASTAL

Landscape archetype subtypes: claimed areas, estuaries, dune systems

Stakeholders involved and roles

- General public (surveys)
- Coastal Ministry (National Administration) Advisor
- IHCantabria (Uni. Can-FIHAC) Project coordination. Design, baseline and monitoring
- Environmental NGOs (SEOBirdlife as technical advisor)
- Complex Governance at different levels (national, regional, municipality)

Key Community Systems (incl. socio-econ impacts)
- Ecosystem, biodiversity, invasive species, water system
- Road
- Tourism and recreational resources

Main regulatory function
- Coastal protection

Climate risks
Sea level rise, Flooding, Soil erosion

Co-benefits
- Biodiversity, carbon sequestration, water quality

Ownership and roles

Public

Enabling conditions:
-

Description of Demonstrator

Keywords: Coastal protection, Dyke removal, Natural tidal regime, Improve biodiversity, Monitoring the evolution of some EESS, carbon sequestration

Description

Solution implemented in 2019. Removal of a dyke to partially restore the natural tidal regime in an estuarine system.
The dyke could not be totally removed as it was used by the local communities to access the beach (as a shortcut). Thus, an intermediate solution with the municipality was adopted. The dyke height was lowered to allow water to surpass during high tides but allow people to cross during low tides. In addition, a small area of the dyke was totally removed to allow complete water circulation and covered with a small bridge to allow people passing.

Co-design process and improvements needed

Involved stakeholder groups:

·**National administration: Ministry of Environment** (Coastal and Marine Environments). The Spanish coastal zone has been designated as public domain and is managed by the Ministry of the Environment. Therefore, any action must be communicated and approved by the Ministry. Moreover, this agency is responsible for coastal flood risk management and climate change adaptation.
·**Local administration**: The municipalities are responsible for the management of its territory in terms of access, use management, permits and building licenses…
·**Citizens/tourists**: For some residents, the possible changes in the access to the beaches (in spite of being a dangerous access) could be a problem.
Non-profit associations: The Oyambre estuary is part of several protected areas and there are many natural values that must be preserved. Therefore, environmental NGOs were involved in the design of the coastal solution

Co-design actions:

- A map of coastal stakeholder were carried out
- Technical dissemination actions (i.e. workshops and discussion tables) were held with:
  - Managers and competent authorities
  - Research centers and universities
  - Conservation entities
  - Neighbors and citizens
- Public surveys to citizens and tourists
- Face to face meetings with local and national autorities

Future actions

Since the action was implemented few years ago, the co-design process within NBRACER is more focused on mainstreaming and replication potential, i.e., how to increase the implementation of this solution in other estuaries in Cantabria and other EU regions.

We will try to achieve this by two complementary approaches:
1) Providing scientific evidence of its effectiveness in regulating flooding and erosion, as well as improving biodiversity and mitigating climate change.
2) Engaging with society and communicating existing knowledge about the problems associated with climate change on the coast, as well as the various approaches/strategies that can be implemented to adapt our coasts.

Needs:

In order to achieve the co-design goals, standarized processes for stakeholders identification are needed as well as standarized approached for public dissemination and engagement.

Governance and other enabling conditions

Financial aspects:
- The implementation of the solution was supported by the EU LIFE Programme through the CONVIVE LIFE project.

Technical aspects:
- The dike was in very poor condition, so partial conservation was not possible. This implied changes in the technical design of the final solution.

Governance and **social** factors:
- The removed infrastructure was used for pedestrian access to the beach, so the final design of the project had to ensure that access to the beach was maintained
- Local (Municipality), regional (Cantabria Government) and national (Ministry) administrations are involved in the management of the area.
- The area is included in two protected areas: SAC Rías Occidentales y Duna de Oyambre (Natura 2000 network) and Natural Park of Oyambre.

Monitoring and selected KPIs

The monitoring strategy for this NbS focuses on **evaluating its effectiveness in reducing erosional problems and the flooding risk, as well as conserving biodiversity** by control of IAS.

Monitoring approach
- Reduce flooding: FIHAC and UC are developing flood maps for different CC scenarios.
- Reduce erosion: FIHAC and UC are analysing the evolution of mudflats and changes in the beach that closes the estuary. Sedimentation/erosional rates at some have also been monitored.
- Co-benefits: FIHAC and UC are monitoring the CO2 storage, changes in biodiversity and the water quality

Key Performance Indicators (KPIs)
- Sedimentation/erosional rates (cm y-1)
- Mudflat and beach extension close to the action: surface (m2) of these habitats
- Flooded area: surface water extension
- Soil Carbon storage: Changes in soil organic carbon stocks within the top 20-40 cm (g Corg m-2).
- Biomass carbon storage: Organic carbon content in vegetation biomass per surface area (g Corg m-2)
- Vegetation communities and habitats: species composition and distribution
- Presence of plant invasive alien species (IAS): surface area occupied by IAS
- Benthic biodiversity: Diversity (Shannon index) and abundance of benthic

Climate risks, Key Community Systems, Ecosystem Services

Climate Risks	Key Community Systems	Ecosystem Services
- Soil erosion - Sea level rise - Flooding	- Ecosystem - Biodiversity - Invasive species (IAS) - Water system	- Coastal protection - Biodiversity - Carbon storage - Water quality

How are KCS impacted:
Dike removal → Reestoration of natural hydrodinamic conditions:
→ IAS control
→ Estuarine biodiversity and functioning recovery
→ Water quality improvement
→ Reduce flooding and erosion

ESS:
- Coastal protection (reduce flooding and erosion)

Co-benefits
- Carbon storage capacity
- Biodiversity
- Water quality

References

[1] LIFE AdaptaBlues & Revista Quercus. (2024, July). *El estuario de Oyambre: Un laboratorio vivo en el litoral cantábrico. 461*, 26–33. (https://www.revistaquercus.es/noticia/8819/quercus-experience/el-estuario-de-oyambre:-un-laboratorio-vivo-en-el-litoral-cantabrico.html)

[2] https://lifeadaptablues.eu/es/

[3] https://convivelife.es/areas-de-actuacion/estuario-de-oyambre/

Water level management in Oudlandpolder: Uitkerkse Polder

Authors: Fien Goovaerts (VLM); Bastiaan Notebaert (VITO), Els De Roeck (PWF)

VLM

VITO

Prov WFl

Scale: regional

Summary

Brief description and objectives:
In order to achieve an agreement on water levels, the water level agreement ('peilbesluit') for the Oudlandpolder is under construction (2024-2027). This is an agreement on surfacewater levels for different compartments of a region considering dominant use and optimal conditions in dry and wet periods. NBRACER will support the proces to come from a vision to an agreement on landscape scale and to a proposal for design. This is a pilot region and one of the first in Flanders to apply this aproach. Regarding its specific context of a polder landscape it is suited well as an example because controlling waterlevels is more easy in flat and more regulated watersystems. Outscaling is a challenge because of its specific characteristics, but the general process can serve as an interesting pioneering project with high potential for upscaling and outscaling in several landscapes and regions.

Landscapes: Coastal, rural

Landscape archetype subtypes: Polders
Oudlandpolder, Uitkerkse Polder (natural use dominant)

Stakeholders involved and roles
- Province West-Flanders
- Vlaamse Landmaatschappij
- VMM
- Regionaal Landschap
- Municipalities
- Natuurpunt
- Departement Omgeving
- ILVO
- Westtoer
- Polders (Blankenberge)

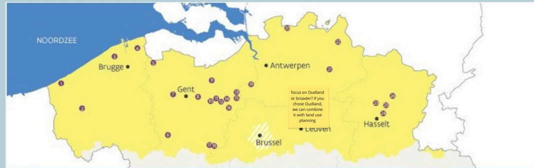
Main regulatory function
- watermanagement

Climate risks
- Drought
- Flooding
- Water quality and salinization

Co-benefits

Ownership and roles
- VLM: projectmanagement
- Province: active actor and watermanager
- VMM: responsible for peilbesluiten
- Gemeente: active actor representing the community
...

Enabling conditions
- Governance: watertoets



Nummer	Naam gebied
1	Oude Veurnevaart-Langeleed-Lenspolder
2	Blankaart
3	Oudlandpolder
4	Isabellavaart-Zwinnevaart
5	Polder van Maldegem
6	Scheldemeersen - Meldenmeersen - Langemeersen
7	Oude Kale
8	Damvallei
9	Moervaart-Zuidlede
10	Kalkense Vaart
11	Leegpoed-Turfput-Berlarebroek en Donkmeer
12	De Konkel
13	Moerzeke-Gespoelde Put/Grembergen

Nummer	Naam gebied
14	Sint-Onolfspolder en Meirdam
15	Vlassenbroek
16	Denderbellebroek
17	Zandbergenplein
18	Klakvijver
19	Oudbroek-Schellandpolder
20	PS Darmloop - De Maatjes
21	De Zegge
22	De Liereman (Oud-Turnhout / Arendonk)
23	Vallei Laambeek
24	Wik, Bokrijk, Kiewit, Zusterkloosterbeek, Schrijnebroeksbeek
25	Roosterbeek, Slangbeek en vijvercomplex Midden-Limburg
26	Schietveld - landbouwgebied van Peer

Description of Demonstrator

Keywords: water level management, land use, agriculture, nature

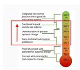
Water level management in coastal polder landscape is about:
- Water level management of polders and floodplains
- Combining water level management with land use changes (optimizing land use and water level management spatially)
- Agreements on waterlevels for compartments of the polder.
- Combining the new waterlevels with other NbS to create beautiful and context specific new landscapes for the users.

The general objective is to control drainage and site restoration to more natural water levels by more flexible (in time and space) water levels. Depending on the dominant use of the compartment, these waterlevels are controlled to - in priority - serve food production or natural landscape values, depending on the compartment. For the Uitkerkse Polder it concerns (protected) natural landscape values. To make sure that the waterlevels (waterpeilen) match the needs (behoeften) and the use of the area, in some cases land is swapped and rearranged to maximum cluster agricultural use and separate this from the high natural valuable landscapes.

It is a strategy that deals with conflicting interests from different users and prevents~~ing~~ conflicts and inefficiency. This strategy consists of a high scale co-design proces with different steps. Learning from this proces can learn us how to deal with similar conflicting interests related to water and climate resilience of different users in polders and other flat coastal landscapes.

We will focus on compartment 4 of the Oudlandpolder, Uitkerkse Polder, with a dominant use for (protected) nature.

TRL level: medium



suggestion:
to fit in the NBRACER framework I would realy focus on one landscape (coastal = polders) with the specific contextual challenges and enablers; because you chose the Oudlandpolder you can also mention the difficulties of below-high-tide water (level) management and problems of discharging towards the sea - which makes this demo very relevant for other low lying coastal zones
Bastiaan

added to text

Co-design process and improvements needed

Involved stakeholder groups:
Stakeholder mapping: ~~(see figure and MIRO)~~ Stakeholders are reached through regular workshops and interactions. As demo coordinator, VLM teams up with local partners incl. water managers, landscape designers, the Province of West-Flanders, the Flemish Environmental Agency, ... NBRACER supports this project in organizing field visits and workshops with local farmers, nature managers, watermanagers and identifying enablers and barriers to implementation. We link to other existing projects in the region, incl. Weerbaar Water-Land-Schap Bovenloop IJzer and Integrale Waterstrategie IJzer & Handzamevallei (link) (coordinated by the Province of West-Flanders), and other initiatives from the Flemish Government in the region.

Involved in Peilbesluit Uitkerkse Polder:
- Farming organizations
- Nature organizations
- Water managers
- VLM
- Landowners (agriculture and nature)

Decision making for Peilbesluit Uitkerkse Polder:
- Water managers (polders and wateringen)
- VMM
- Province

In the EU project COASTAL a co-design process was also implemented in the area.

For NBRACER we will do the stakeholder mapping with the projectteam.
Important: we do stakeholder mapping and all actions for Uitkerkse polder, not entire Oudlandpolder

Figure: stakeholder mapping for this NbS in the Boven IJzer region, made during NBRACER. Digital version at LINK. (copy updates)

suggestion:
- focus on the raamakkoord in which a lot of co-design has happened
- the work in COASTAL was also co-dsign, should clearly be mentioned
- I would focus on the combination of land use change and water level management (like in COASTAL), not WLM alone
- we should make more clear which co-design actions still happen in NBRACER - as much has been done
- climate risks: on site pluvial flooding, off site pluvial flooding (storing rainwater from nearby villages for instance); drought
Bastiaan

to do WP leads: Add high-resolution picture from original MIRO: **be careful not to share this in report, it is more info that provides insight in the proces, not objective enough and not to be shared with European partners directly, only through process and more generalised. all stakeholders are mapped in this MIRO and exercise**

Co-design actions
NBRACER leverages the strengths of various existing projects in the region by further supporting through co-design and identification of barriers and enablers. The co-design process consists of five key steps: we support issue framing and knowledge gathering, engage in the co-design of potential solutions, and conduct partial validation of these solutions with stakeholders, ultimately leading to informed decision-making.

Here focussed on the enabling factors of '**knowledge and data**' and '**governance and engagement**'.

Proces in short: **Peilbesluit Uitkerkse Polder**: VLM supports the further development of a landinrichtingsplan based on the raamakkoord Oudlandpolder and Peilbesluiten for compartment 4 uitkerkse Polder. Critical points to tackle for the Oudlandpolder pilot are (1) drainage of rainwater that can result in local flooding, (2) salinisation of rivers and groundwater in dry periods and (3) For food production the water levels are traditionally low to protect the crops, however this is in contrast with the need to safe water and also treatens the natural value of the area. For this pilot we will mainly focus on the third point and research how agreements on a compartment level can support the better use and climate resilience of the polder landscape. In the co-design proces we focus here on high level (often governmental) stakeholders and how the proces can be supported by a good collaboration and agreement of all high level stakeholders. We investigate the experiences of these key stakeholders with this aproach and try to identify key success factors and lessons learned.

Detailed proces:
Enabling factor: 'governance and engagement'
(1) Join some colaborative meetings with local actors for the Uitkerkse Polder and observe and report on findings and give advice towards the project what could be changed or improved.
(2) Interview 1-1 some key stakeholders about the proces and there experiences. (suggestion: projectmanager, hydrologist, agricultural expert, polder manager, province of WFL, ANB (nature management), ABS (agricultural representative))
(3) Investigate the watertoets and links to climate resilience.
(4) Write a report on findings and collect all interviews. Optional bonus: Create a podcast (supported by WP8) with these interviews on 'peilbesluiten'?

Enabling factor: 'data and knowledge'
(1) Collect existing literature and research and follow up new research on the topic (with research partners: UGent, Merlin, Inagro, KULeuven, VITO, WLS,...)
(2) Be present at events where knowledge and data about this NbS are shared. (CIW, internal network of hydrologists, ...)
(3) Make an overview of good sources for data and knowledge on the NbS
(4) Make a regional translation of these data and knowledge for Machuit as replicator area: can this be outscaled to Machuit yes/no? why?

Some questions we hope to answer:
- *What are the key enablers and barriers in this process?*
- *Does the region succeed in involving new stakeholders and in communicating to the wider public?*
- *Which are the barriers along the co-design process and issues still to be solved?*
- *What questions do the key stakeholders have still about the process and how did they experience it looking back at it?*
- *How do the key stakeholders look at the future and what are their hopes and fears?*
- *Are there risks for maladaptation for the region resulting from the process and how is this monitored?*

Governance and other enabling conditions

Thus far, we have identified these enabling conditions (starting with the most important)

(1) Governance and engagement: • What is the governance structure behind the demonstrator (incl. funders and decision makers)?
We consider as one of the main issues that legislation is not supporting the rewetting of polders needed to build climate resilience. The legislation (watertoets wetgeving, by CIW) is good applicable for bigger infrastructural projects in urban spaces. however, it is insufficient applicable for open spaces in rural landscapes and polders. In Flanders, every project has to be in line with this legislation and this is tested before implementation. The problem is that it in its current format will not stimulate good watermanagement for polders and blocks sometimes the proces to change the watersystem to its landscape-related and user related needs. This becomes more clear and more urgent when considering climate risks and the need to build a climate robust watersystem.

(2) Knowledge and data: • Are there any gaps on knowledge and data to increase the readiness level of the solution?
To support the changes in governance and legislation we need more data and evidence of the functioning of the watersystem in polders. To understand better how polder managers look at the watersystem and how it could be changed we need to better understand their point of view on this as well.

(3) Finances and resources: • Are there any needs for extra financing resources to mainstream the solution?
This is always an important aspect and enabler, but here we have a good basis for finances and resources.

(4) Behaviourial change: • If relevant, what is the perception of stakeholders and citizens over the solution? Is there willingness for the behavioural and systemic changes needed to mainstream this solution?
This case is situated on a higher (regional) level. For this reason, it is less important than for other NbS in the region. Also, the stakeholders with the highest influence are situated on the higher (scale) level. Convincing farmers about the use of peilbesluiten is of course still something to consider, but here we decided to focus on other aspects of the case. By interviewing some representatives of the farmers we hope to get some understanding.

Monitoring and selected KPIs

No physical quantitative data will be taken.

In this NbS, we focus on qualitative data to investigate this type of water level management.

- Data gathered from attending meetings related to this water level management.
- Interviewing key-stakeholders to investigate the socio-economic and governmental aspects.
- Gathering opinions and perceptions of landowners, farmers, and other stakeholders.
- Identifying enabling conditions and barriers, also including literature research.
- Gather lessons learned

We still need to research the tools that can be used for this (but we already know that there are not many tools available for this NbS).

Climate risks, Key Community Systems, Ecosystem Services

Climate Risks
Drought
Flooding (fluvial)
Biodiversity
Water quality/salinisation

Key Community Systems
Water system
Food system

To a lesser extent: critical infrastructure (potentially less flooding)

Ecosystem Services
depends on the context:
higher natural value
better water quality
better food production
increased health
...

How are KCS impacted:
- Water management
  - water level: positive (focus)
- Land use & Food systems
  - food production on private fields (small scale): both positive and negative (possible disservices depending on context)
  - food production on private fields (large scale): both positive and negative (possible disservices depending on context)
  - protected species: mostly positive
- Ecosystems & NbS
  - biodiversity: mostly positive

How are KCS impacted:
Health & Wellbeing
- recreational: positive
- heat reduction (koelteplekken): positive
- sense of being: positive ?

Critical infrastructure
- some smaller roads: less flooding
- some private houses: less flooding

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...

Sustainable farming practices

INAGRO

Prov WFI

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Scale: local

Summary

Brief description and objectives: Non tillage and carbon farming are sustainable practices aimed at better and more natural soil management resulting in a more climate robust agriculture. Evaluation of the long-term benefits of carbon farming and the benefits of non tillage in polder landscapes are crucial in helping farmers to implement these practices.

Landscapes: Rural; Coastal

Landscape archetype subtypes: Polders

Stakeholders involved and roles
- Citizens - farmers (implementation)
- Research - INAGRO (support)
- Government - PWF, local municipalities (regulation)

Key Community Systems
- Landscape and food systems
- Ecosystem
- Water management

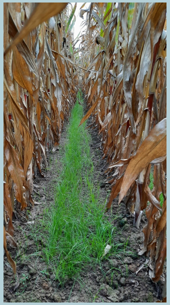
Main regulatory function
- Improved soil quality

Climate risks
- Extreme weather events, erosion, loss of biodiversity, soil degradation, food and water insecurity

Co-benefits
- Biodiversity
- Carbon capture
- Water infiltration

Ownership and roles
- farmers (excecutors)
- INAGRO (research and support)
- PWF (regulation)

Enabling conditions
- Technical knowledge
- Financial incentives
- Time management



Description of Demonstrator

Keywords: carbon farming; non-tillage agriculture, sustainable farming, soil management practices

In this demonstrator, we focus on two sustainable **farming practices**: carbon farming and non-tillage agriculture. These practices result in a more natural and healthier soil system. This should make farmers less succeptable to climate effects, especially drought and (to a lesser extant) flooding, as the natural soil water system (availability of water for crops in the unsaturated zone, infiltration, ...) is restored.

Carbon farming involves measures that sequester carbon dioxide in the soil by enhancing soil organic matter. Increased soil organic matter improves overall soil quality, benefiting farmers through higher yields and reduced nutrient and water demands. It also enhances soil biodiversity and health. By capturing carbon in the soil, CO2 emissions are mitigated, addressing both adaptation and mitigation simultaneously [2].

Non-tillage farming is a technique that avoids intensive turning or mixing of the soil. This results in more crop residues remaining on the soil surface, protecting the soil against erosion and increasing soil moisture content. Reduced soil compaction leads to better water infiltration. For farmers, this technique saves time and fuel costs [3].

Co-design process and improvements needed

Involved stakeholder groups:
- Farmers play the most important role as they are responsible for the implementation of these practices
- Local/regional governments: the municipality of Beernem and the Province of West-Flanders are also involved; they offer a support base for the implementation of carbon farming techniques by offering a financial incentive.

Sustainable farming practices encompass two separate demonstrations: **non-tillage agriculture** and **carbon farming**. Both of these demonstrations involve on-farm experimentation, meaning they are conducted on commercial farms at a commercial scale in collaboration with farmers.

The aim is to understand farmers' preferences regarding these NbS and to identify enablers and barriers. This will help determine what is needed to upscale and mainstream these NbS. Already quite a lot of information has been gathered on the potential of these techniques, the co-design process within NBRACER will be mostly focused on mainstreaming these techniques.

Non-tillage agriculture
There is already considerable experience with non-tillage on sandy and loamy soils, but not for heavy clay soils in the coastal polders. To mainstream this technique and increase its implementation in different soil contexts, scientific evidence of the effects of non-tillage compared to the traditional practice of plowing before winter in the polders needs to be gathered. This demonstration is located on several fields at different locations in the polders of West Flanders.

Carbon farming
The storage of carbon in the soil is a work of generations. Although this increase in soil organic carbon content is a slow process, other benefits are expected and may not take as long to realize. Further scientific evidence of the benefits obtained after a shorter term (+/-5 years) on a local scale might be the convincing factor for some farmers. In this study we plan to evaluate the effects these measures have had after they have been practiced since 2020-2021. This demo is located in Beverhoutsveld in West-Flanders. For this, we collaborate with an ongoing project Water-Land-Schap Beverhoutsveld, funded by VLM.

Governance and other enabling conditions

Financial aspects:
- Combining sustainable agricultural practices (carbon farming, organic manure, non-inversion tillage, agroforestry) can bring multiple benefits for investment [1].
- A sharing system for agricultural machines could help de-risk individual transition investments and upscale implementation (new market creation) [1].
- Consumers or governments might be willing to pay for the carbon sequestration in a carbon credit market system [2].
- Non-tillage leads to lower fuel costs and saves times [3].

Technical aspects:
- The effectiveness depends on soil type and other regional factors [1]. The impact on different crops (management and yield) is crucial for farmer implementation [1].
- Requires long time for implementation and must be consistently monitored during and after implementation [1].
- Difficult to measure and quantify carbon uptake as this is a work of generations.
- When not correctly maintained, the carbon can be released again [1].
- Potential negative effect on water quality: depending on the method of building up carbon in the soil, there is a risk for increased phosphate, nitrate and pesticide pollution [1].

Governance and **social** factors:
- (Private) landowners and farmers have to be willing to collaborate [1].
- These NBS can be implemented by only changing management and do not necessarily include a land use change or land exchange [1].

Monitoring and selected KPIs

Different soil parameters will be monitored, including:
- Chemical soil analysis (CF&NT)
- CEC and HWC (CF)
- Aggregate stability (CF)
- Infiltration rate (CF&NT)
- Soil compaction (CF&NT)
- Bulk density, TAW, RAW, porosity and pF curves (CF&NT)
- Soil moisture content (NT)
- Soil microbial analysis (CF)

Crop parameters will also be monitored:
- Yield (NT)
- Crop emergence (NT)

For this KPIs, NT stands for non-tillage and CF for carbon farming.

Climate risks, Key Community Systems, Ecosystem Services

Climate Risks	Key Community Systems	Ecosystem Services
- Extreme weather events - Erosion - Soil degradation - Loss of biodiversity - Food and water insecurity	land use and food system Ecosystem Water management	Improved soil quality Biodiversity Carbon capture Water infiltration

How are KCS impacted:
- Landscape and food system: Our food security is threatened by the changing climate. Carbon farming and non-tillage agriculture can help make agriculture more climate robust. These measures tackle climate adaptation and, in the case of carbon farming, climate mitigation.
- Ecosystem: Non-tillage and carbon farming aid in building a more natural and healthier soil system. This includes a richer soil biology.
- Water management: Both techniques support a better water infiltration and water retention in the soil.

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